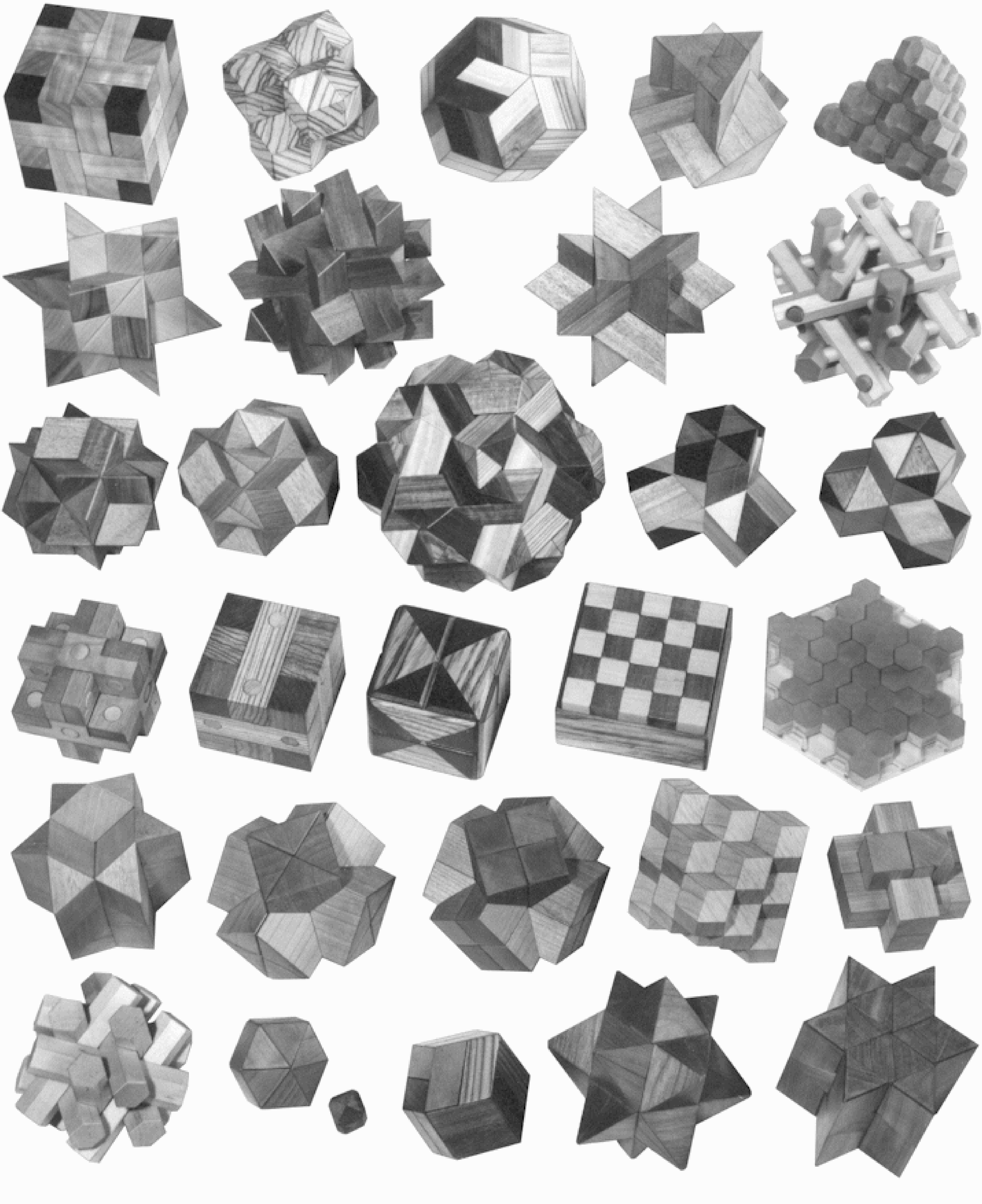
PUZZLE CRAFT

By Stewart T. Coffin



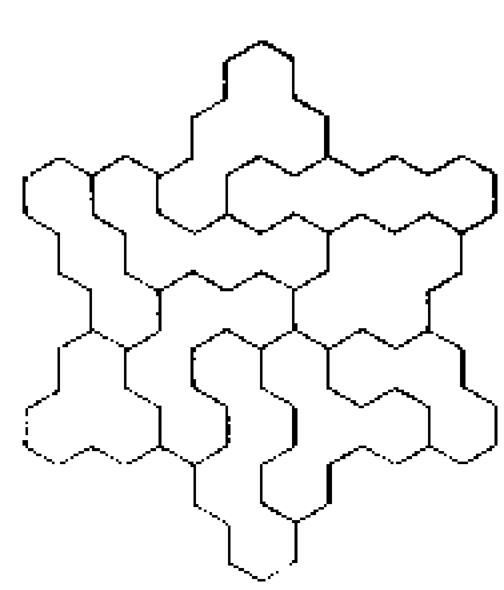
PUZZLE CRAFT

Preface to 1985 Edition

Puzzle Craft was begun in 1974 as a newsletter of very limited circulation having to do with mechanical and geometrical puzzles, especially those which could be made in the classroom or shop. It was intended for persons who like to design them, make them, collect them, or just do them. It started out as an adjunct to my cottage industry of designing and making wooden puzzles, and its purpose was as much to collect information as to disseminate it. In 1978 the back issues were revised and assembled into a 24-page booklet. Booklet No. 2 "Polyhedral Puzzles," which described my own puzzle design efforts, was first published in 1981. In 1982, Booklet No. 3 "Woodworking Techniques" was added. In 1984, all of these together with a new Part 4 "Wooden Puzzles" were assembled into one book. In this 1985 edition, the first three parts have been considerably revised, a few new designs have been added in Part 4, and the cover and binding improved.

We have these sheets run off at the local copy center a few hundred at a time, and do the binding right here in my shop as orders trickle in. The advantage of doing it this way is that revisions and additions are always coming to light, and this allows them to be incorporated almost immediately. With this edition, a "Contents" page has been added and the page numbering made consecutive throughout; but because of subsequent insertions there may be some anomalies in page numbers. Suggestions, corrections, and contributions are always welcome.

Among those who have contributed information for Puzzle Craft or helped in some other way are the following, listed in no particular order: David and Joel Ferola, Norton Starr, Jerry Slocum, Hans Havermann, Joseph Lemire, Ed Hordern, William Siggson, Bill Cutler, David Barge, Mike Beeler, Martin Gardner, Kathy Jones, Woodrow Carpenter, John Ehrman, Tom Rodgers, Louis Rosenblum, Will Shortz. Assisting in shop and office have been my wife Jane and our three girls - Abbie, Tammis, and Margaret.



CONTENTS

PUZZLE CRAFT

Part 1 - Mechanical and Geometrical Puzzles

Bibliography

Until the publication of Puzzle Craft and a few other recent books, the person looking for general information on mechanical and geometrical puzzles faced peculiar difficulties. Where would you start? Probably your local library. A search through the card catalog under "Puzzles" might reveal a few books on crossword puzzles or mazes and one or two on mathematical brain teasers, but nothing on what we are seeking. Browsing in the stacks presents another problem, for it is not clear in the Dewey Index system how books on this particular subject should be shelved. They are one of those ambiguities which any cataloguing system has. An authority informs me that Puzzle Craft would probably be catalogued under 745.51, "Handicrafts - wood," but possibly under 793.73, "Puzzles and Puzzle Games." Don't waste too much time looking; even large libraries have very few if any books on mechanical and geometrical puzzles. As for books dealing specifically with their design and construction, almost none have ever been written. But if you include books which have at least a chapter on mechanical puzzles, there are quite a few. Some of the more interesting are listed below:

Puzzles Old and New, by Professor Hoffmann (Angelo Lewis), Warne & Co., London, 1893. An excellent book on all sorts of puzzles, rare.

Miscellaneous Puzzles, by A. Duncan Stubbs, Warne & Co., 1931. Covers some of Hoffmann's ground, but mostly tricks and novelties.

Illustrated Magic, by Ottokar Fischer, The Macmillan Co., New York, 1942. Contains a chapter on some classic mechanical puzzles.

Fun With Wood, by Joseph Leeming, J. B. Lippincott Co., Philadelphia, 1942. Has a chapter on some simple wooden puzzles and how to make them.

Wonders in Wood, by Edwin M. Wyatt, Bruce Publishing Co., 1946. Has a few pages on making wooden puzzles.

Puzzles in Wood, by Edwin M. Wyatt, Bruce Publishing Co., 1956. A good book which describes how to make and solve a variety of burrs and other easy wooden puzzles. Now reprinted and available from: Woodcraft Supply Corp., 41 Atlantic Ave., P. O. Box 4000, Woburn, MA 01888.

Mathematical Puzzles and Other Brain Twisters, by A.S. Filipiak, A. S. Barnes & Co., Fourth Printing, 1964. Although you might not guess it from the title, this book describes a variety of mechanical puzzles. It has been, and may still be, available from Publishers Central Bureau, 1 Champion Ave., Avenel, NJ 07131.

Creative Puzzles of the World, by Pieter van Delft & Jack Botermans, published in the U.S. by Harry N. Abrams, Inc., 110 East 59th St., New York, NY 10022, 1978. By far the best book on puzzles ever published. Excellent photographs and drawings in superb full-page color plates. Now unfortunately out of print I am told, but the authors are reported to be working on a sequel to it.

A Yankee Way with Wood, by Phyllis Meras, Houghton Mifflin Co., 2 Park St., Boston, MA 02107, 1975. Has a chapter on my geometrical puzzles, and tells how to make the Altekruse burr puzzle.

Wooden Puzzles and Games, Intriguing Projects You Can Make, by Kenneth Wells, Sterling Publishing Co., 1983.

There are many books on mathematical recreations and puzzles in general. We can't list them all here, but the following are a few selected ones which relate more or less to the particular types of puzzles discussed in Puzzle Craft:

Mathematical Recreations and Essays, by W. W. R. Ball and H. S. M. Coxeter, 12th edition, 1974, University of Toronto Press, 33 E. Tupper St., Buffalo, NY 14203. A classic book on a variety of subjects such as polyhedra, polyominoes, the Chinese ring puzzle, and Tower of Hanoi.

Mathematical Snapshots, by Hugo Steinhaus, 3rd edition, 1969, Oxford University Press, 16-100 Pollitt Dr., Fairlawn, NJ 07410. An excellent book on mathematical recreations, with emphasis on geometrical.

Polyominoes, by Solomon W. Golomb, Charles Scribner's Sons, New York, 1965.

Shapes, Space, and Symmetry, by Alan Holden, Columbia University Press, 136 S. Broadway, Irvington-on-Hudson, NY 10533, 1971. There are too many books on polyhedra and related subjects to list them all, but this is one of the best ones.

Recreational Problems in Geometric Dissections and How to Solve Them, by Harry Lindgren. Updated by Greg Frederickson, 1972. Dover Publications Inc., 180 Varick St., New York, NY 10014.

Geometry and the Imagination, by Hilbert and Cohn-Vossen, Chelsea Publishing Co., 432 Park Ave. S., Rm 503, New York, NY 10016, 1952.

The Graphic Works of M. C. Escher, Hawthorn Books Inc., 260 Madison Ave., New York, NY 10016, 1967.

The Geometric Foundation of Natural Structure: A Source Book of Design, by Robert Williams, Eudaemon Press, republished by Dover Publications Inc., 180 Varick St., New York, NY 10014. Well illustrated source book of design inspiration. Geometric forms, polyhedra, tesselations, and packing of polyhedra and spheres.

Puzzles and Paradoxes, by T. H. O'Beirne, Oxford University Press, 1965.

Winning Ways for Your Mathematical Plays, by Elwyn R. Berlekamp, John H. Conway, and Richard K. Guy, Academic Press, Inc., 111 Fifth Ave., New York, NY 10003. In two volumes; Vol. 2 is of particular interest.

Pionerskaya Igroteka, by Efim Minskin, Molodaya Gvardiya, Moscow, 1966. Wooden puzzles, ring-string-ball & wire puzzles. In Russian, but well illustrated.

The Ring of Linked Rings, by S. N. Afriat, 1982, Duckworth and Co., Ltd., The Old Piano Factory, 43 Gloucester Crescent, London NW1 7DY. On Chinese rings puzzle and Tower of Hanoi.

Ingenious Ring Puzzle Book, by Chung-En Yu, Canton, 1958. English translation by Yenna Wu, issued by Jerry Slocum at the Fourth International Puzzle Party, 1981.

Order in Space: A Design Source Book, by Keith Critchlow, Viking Press Inc., 625 Madison Ave., New York, NY 10022, 1970.

Hypergraphics: Visualizing Complex Relationships in Art, Science, and Technology, edited by David W. Brisson, published by Westview Press, 5500 Central Ave., Boulder, CO for the American Association for the Advancement of Science, 1776 Massachusetts Ave., Washington, DC. With the home computer now a reality, it is conceivable that future puzzle designers will model their creations on a display rather than in the workshop. This book and many other computer graphics books will lead the way.

Orderly Tangles (Cloverleafs, Gordian Knots, and Regular Polylinks), by Alan Holden, Columbia University Press, 1983.

Obviously, most of the books listed in this bibliography are no longer in print, and many are scarce. Perhaps more will be republished if there is enough demand.

Just as this was being typed, I received from Will Shortz of Games Magazine his Puzzleana, "A Bibliography of Rare and Interesting Books and Magazines Relating to Puzzles, January 1985." It contains 465 items listed by category, plus an alphabetical index. My first reaction was that I would have to do the job all over again, but he lists only twelve under "mechanical" puzzles, and I believe we have included the important ones already.

(One of my helpers has informed me she was taught in school that the bibliography always comes at the end of a book, not the beginning. Just one more example, as if any were needed, where a smattering of education is worse than none at all. It is included here because so many readers express a particular interest in it.)

Periodicals - Magazines and Newsletters

There are very few which deal specifically with puzzles, and none I am aware of which deal specifically with mechanical and geometrical puzzles.

Scientific American, 415 Madison Ave., New York, NY 10017, had for many years a monthly column by Martin Gardner on mathematical games, puzzles, and recreations. Martin Gardner has authored several books based on these columns. The six-piece burr and other mechanical puzzles were discussed in the January 1978 issue of Scientific American. The games column has now been discontinued. A new column "Computer Recreations" is conducted by A. K. Dewdney, the September 1985 issue of which is scheduled to be on mechanical puzzles.

World Game Review, edited and published quarterly by Michael Keller, 9 Chadman Court, Baltimore, MD 21207. An excellent new publication in informal newsletter format with a wealth of information on games and puzzles, well worth the $8.00 subscription judging from the one issue I have seen. Not very much on mechanical puzzles, but if you have ideas, write to the editor and he will probably try to oblige.

Games, published monthly by Playboy Enterprises, Inc., 919 N. Michigan Ave., Chicago, IL 60611. Subscriptions: P. O. Box 10148, Des Moines, IA 50340. Has all sorts of games and puzzles.

Journal of Recreational Mathematics, published quarterly by Baywood Publishing Co., 120 Marine St., Farmingdale, NY 11735. Has articles on dissections, tesselations, polyominoes, combinatorial puzzles, packing, and occasionally mechanical puzzles.

Abacus, published quarterly by Springer-Verlag, 175 Fifth Ave., New York, NY 10010. Has a column on "Problems and Puzzles," Richard V. Andree editor. Fall 1984 issue had article on 3D block puzzles.

Fine Woodworking, published bimonthly by The Taunton Press, 52 Church Hill Road, Box 355, Newtown, CT 06470. Had puzzle articles in Issue No. 14 and No. 49, back issues available.

Sources of Puzzles

Rhombics, 36 Pleasant St., Watertown, MA 02172. Manufacturer of high quality wooden puzzles.

Kadon Enterprises, Inc., 1227 Lorene Drive, Suite 16, Pasadena, MD 21122. Inventor and manufacturer of new and original high quality games and puzzles.

World Wide Games, Box 450, Delaware, OH 43015. High quality wooden games and a few puzzles.

Mag-Nif Inc., 8820 East Ave., Mentor, OH 44060. Manufacturer.

Parker Brothers Inc., 50 Dunham Road, Beverly, MA 01915. Manufacturer.

Creative Publications, 3977 East Bayshore Road, Box 10328, Palo Alto, CA 94303.

Skor-Mor, 300 Babcock St., Boston, MA 02215. Manufacturer, mostly in plastic.

Lumberjack Toys, Inc., 2180 Bryant St., San Francisco, CA 94110. Well crafted topological puzzles in wood and brass.

Gordon Brothers & Associates, 5831 Rosebud Lane, Unit B, Sacramento, CA 95841. Manufacturer.

Paragon-Reiss, 230 Fifth Ave., New York, NY 10001. Manufacturer.

Synergystics Research Corp., 650 Avenue of the Americas, New York, NY 10011. Manufacturer.

Pentangle, Over Wallop, Hants, SO20 8JA, England. One of the world's few manufacturers and suppliers specializing in puzzles.

Tenyo Co., Ltd., 3-1, 2-chome Shintomi, Chou-Ku, Tokyo, Japan.

Eljo Games Co., P. O. Box 2141, Syracuse, NY 13220. Manufacturer of "The Enigma" wire puzzle.

The Grail, Inc., 914 Park Ave., Laramie, WY 82070. Manufacturer of bead and chain puzzle.

Smithsonian Institution, Mail Order Division, P. O. Box 199, Washington, DC 20560.

Stave Puzzles, Main St., Norwich, VT 05055. I don't normally think of jigsaw puzzles as being within the scope of this book, but I include this one source of them because they are so extraordinary.

Tetra Toys, 1 Queens Ave., McMahons Point, NSW 2060, Australia.

Ole Uncle Smiley's Original Old Country Grandpa Puzzles, Ray. R. Rylander, 805 E. San Rafael St., Colorado Springs, CO 80903. Makes and sells burr puzzles at craft fairs. Quoting Ray: "Everything is driven by an antique gas engine with long flapping flat belts, smoke, noise and dust." His prices are hard to match - mail orders welcome.

Le Club Jeux Descartes, 5, rue de la Baume, 75008, Paris, France.

Tysswayr Products, P. O. Box 36657, Albuquerque, NM 87176-6657. They run an ad in Games magazine for paper puzzles.

Johnson Smith, 35075 Automation Drive, Mt. Clemens, MI 48043. Mail order supplier, established in 1914. In the interests of historical memorabilia, I would just like to mention here that their 600-page catalog of the 1920's and 1930's contained probably the most amazing assortment of games, tricks, novelties, and puzzles ever to be compressed between the covers of one book. The first puzzle I owned was their 21-piece burr - price 15¢ postpaid (I still have it). One of the most fascinating toys ever sold was their "putt-putt" boat, powered by a small candle and priced at about 50¢ as I recall. I wonder why no one makes them now? The company is still in business, and there must be a few puzzles somewhere in their 80-page catalog, although I didn't have the patience to search.

Puzzle Collections, Displays, and Museums

I am not aware of permanent puzzle collections on public display in any museums. There are many large puzzle collections in private hands, some of which may eventually find their way into institutions. Jerry Slocum's collection in California is said to be the world's largest. There are other large collections in Toronto and England.

Amherst College has a fine collection of geometrical puzzles on display in their mathematics building.

In November 1985, a puzzle exhibit said to be by far the largest and best ever assembled will open at the Craft & Folk Art Museum in Los Angeles. It will probably also be shown at the Cooper-Hewitt Museum in New York, the Science Museum of Minnesota in St. Paul, and the City Museum of Munich.

Persons interested in the history of puzzles might be curious to know what puzzles are to be found in large anthropological museums such as the Smithsonian. My limited research in this direction has failed to uncover a single puzzle. The only explanation I can think of for this is that puzzles are a modern phenomenon, and very few are very old.

Who's Who in Puzzles

Interest in collecting, designing, and hand-crafting puzzles is worldwide. In the U.S. alone, there are dozens if not hundreds of craftsmen designing, making, and selling puzzles out of their home workshop. Most are too small and haphazard to be included in our listing of manufacturers. Many would prefer to keep it that way. The best way to find out more is simply to become involved somehow, follow some of the periodicals listed, keep your eyes and ears open, and write letters. I receive puzzle mail from correspondents in about thirty foreign countries, much of which I don't even have time to answer. Many want to swap puzzles, especially those living behind the Iron Curtain, for this is the only way they are allowed to obtain merchandise from the Free World.

Patents

There is one excellent source of information on mechanical puzzles, easily accessible to anyone - the files of the Patent Office. I have in mind the U.S. Patent Office in particular, but there may be others of interest elsewhere. The task of searching for puzzle patents is greatly simplified by the fact that all patents are classified by subject. All puzzle patents are found in one of the following subclasses:

Class	Subclass	Description	No. of Patents	No. of Cross Ref.
273	153	PUZZLES	136	89
"	154	Balancing Ovoids	19	0
"	155	Folding, etc.	50	32
"	156	Take-aparts	116	39
"	157	Geometric, etc.	211	86
"	158	Bent wire	70	6
"	159	Flexible cord	50	5
"	160	Mortised blocks	55	23

(numbers are of Jan. 1974)

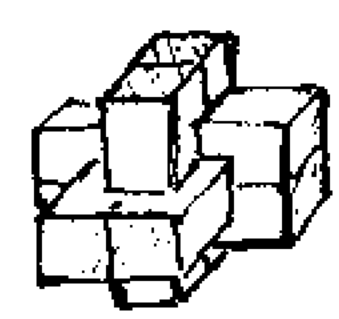
Patents may be ordered by number from the Patent and Trademark Office, Washington, DC 20231 at a price of $1.00 per copy. If you wish to obtain all patents in a certain subclass, you may inquire as to how many there now are in that subclass and then order the lot. You may also place a deposit and have future patents in that subclass sent to you as they are issued. You may obtain indexes, classification manuals, and all sorts of other useful things. For more information, order "General Information Concerning Patents" from the U. S. Gov't Printing Office, Washington, DC 20402, price $2.00.

You may examine patents at the Search Room of the U. S. Patent Office, 2021 Jefferson Davis Highway, Arlington, VA, or at any one of about twenty libraries located throughout the country, as listed in the above booklet.

Ten years ago, I obtained copies of about half of all puzzle patents issued at that time, including all in subclasses 153, 156, and 160. I spent months studying them and reported on what I judged to be the more interesting ones in one issue of Puzzle Craft. This is a reedition of that report. I made up my own categories of classification, which was quite a task because so many areas overlap, and some are so weird as to defy any sort of logical classification.

Standard Six-piece Burr

One of the most familiar of all puzzles, to be discussed in detail elsewhere in Puzzle Craft. No one seems to know when, where, or by whom this puzzle was invented. It has thousands of minor variations depending on how the sticks are notched, and at one time the Patent Office allowed persons to patent their own favorite versions at will.



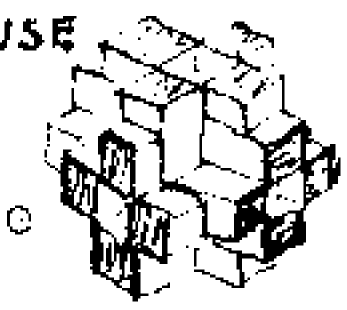
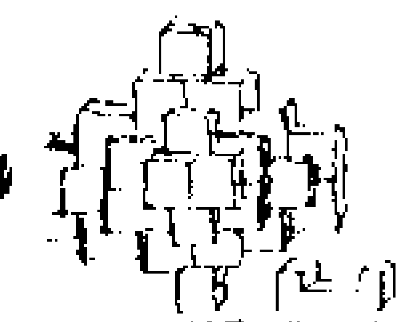
Thus we have #1,225,760 of Brown, 1917, which is a conventional design with sliding key, and two pieces with blind corners. #1,261,242 of Keiser, 1918, is a standard version with sliding key. #1,388,710 of Hime, 1921, is identical to Keiser except for the addition of holes in one end of each piece through which a length of cord is strung. #1,425,107 of Levinson, 1922, is a simple and familiar symmetrical version with key. Showing somewhat more originality, #2,836,421 of Turner, 1958, discusses multiple combinations possible with an assortment of pieces. #1,350,039 of Senyx, 1920, is almost identical to Keiser.

Variations of Standard Burr

#767,645 of Kelly, 1904, has rectangular cross-section sticks and tapered key piece. #906,450 of Murf & Krompigel, 1908, has complicated, non-integral notching. #943,496 of Weigt, 1909, has a non-symmetrical arrangement of sticks. #1,099,159 of Banic requires a loose fit so that one piece can rotate. #1,542,148 of Kramariuk, 1924, has an internal locking mechanism which prevents it from sliding apart.

More Complicated Rectangular Burrs

The earliest is #430,502 of Altekruse, 1890. This is a familiar burr of twelve identical pieces which is widely made and sold today. It is discussed elsewhere in Puzzle Craft. The patent gives one solution but fails to point out that there are several other solutions.

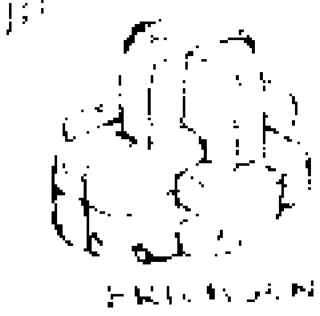
ALTEKRUSE


NELSON

#588,705 of Nelson, 1897, is an attractive symmetrical assembly of essentially twenty-four pieces. (A simplified and improved version is produced by Pentangle as their "Woodchuck" puzzle.)

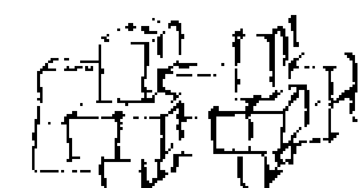
CURTIS


#781,050 of Curtis, 1905, is a non-isometric eleven-piece burr.

#985,253 of Erickson, 1911, is essentially the same idea as Curtis.

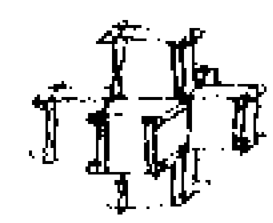

DULGEROFF


#1,129,281 of Dulgeroff, 1915, is practically identical to Nelson, but the end faces are beveled, changing the appearance.


DAUTREMONT

#1,221,149 of d'Autremont, 1917, is a complicated ten-piece burr with pins and holes added.

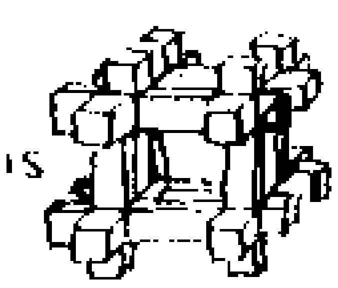
#1,374,729 of Gisa, 1921, is an interesting variation of Nelson, having a different key piece and a box-like configuration.


GISA

SCHENK

#1,455,009 of Schenk, 1922, is a symmetrical and attractive 24-piece burr, but the notchings appear discouragingly complex.

#2,473,369 of Harris, 1949, is a complicated 12-piece burr with rotating keys. It appears to be one which has been on the market recently.

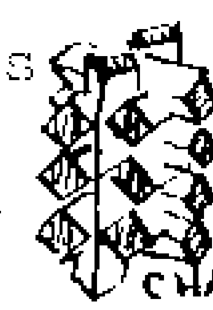
HARRIS


There is also a British patent #1,048,841 of Sihra, 1966, showing a large and very complicated assembly, with lengthy instructions.

There are cross-references to several other patents based on the standard six-piece burr principle including furniture, toy banks, rattles, picture frames, and candlesticks.

Diagonal Burr

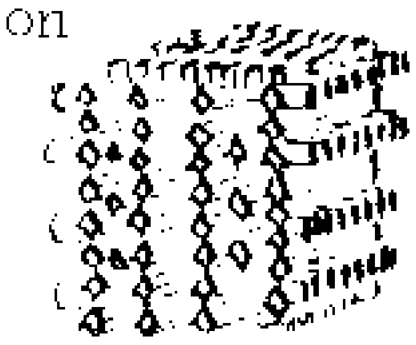
We have no clue as to who might be the inventor of this classic configuration. The earliest patent seems to be #395,816 of Chandler, 1888, which shows a more complicated 12-piece version with sliding key.


CHANDLER

HOY

#766,444 of Hoy, 1904, shows the basic six-piece version with sliding key, but disguised by a spherical shell.

#774,197 of Pinnell, 1904, is a horrendously complicated assembly of 102 diagonally notched sticks, (the patent notes that no model was submitted!).


PINNELL

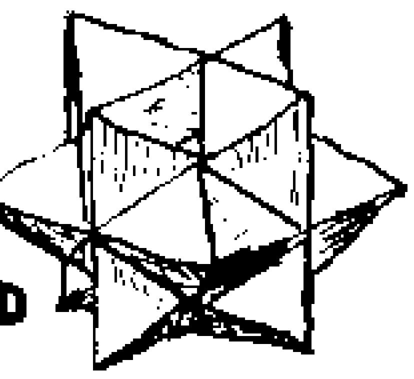
#779,121 of Ford, 1905, seems to be the earliest description on record of the classic symmetrical diagonal burr. Curiously, in his description, Ford shows a very awkward method of assembly, rather than the simple mating of two halves.


FORD

#819,894 of LaPierre, 1906, is simply the diagonal burr with extra notches so that it falls apart by itself (he calls it a "trick ball").

#1,546,024 of Reichenbach, 1925, is another diagonal burr with sliding key and spherical shell, similar to Hoy.

Finally, Swiss patent #245,402 of Iffland, 1946, again regresses to the old version with sliding key, but with the ends beveled to form the intriguing first stellation of the rhombic dodecahedron, a classic puzzle design.

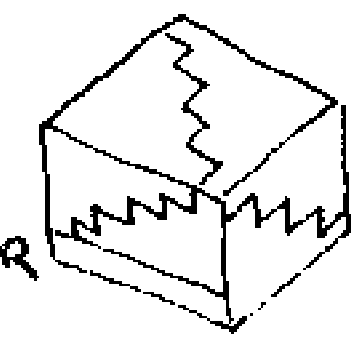
IFFLAND


Other Solid Geometrical Puzzles

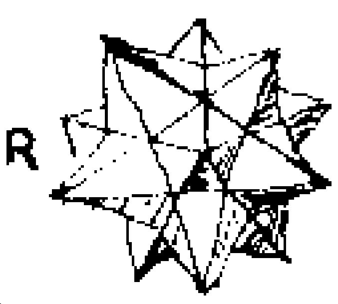
#332,256 of Keeler, 1885, has blocks which form a 5x5x5 cube.

#499,383 of Hanson is a seven-piece ball (not shown).

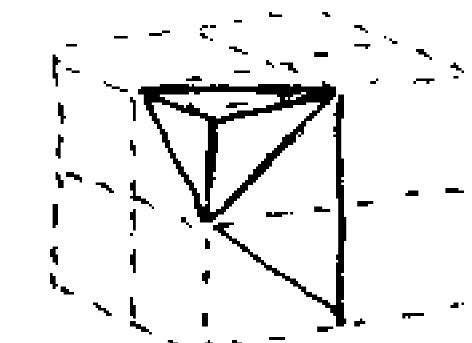
#524,212 of Porter, 1894, has six pieces which form the first stellation of the regular dodecahedron.

KEELER


#1,100,828 of Heard, 1914, is a complicated cubic assembly of many notched pieces. #1,189,527 of Barnhart, 1916, shows six complicated pieces forming a cube. #2,034,830 of Peffley, 1936, appears to be a complicated laminated ball; likewise #2,178,190 of Steinhardt, 1939, and #2,574,158 of Sullivan, 1951. Steinhardt tries again in 1953 with #2,625,399. #3,461,574 of Larsen, 1969, discusses various polyhedral models as educational toys, (none of the above shown).

PORTER


#3,645,535 of Randolph, 1972, describes interesting diagonal dissections of the cube.

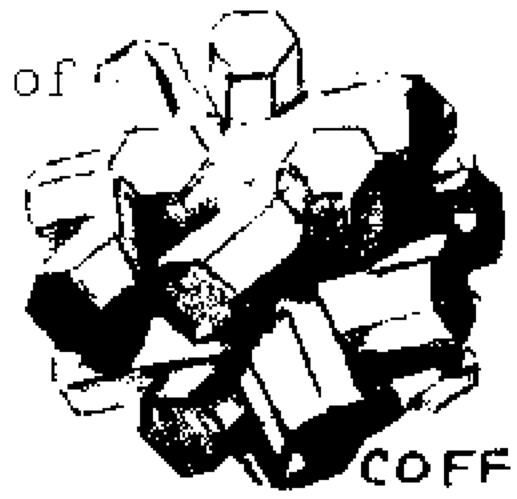

RANDOLPH

Other Non-Cartesian Notched Stick Designs

#3,372,936 of Sanson, 1968, is a complicated assembly of twenty-four notched hexagonal sticks (not shown).

#3,546,049 of Kostoch, 1970, does not discuss puzzles but illustrates interesting symmetrical arrangements of groups of rods in space.

#3,721,448 of Coffin, 1973, is a symmetrical assembly of twelve notched hexagonal sticks.


COFFIN

Mechanical Mazes

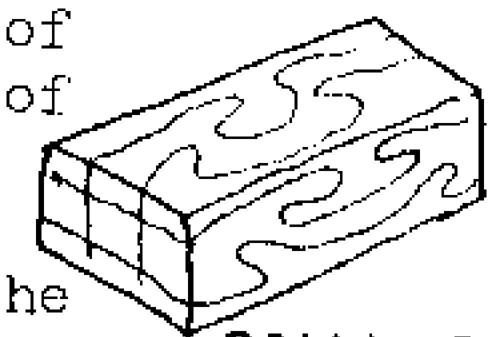
I have placed 31 patents in this category, only a few of which I will mention. The others appear to be too trivial to mention, or else I can't figure out from the description how they are supposed to work. #426,569 - spherical maze. #598,855 - two-sided maze. #598,889 - the first of many having multiple rotating discs. #616,765 - if wrong route is taken, soldier's head flies off! #432,865 - rotating disc type. #615,381 - cylindrical maze. #609,941 - remove ring from bicycle. #766,118 - improved rotating disc. #896,344 - movable split (helical) ring. #932,147 - movable ring with two perforated plates. #2,011,266 - maze with movable sections.

Obstetric Puzzles

Into this category I have put devices having a hollow body with something loose inside, which you attempt to extricate through an opening. Usually the container is opaque, with walls, tubes, and recesses inside, and a small opening into which a shot or marble is dropped; and you cannot shake it out again unless you are either very lucky or very persistent, or both. There are ten of them, and since none appear to be unusual or have advantage over others, I list them all: #607,257; #680,434; #666,022; #568,232; #633,034; #729,147; #818,128; #1,021,281; #1,154,136; #3,689,074. The last appears to be a puzzle recently on the market, made of walnut.

Solid Jigsaw-Type Puzzles

#245,533 of McChesney, 1881, sets forth the basic idea of sawing solids with jigsaw-type cuts in more than one plane. #343,516 of Collins & Odell, 1886, and #2,201,724 of Gable, 1940, are more of the same with minor refinements.



COLLINS

#2,923,551 of Pope, 1960, uses dovetail joints.

#3,107,918 of Elden, 1963, is an unusual puzzle involving the mating of irregular contoured surfaces.

#3,578,331 of DeCast, 1971, is a jigsaw-type puzzle in the form of a spherical or cylindrical shell.

Somewhat related to this category is #2,493,697 of Raczkowski, 1950, in which a solid figure is built up by stacking flat laminations on a spindle in the correct order.

DECAST

Magic Boxes, etc.

There is a large category of patents for devices in which two or more parts are held together by some internal (and infernal) mechanism which is hidden from view, and one must proceed to disengage them as best one can. Many of them are so complicated that it appears they would require many hours of painstaking work in a well equipped machine shop to be produced, and why someone went to the expense of patenting them is a mystery.

There are 40 patents in this group. I will mention only a few selected ones.

LOYD

#112,823 of famous puzzle inventor Sam Loyd, 1871, the oldest.

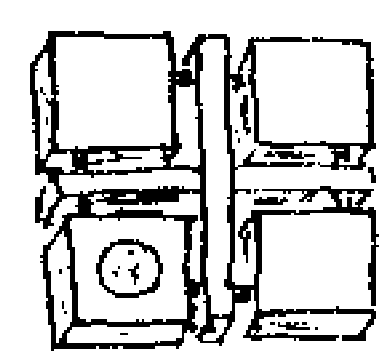
#435,804 - essentially a combination padlock, a favorite device.

#447,631 - plunger stuck in a bottle.

#536,220; #600,280; #709,888; #800,995; #1,111,337; #1,733,772; #2,794,645; #3,650,379 - all have steel balls inside which must be manoeuvered about.

#865,207 - ring on key is removed by taking off end of key.

#2,181,116 of Boyle, 1939, consists of four square blocks and two cross members, all held together with internal dowels. The familiar commercial version of it has a penny inside one of the blocks. #2,207,778 is a triangular version of the same puzzle, but it does not seem to have enjoyed as much success as the square version.

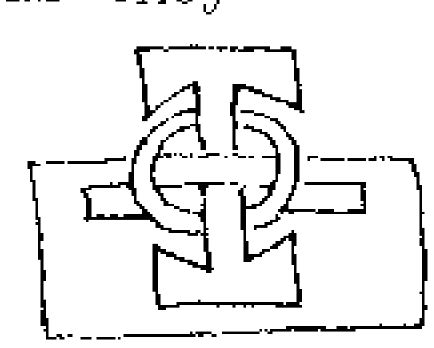


BOYLE

Disentanglement Puzzles

This is another large and poorly defined category in which we include puzzles having two or more pieces of irregular shapes which must be disentangled from each other. (We exclude Wire Puzzles from this group, as they belong in a distinct class of their own.) There are 30 of them, and I list only those which appear to be more interesting or less repetitious, although it is very hard to judge from the descriptions.

486,141



#448,974 - ball is held inside pivoted rings.

#486,141 - three parts, one of which is flexible.

#495,724 - looks interesting, but how does it work?

#496,263 - wooden member must be steamed and compressed in a vise to remove!

554,565

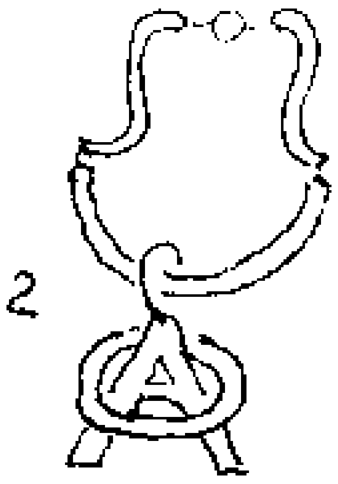
#495,997 - prisoner in chains must be undressed.

#558,009 - ball with spines is stuck in cage.

#554,565 - a sort of maze with fixed pins and movable disc.

#637,352 - remove flat ring.

637,352



#779,861 - remove heart-shaped ring, looks neat.
#964,740 - fold long band to fit in small box.
#1,016,221 - remove ring from figure.
#1,138,108 - separate three flat pieces.
#1,143,418 - remove elliptical ring.
#2,162,278 - separate D-shaped parts.


2,241,490

#2,241,490 - separate three grooved rings, just one more example of a simple puzzle which looks interesting, but the patent simply fails to explain how it is supposed to work.

Positioning of Loose Parts inside Container

Everyone is familiar with the novelty consisting of a shallow box with window on top, containing small balls which must be rolled into holes. Believe it or not, there are several patents on devices of this sort, seven by my count. They all look about the same to me.

Puzzles Using Liquids

There are six of these. Three of them are variations on the category above. Two of them are in the nature of tricks with bubbles. The last one is the prize - it is a pitcher which cannot be poured out of without spilling, (our kids are so clever they can do this with an ordinary pitcher).

Puzzles Using Magnets

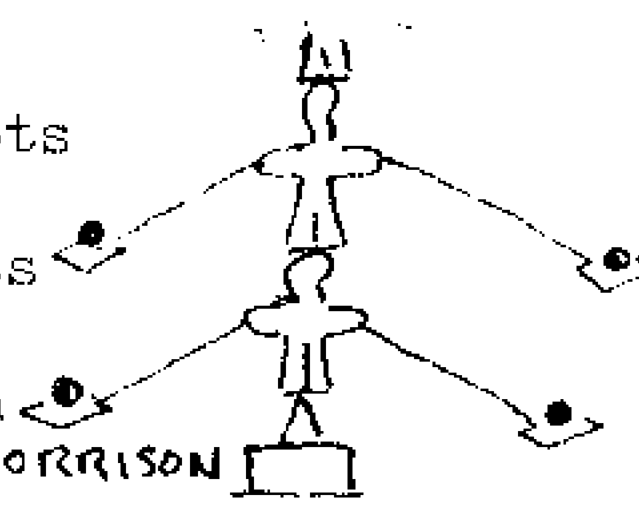
#735,269 - disc held by magnet is dropped into slot.
#2,795,427 - magnetic treasure chest is located with compass.
#3,033,573 - letters are positioned using a magnet.
#3,116,929 - piece is moved along "tortuous pathway" using a magnet.

Puzzles Using Balancing Weights

#580,839 of Backus, 1897, has tabletop which tilts on pivots if weights on top are not perfectly balanced.

#595,283 of Smallwood, 1897, has bicycle wheel with weights which turn if not balanced.

#3,614,106 of Morrison, 1971, involves pivoting trays with balancing weights.

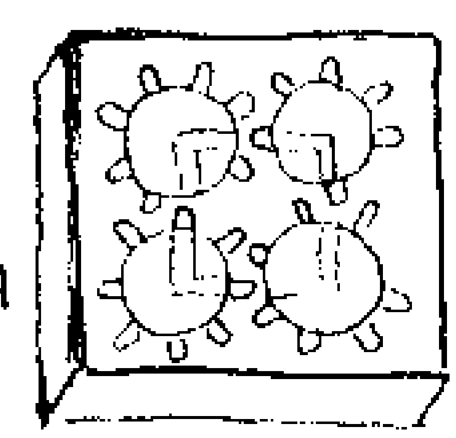

MORRISON

Puzzles with Shifting Blocks, Pegs, Gears, etc.

#232,394 - physical embodyment of a word puzzle (three travelers come to a river, two cross, etc.).
#472,292 - four plungers must be inserted in correct order.
#627,127 - balls must be moved about by rotating disc.
#746,105 - strips of wood must be lined up in correct order to receive keys.


746,105

#834,065 - blocks are shifted to form square or circle.
#911,461 - gears with missing teeth must be rotated to correct position.


911,461

#2,905,474 - "push peg puzzle."
#3,216,558 - must be the ultimate in complexity of sliding block puzzles, with several hundred shifting parts and a description that would take days to comprehend.

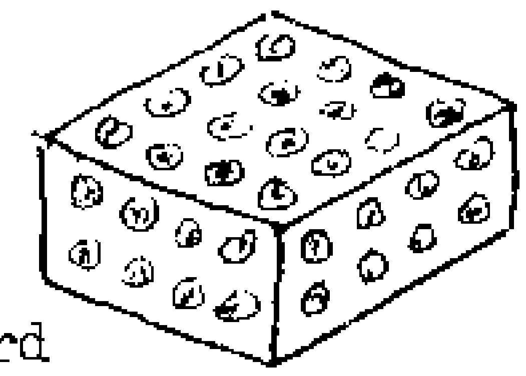
Puzzles with Numbered Blocks

There are many of these which are simply mechanical versions of the familiar "magic squares" puzzles, or minor variations thereof, in which typically numbers in rows and columns must total a certain amount, such as: #284,037; #455,066; #470,717; #487,063; #700,573; #728,249; #1,121,697; #1,166,271; #1,251,822; #1,260,541; #1,457,383; #1,561,098; #1,959,040; #2,202,078; and #3,189,350.

#347,596 - a numerical shifting block puzzle.

#416,344 of Rice, 1889, an ingenious shifting block puzzle using using seven numbered or lettered blocks inside a cubic box.

#483,912 - square numbered pieces are moved on a board according to rules.



WOOSTER

#860,887 - triangles with spots.

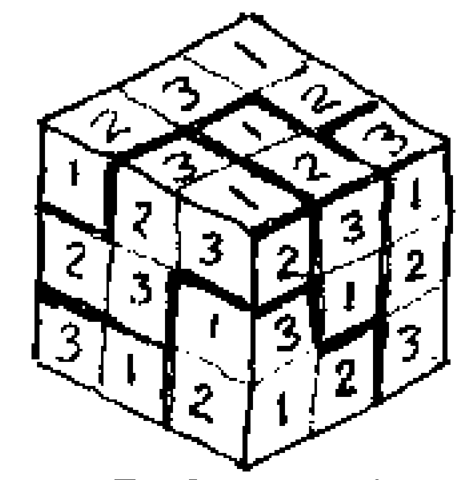
#873,313 - numbered cards form 2-digit numbers.

#1,518,889 of Wooster, 1924, similar to Rice except 31 blocks in rectangular box.

#1,558,165 - hexagonal pieces are arranged so numbered edges match.

#1,978,107 - complicated pastime with many numbered blocks and six-page description.

#3,638,949 - Soma-type puzzle with numbered blocks has numerical patterns on faces.

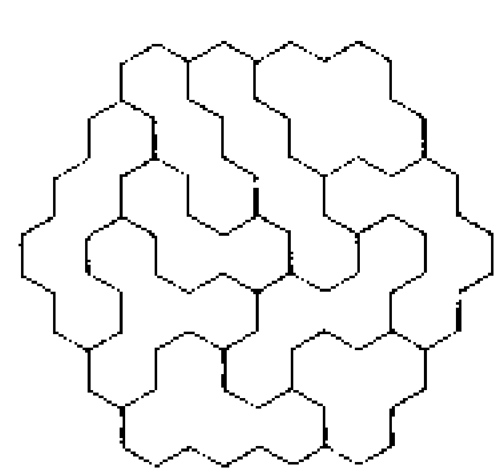


3,638,949

That is as far as we are going with puzzle patents. (In a later section we will discuss patenting and licensing your own puzzle inventions.) Perhaps the reader will be curious enough to carry on from here. There are many categories we have skipped over. It is a fascinating field of study, but very time consuming. Sometimes a glance at the drawings will reveal the essence of the puzzle, but often one must labor through lengthy and convoluted descriptions, and even then you're not sure how it is supposed to work.

Note the dates. There are almost none before 1885, but a flood of them between 1890 and 1910. There must have been a puzzle fad then (or perhaps a puzzle <u>patent</u> fad!). Interesting how the same basic idea will be patented over and over again. Often the first ones are the best, and the later ones just more complicated. Very few were ever a commercial success. Many are simply far too complicated to be manufactured, and why anyone went to the expense of patenting them is a mystery. As for the ones like balancing weights on a bicycle wheel, if that could ever be a popular pastime then I will have to rewrite much of <u>Puzzle Craft</u>. Perhaps someone just wanted to own a patent.

On the first sort through, about half went into a big pile marked "toys, novelties, and pastimes," which we have not even mentioned. I would not dismiss them outright though - one never knows. Sometimes the simplest of things have the greatest appeal. Who is there who did not have at least one simple puzzle among their early childhood treasures? Even just the descriptions are fun to read.

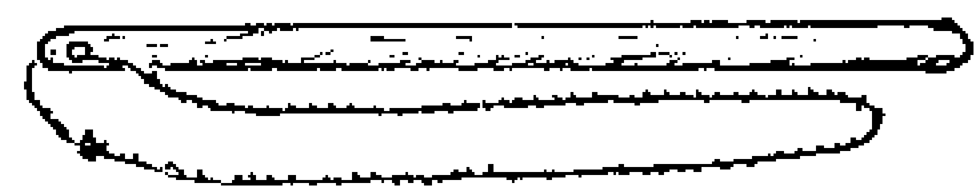


TOPOLOGICAL PUZZLES

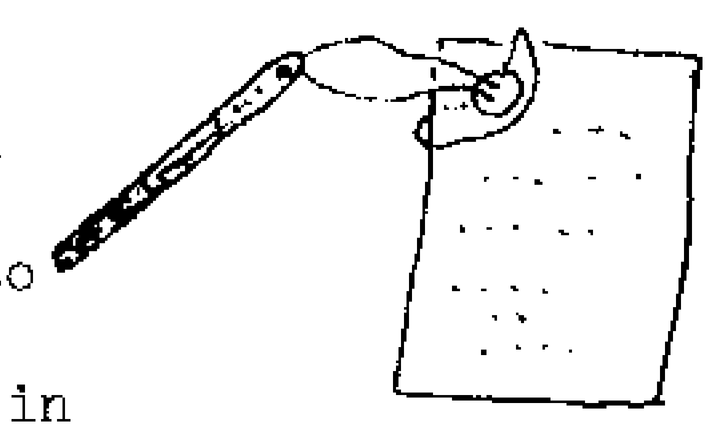
Now on to some puzzles you can make in your shop. We start off with topological puzzles as rather a digression from the main theme of Puzzle Craft because they are among the easiest to explain and to make, so a good way to get started in puzzle making as a hobby or business.

Topological puzzles have some part or parts which are necessarily flexible, such as cord or leather. Usually the object is to disassemble or remove some part. Many require only some cord and pieces of wood with holes, or other similar materials, without any close tolerances. Their particular charm is that they often appear to be and in fact are very simple in their embodyment, yet they can be exceedingly difficult and confusing to solve.

The Buttonhole Puzzle

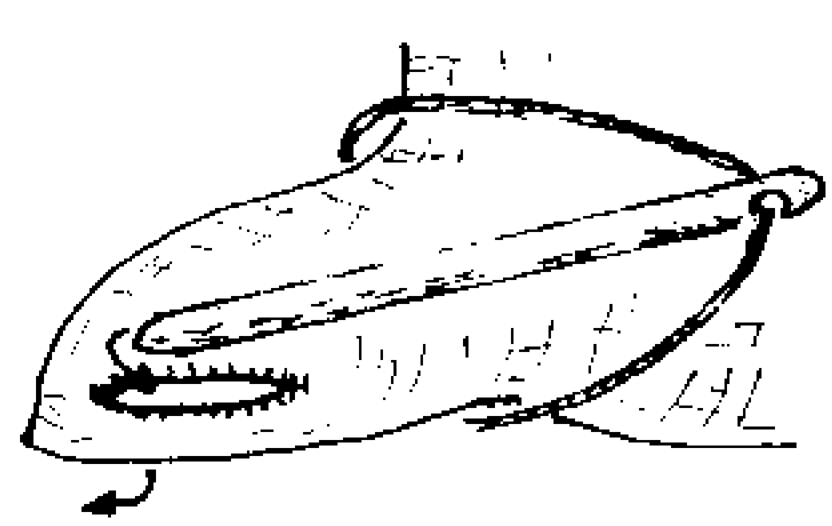


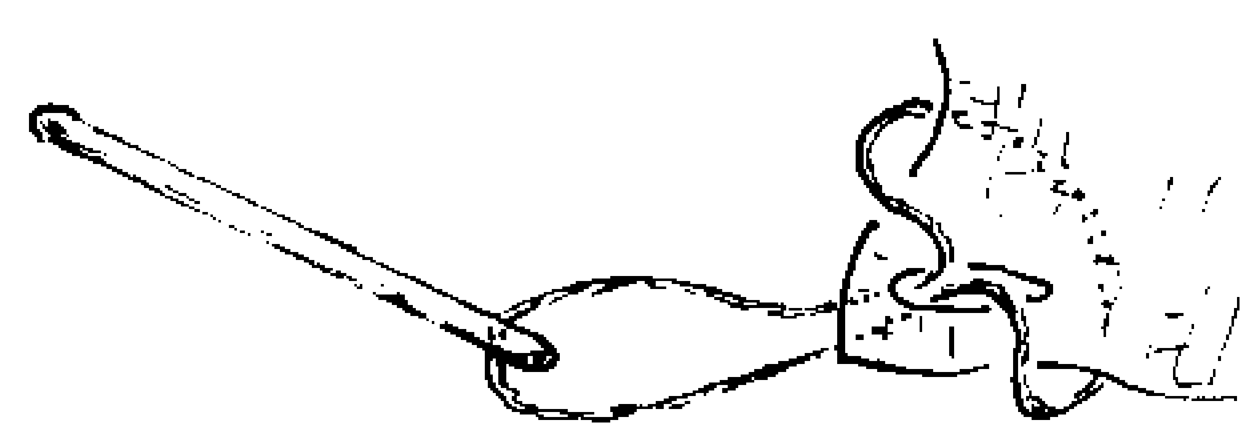
One of the simplest yet most bewildering devices ever conceived. This puzzle belongs in my selection of the ten best puzzles ever invented. According to Dudeney, it was probably the inspiration of famous puzzle inventor Sam Loyd. It is known by many as the "Idiot Stick," and over the years it has acquired various other names, some of which I would be embarrassed to even mention. We used to sell these in great numbers at craft shows. Ours were made of about fifty different kinds of exotic woods - it was a good way to use up wood scraps. Ours came with an instruction and identification sheet which had a practice buttonhole punched in one corner, to which the puzzle was attached. Sometimes we put them on the customer's clothing, and every now and then someone tells me that they are still on there, more than ten years later.



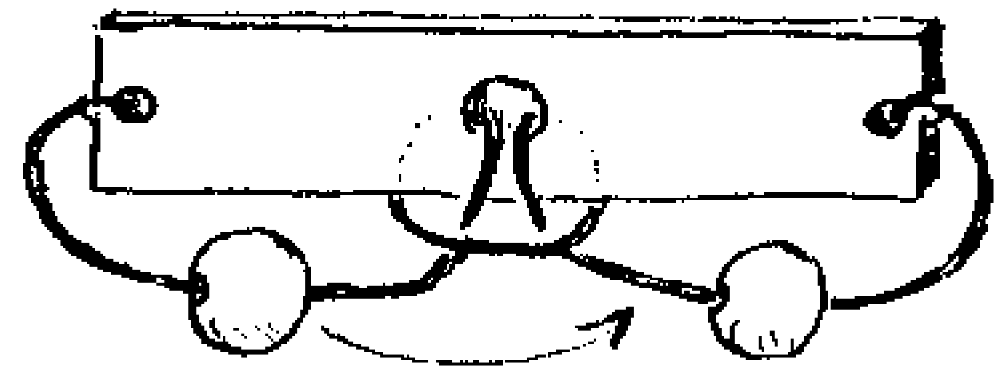
The stick is about 5 inches long, and small enough to pass through buttonholes - no more than $\frac{1}{4}$-inch square. Drill a small hole near one end, and tie a loop of cord in it which is not quite long enough to pass around the other end. We used L.L.Bean's 45 lb.-test dacron fishing line, with the ends heat-sealed and the square knot sealed with a touch of household cement.

Choose a loose material such as a knit sweater to practice on, with a buttonhole large enough for the waxed stick to pass through easily. One near a corner is easiest. Refer to the drawings below. Place the loop of cord around the corner of material containing the buttonhole, and then poke the free end of the stick through the buttonhole and tighten. Reverse to remove. After you have mastered that, stick it on a friend's jacket. After the usual comment of: "Oh, what's so hard about that?" wait for the fun to start. The heavier and stiffer the material, the more fun. You can also work it on such things as belt loops and handbag straps. For a variation, try one with the hole located just off-center, with the loop long enough to pass around one end but not the other.

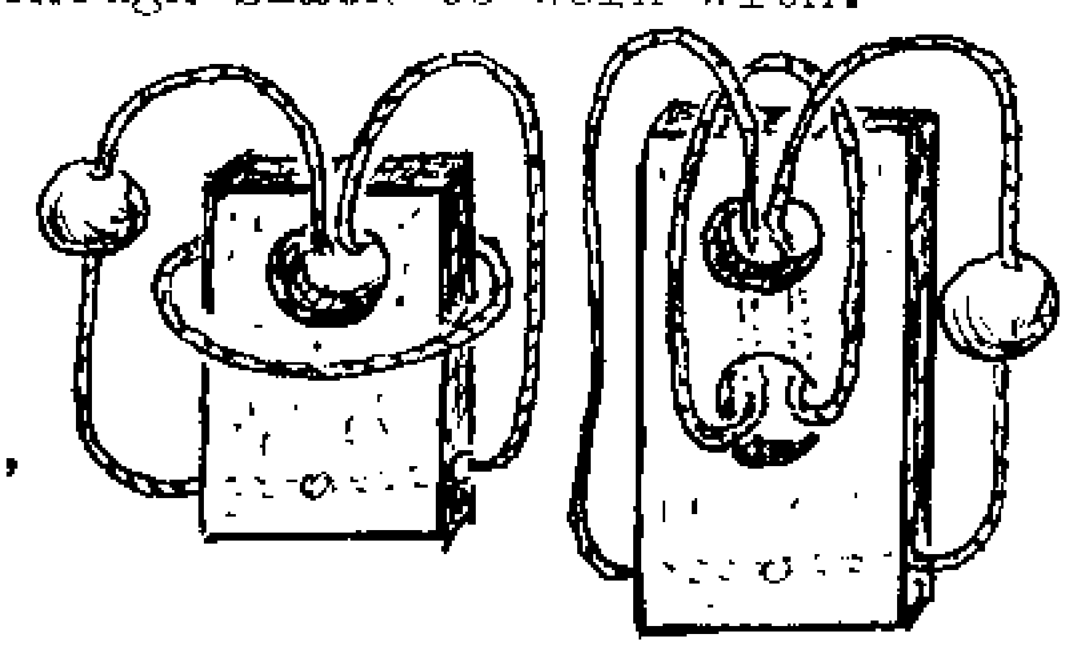




Moving Bead Puzzle



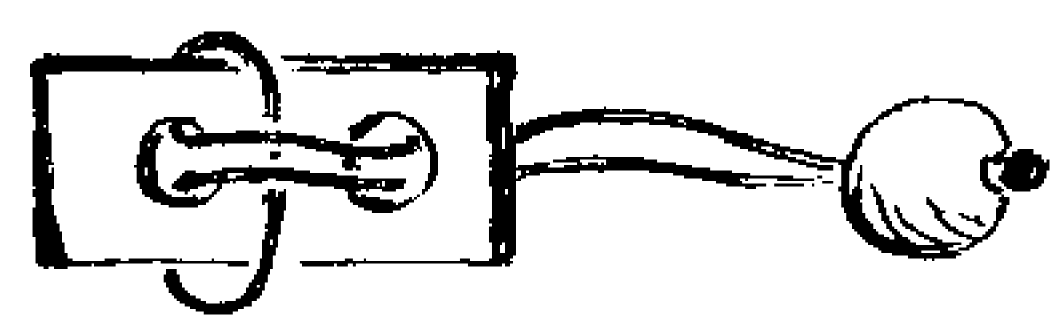
This is another old favorite, and like so many of the others, it probably does not have one generally accepted generic name. Those who make and sell such puzzles tend to think up their own names. It consists of a flat piece of wood with a large hole in the center and smaller holes at either end. A length of cord is knotted to the end holes and looped through the center hole in the particular manner shown, with two beads on the cord. The object is to get the two beads together on one loop, or if they are already together to separate them. Sometimes it is made with only one bead, the object being to move the bead from one side to the other, the sides being marked in some manner. The center hole must be large enough to pass a knot of cord through, but too small to pass the beads through, and the cord must have enough slack to work with.

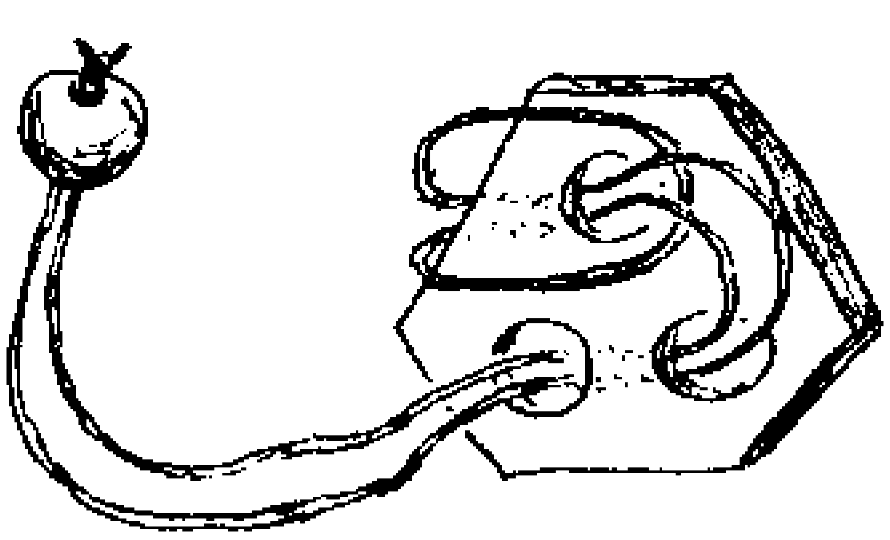


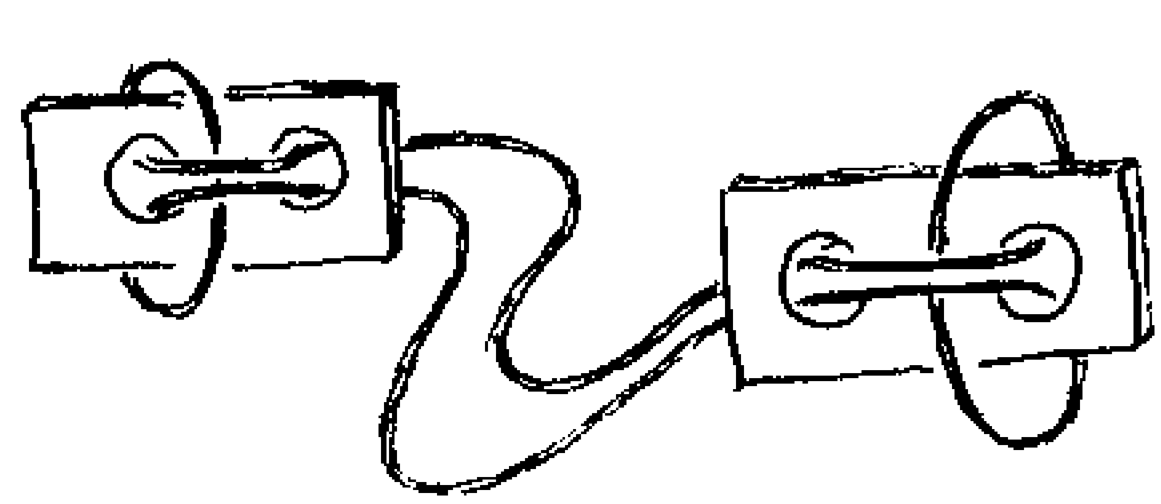
The two puzzles at right are variations of the above, of my own design. The first is topologically equivalent to the original, but the stick is distorted vertically. The cord passes through the small hole at the bottom and the knot is concealed inside this hole. The second version has an extra hole and is more complicated to solve, but it is basically the same puzzle.

Entangled Loops

The astute puzzlist will recognize that many puzzles are topologically equivalent, even though they may appear quite different. An example of this is the large group of puzzles involving an entangled loop of cord. The simplest of these is a loop of cord with a bead one one end and a block of wood with two holes, around which the cord appears to be hopelessly knotted. Again, the holes are large enough to pass a knot of cord but not the bead. Once this little novelty has been mastered, the solution to other puzzles of this type becomes more obvious. Variations on this basic puzzle are limitless. There may be three or more holes, with the cord threaded through in a more complicated route. Instead of the bead on the other end, there may be a symmetrically arranged matching block with holes. Nuts, washers, and other paraphernalia may be threaded onto the loop at various points for added confusion. One classic version uses a pair of scissors in place of the block. Instead of a bead at the other end, the loop may be fastened to something solid like a piece of furniture.

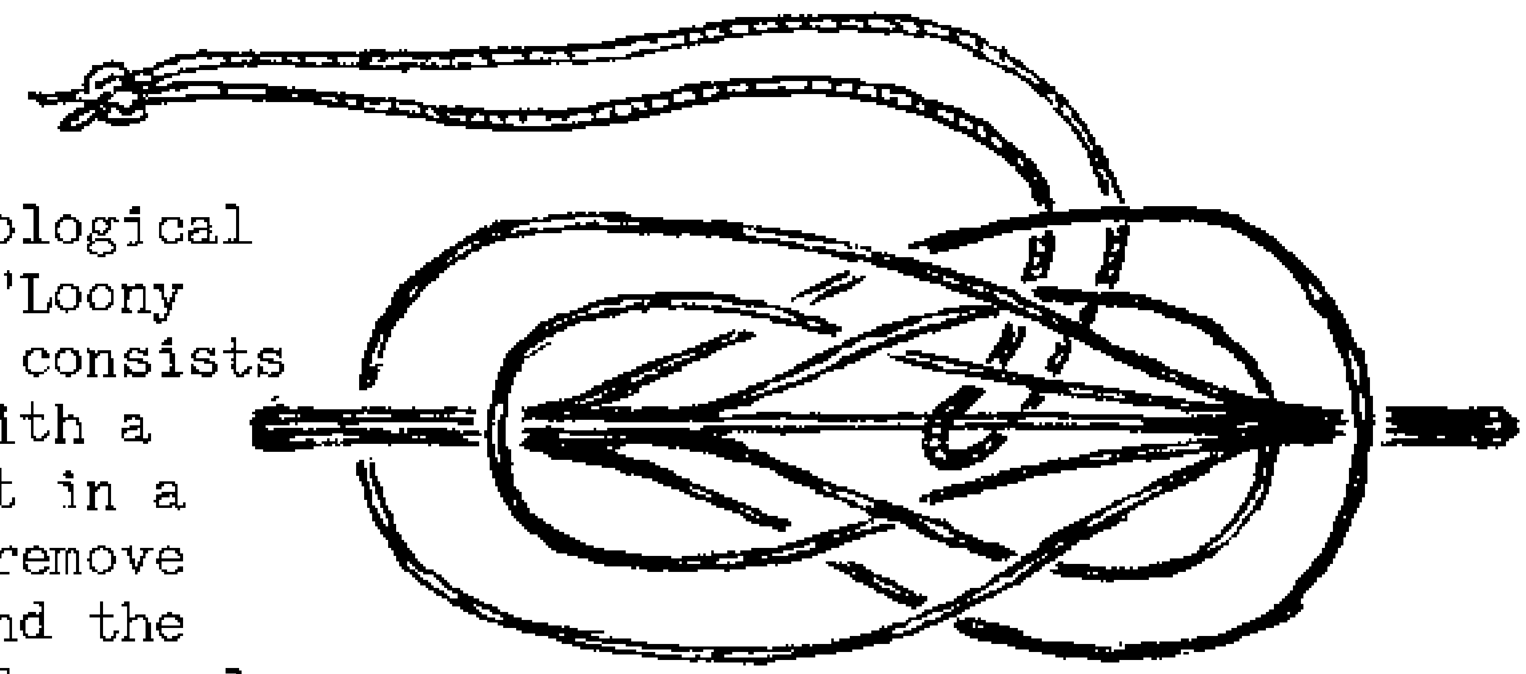


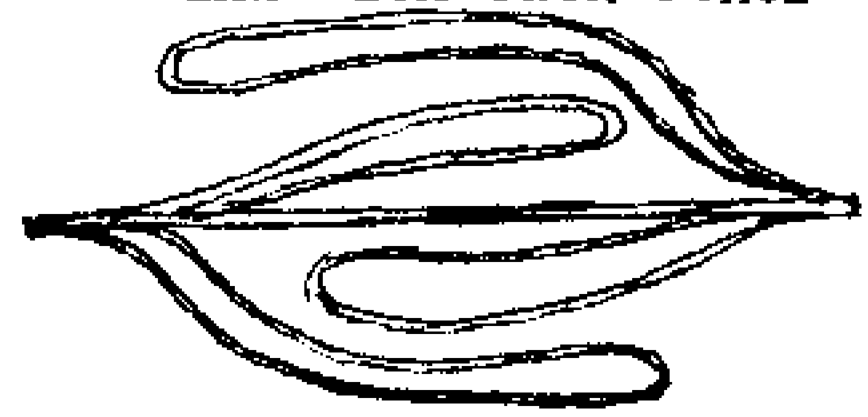




"Loony Loop"

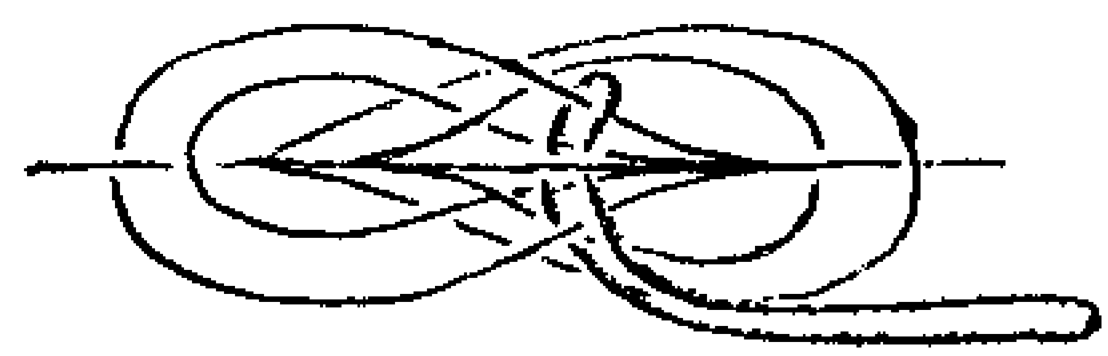
An interesting and unusual topological puzzle is one sold under the name "Loony Loop" and various other names. It consists simply of a straight central rod with a pair of wire loops at each end bent in a particular way. The object is to remove a loop of cord that is looped around the central rod. This puzzle is a good example of a very simple topological arrangement being obscured by a complicated geometrical shape. Since none of the loops of wire link with each other (even though they may appear to), the structure may be represented schematically by the figure shown at right, for which the solution is trivially simple.





In the first edition of Puzzle Craft, I stated that I was not aware of any variations of this puzzle. Since then, I have seen one with three loops at each end instead of two. It must be very confusing, but that doesn't necessarily make it a better design. Often the original versions are the best, which I think is the case here.

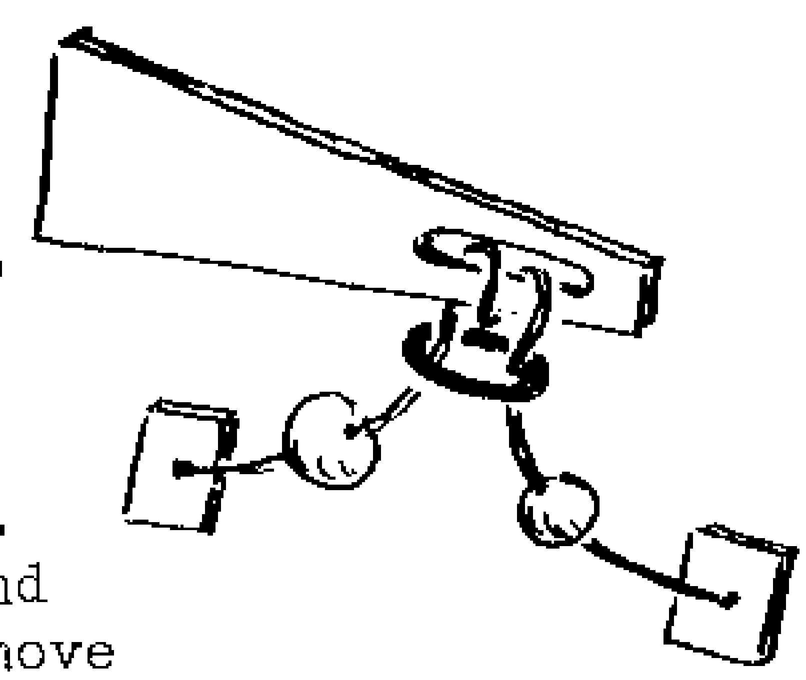
An interesting variation is to untie the loop of cord, thread it through in some new way, knot it and then try to remove it. Obviously some arrangements are possible and some are impossible. Maybe someone has worked out a theory for telling which are which. An example of one arrangement which is difficult but known to be possible is shown at right.



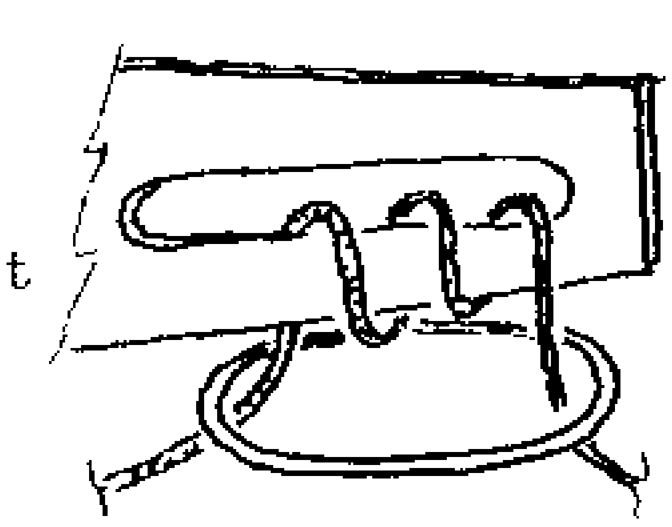
The puzzle is normally manufactured of heavy plated steel wire with welded joints. I had always assumed that this puzzle was of recent origin until I found one in an old collection made of bamboo. Its origin is unknown.

"Wit's End"

Our summary would not be complete without mentioning another popular puzzle, one version of which is sold as "Wit's End." It consists of a slotted board, steel ring, two flat beads and two round beads, all held together with a long cord. The slot is large enough to pass the ring and flat beads, but not the round beads. The round beads will pass through the ring, but not the flat beads. And finally, the ring must fit over the slotted narrow end of the board but not the other end. The object is to remove the ring. It lacks the charming simplicity of some of the other puzzles in this category, and is a bit more trouble to fabricate, but it is fairly interesting.



The various versions of this puzzle now on the market differ mainly only in the various animated shapes used for the slotted board. In the popular version, the cord is looped around the slot twice. In an easier version, it passes through only once. How about a triple loop?

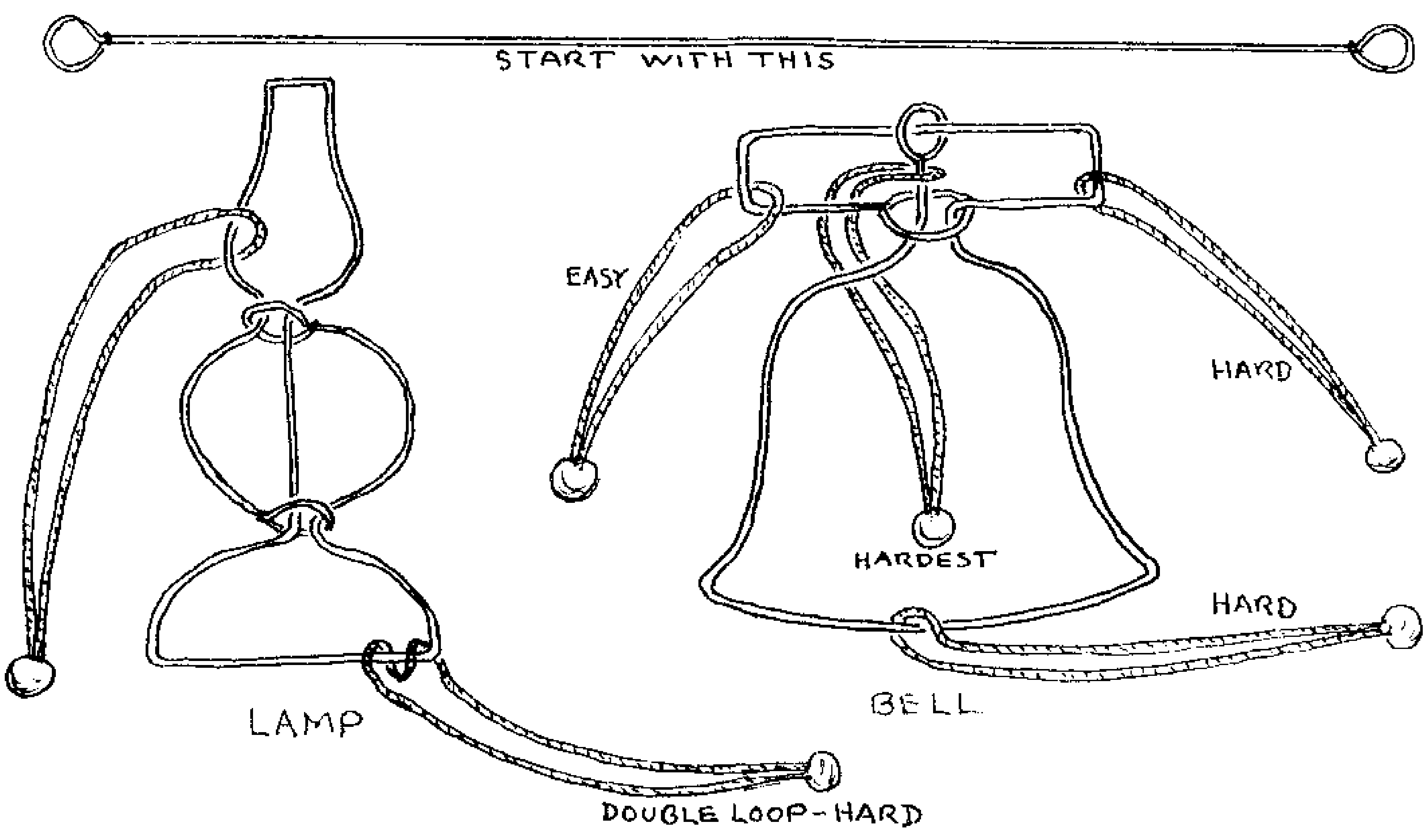


Bent Wire Mazes with Loops of Cord

There is a whole class of puzzles consisting of a single length of wire bent into some interesting configuration, with a loop of cord around some part of it, the object being to remove the cord or put it on again. (These are not to be confused with so-called "wire puzzles," which are made entirely out of bent wire, with the object being to disengage one of the parts. Some of them are extremely clever, but they belong in a separate category, and will not be discussed in Puzzle Craft. Richard Hess of 4100 Palos Verdes Drive East, Palos Verdes, CA 90274, is a designer, maker, and expert on wire puzzles.)

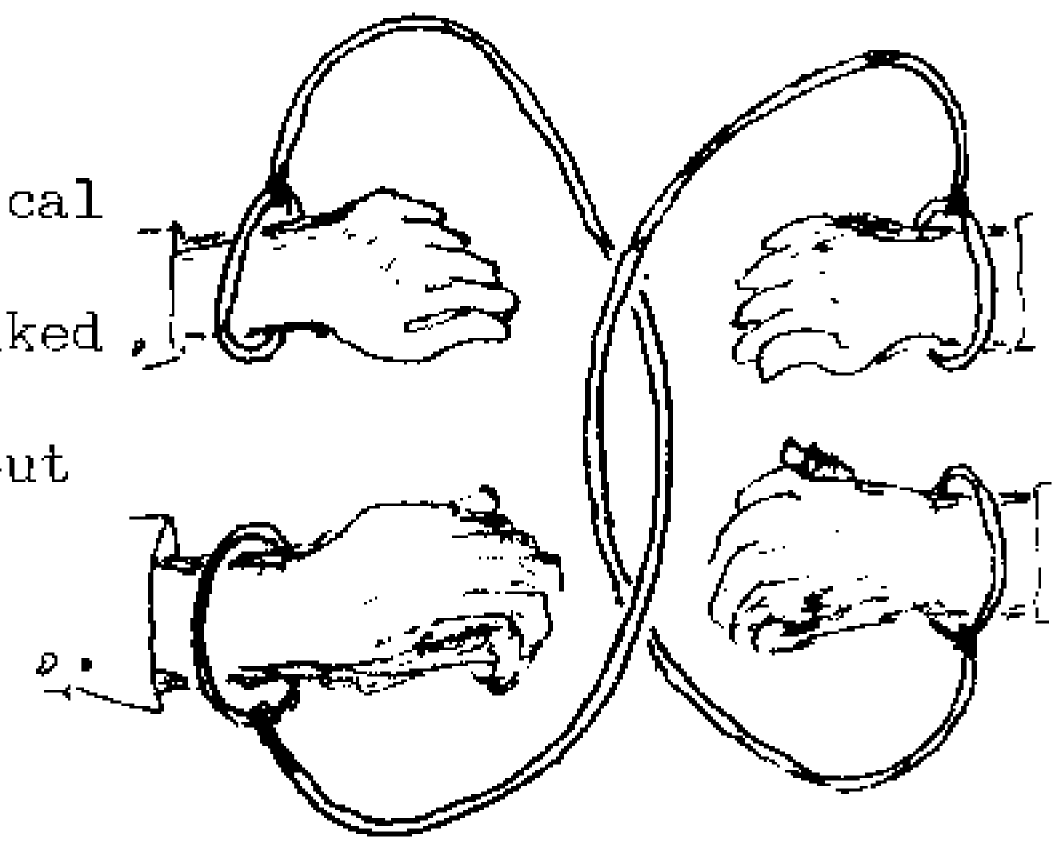
Two examples of wire and loop puzzles are shown below. They are both of my own design, and just about the extent of my efforts in that category. They are very easy to design. Start with a length of some very soft wire, such as #20 single strand copper wire, or solder. Put a closed loop in each end. Then form any animated shape you want, with some of the wire going through the loops. After you have the design, you can make the finished puzzle of stiff wire like the heaviest coathanger wire, plated if you want it to look nice. A loop of cord with a bead attached completes the puzzle.

If the puzzle was made in the manner described, starting with a length of wire with loops on both ends, it follows that the finished puzzle, no matter how complicated it may look, is topologically equivalent to what you started with. Therefore, it must be possible to remove a cord looped around any part of the puzzle except the end loops. You may want to practice with a loop of cord without the bead. It is much harder with the bead, but still possible.



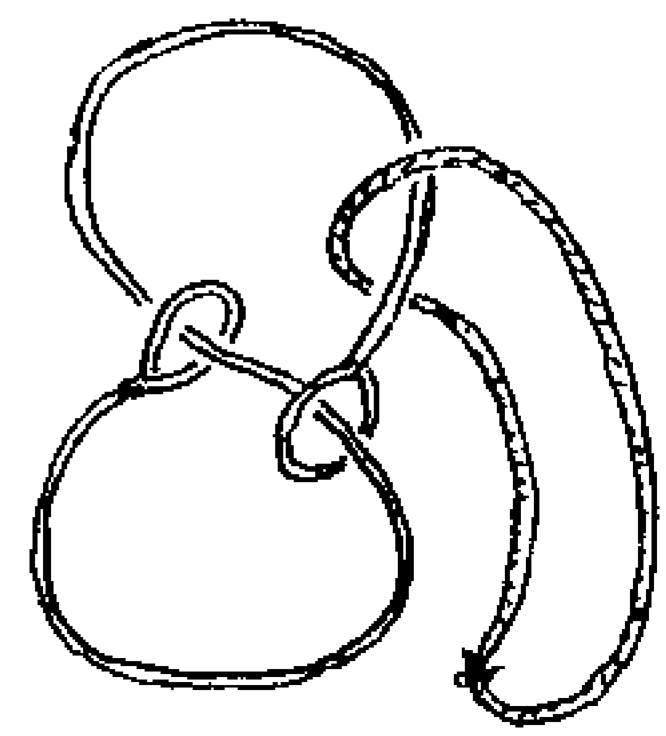
Note: Cord is not drawn to scale; cord must be longer than shown.

Other Pastimes



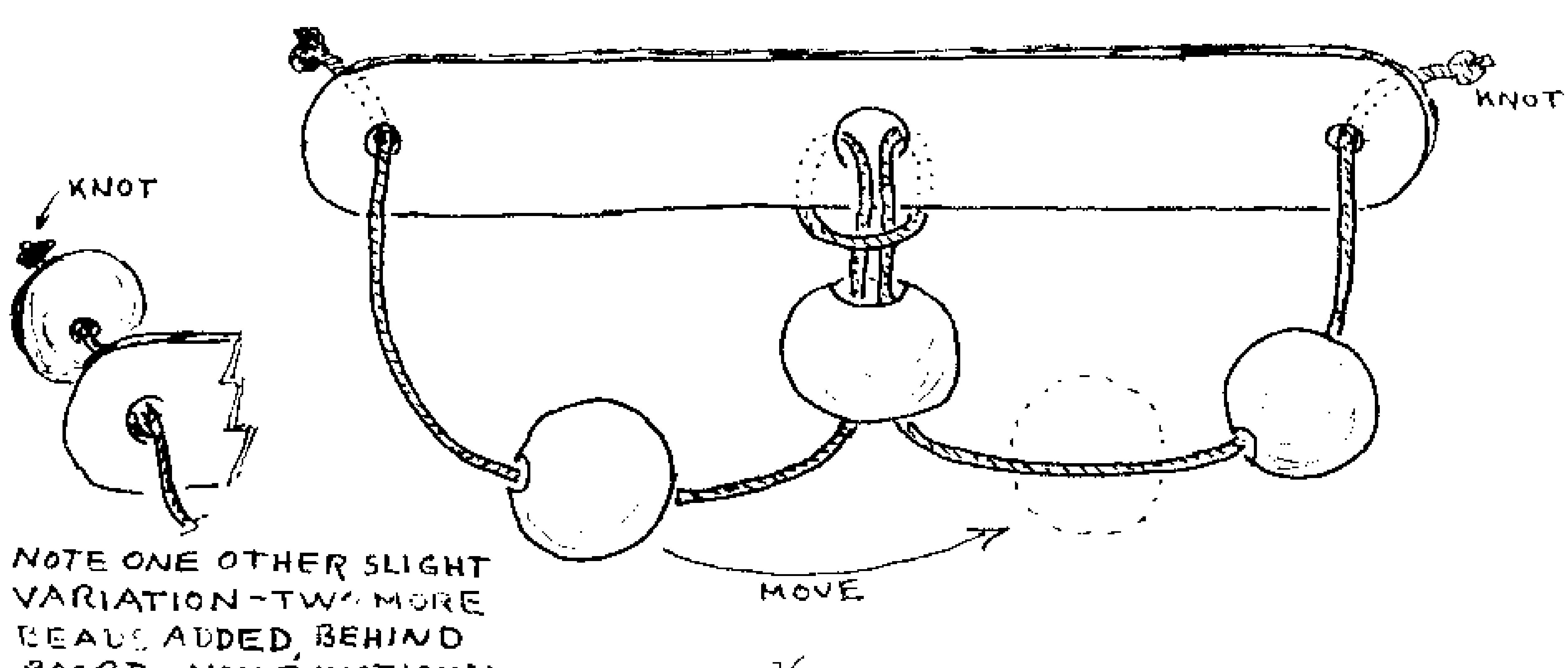
This one is more of a party game than a mechanical puzzle, and probably doesn't even belong in Puzzle Craft, but here it is anyways. Two persons are linked together by a pair of cords knotted to the wrists. The object is for them to separate themselves without cutting or untying the cords. For entertaining variations, tie around waist, ankles, etc.

The Figure Eight Puzzle



Here is one more example of how the simplest things can sometimes be the most entertaining. I was playing around with string and wire one time and came up with the very simple "figure eight" configuration shown at right. The object of course is to remove the loop of cord from the wire. After playing with it and pondering it for a while, I thought it was entertaining enough to include in Puzzle Craft, together with a brief discussion of how to go about it. Many persons have been baffled by it. An article in the September 1976 issue of a now defunct British magazine on games and puzzles points out the similarity of it to the "Double-Treble-Clef" puzzle made by Pentangle, and discusses the solution as they saw it. Then van Delft and Botermans picked it up - it is shown together with their version of a solution on page 154 of their book Creative Puzzles of the World. Next, Royce Lowe of Juneau, Alaska, who makes and sells puzzles in his spare time, decided to have a try at this one. He does not include a solution when he sells it, and I understand that several of his customers have been puzzled by it.

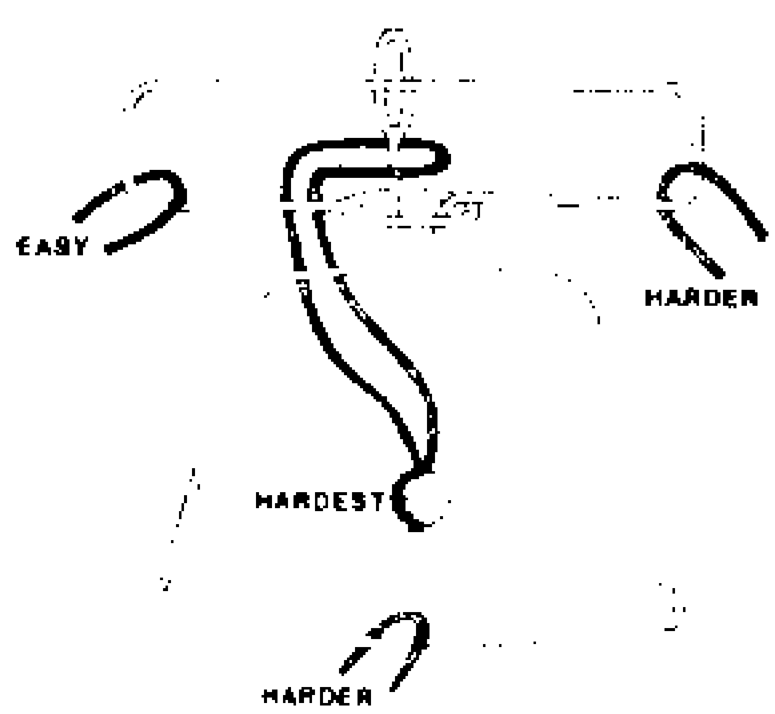
This has been just a random sampling from among a very large category of fine puzzles. For those who would like to learn more about topological puzzles, I recommend the van Delft & Botermans book. The last puzzle we will include (below) is similar to one shown on page 107 of their book, which you will recognize as a variation of the "Moving Bead Puzzle," (page 13). A third bead has been added to make the puzzle more interesting - the hole in this center bead must be of ample size for a loop of cord to pass through.



More on the "Figure Eight" - excerpts from (defunct) Games & Puzzles.

A whole class of puzzles consists of single lengths of wire bent into an interesting configuration with a loop of cord round one part of it, the object being to remove and replace the cord.

Figure 1 is a design by Stuart Coffin. It is equivalent topologically to a single length of wire with a closed loop at each end. This is particularly obvious if the design is made in soft wire, since it can then be unravelled. Conversely it is easy to design such puzzles by forming the



1

loops at the end of the wire and then forming it into an interesting shape. It seems to follow that if the cord is long enough it should be possible to loop it onto or off any part of the figure. However, with a short cord, or beads on the cord which will not go through the loops on the ends of the wire, the challenge is much harder. Indeed, there may be impossible problems of this kind. Can readers find any?
(For experimental work, single strand electrical copper wire is useful, with nylon bootlace cord for the loop. Solder can be used to fix the end loops permanently.)

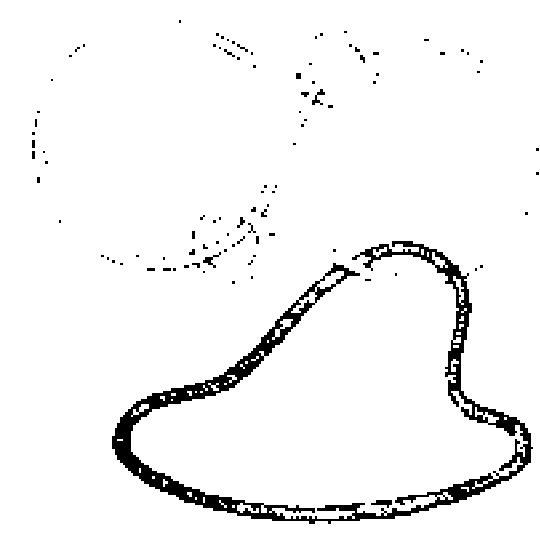
2

Our second figure looks at first sight much like Figure 1, but there is an important difference. You will easily convince yourself, though a proof is not obvious, that one of the end loops was made after the figure was formed and not at the beginning. This figure is typical of many which do *not* unravel into a straight wire with end loops. Yet it can still be solved as owners of the Double-Treble-Clef puzzle marketed by Pentangle will testify. An interesting puzzle to experiment with!

I am grateful to Stewart Coffin for the use of material from issue 4 of his now-deceased magazine *Puzzle Craft* for this article

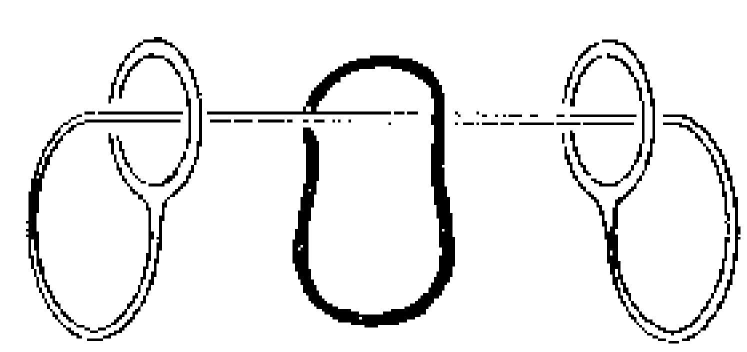
Just as I was wondering what to put in this month's column a delightful letter arrived from C. Croft of Winchester. Delightful, because it was interesting, meaty, clearly written with illustrations and typed with double spacing. A gift from heaven which I am going to quote verbatim.

'Sir, I am the owner of a Looney Loop and a home-made Double-Treble-Clef puzzle, and am an avid reader of your Solid Gold column. The one in issue 52 immediately attracted my attention, and after making both the wire puzzles I was unable to do the second one, and still am. I think it is impossible to remove the second loop.



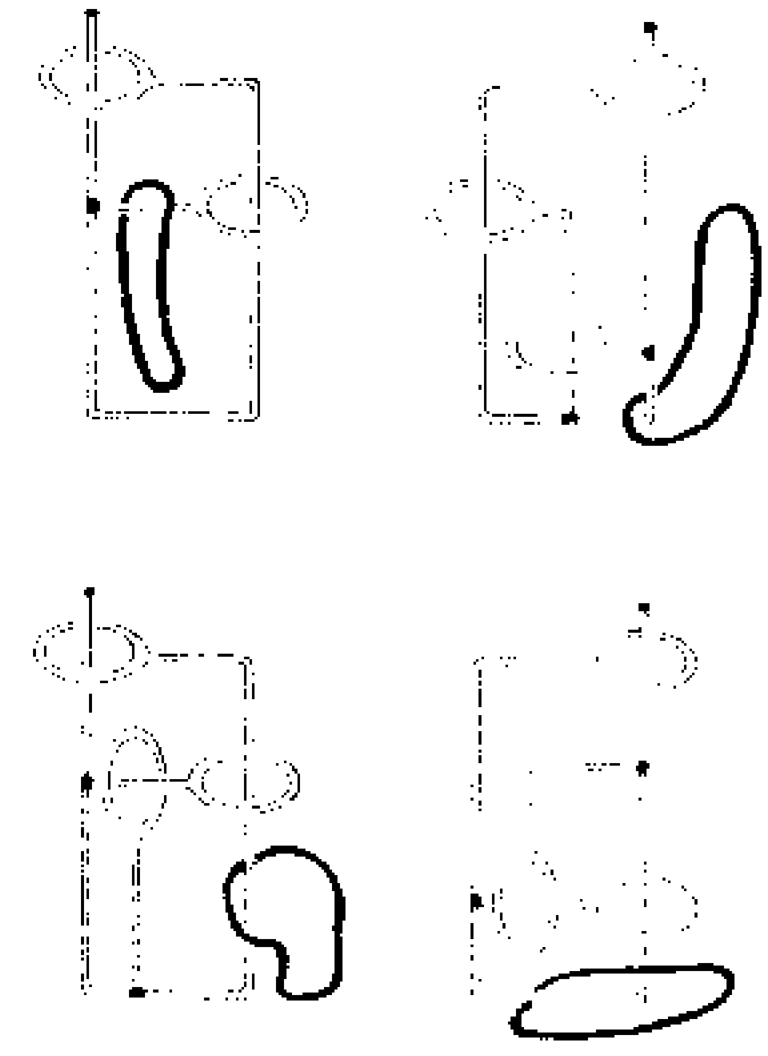
Can the loop be removed?

'However this fruitless search encouraged me to make some similar puzzles, which *are* possible. You will notice that they can all be unravelled, but nevertheless they can prove quite a challenge to undo in your head, especially if there is a large bead which may not go through the loops which makes them harder but still all possible. So far I have been unable to find one which is un-unravellable but possible, that is if you exclude ones like this which can only be unravelled in very soft wire.



'I enclose twelve possible and one impossible puzzle, in appropriate order of difficulty with the impossible concealed somewhere in the line . . .'.

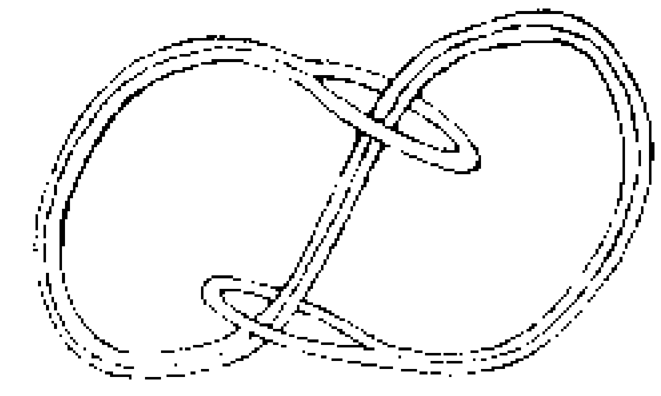
Mr Crofts goes on to point out that his figures, of which we reproduce four, are only topological representations, and that many of the figures can be made with only one or two pieces of wire. I suspect that this *could* change their properties, but I'm not going to stick my neck out further than that, because I fear I was wrong, as Mr. Croft suspects, in thinking the first puzzle illustrated above was soluble. I'm not even going to say whether I think his impossible problem is among the four shown here. Readers are invited to answer these questions and then to progress to the first of this month's Challenges.

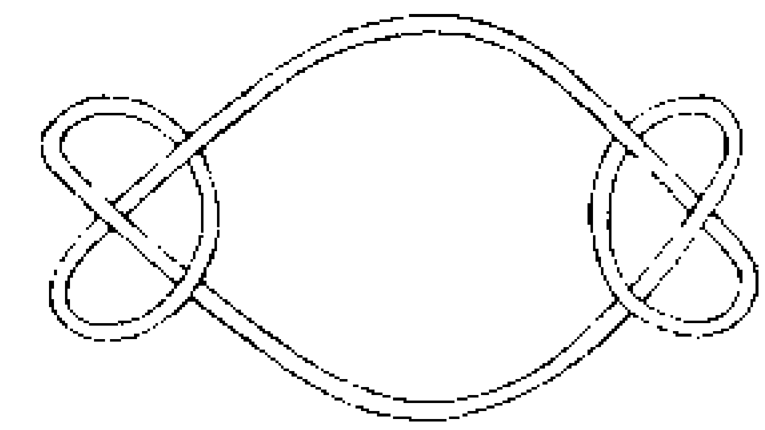


Wire Why

This month's first Challenge arises from Mr. Croft's letter quoted in Solid Gold. It suggests that if such puzzles cannot be unravelled, then a loop on the wire cannot be manipulated off it. Can readers explain why this must be so, or discover a counter-example?

Next Mr Dawes turns his attention to the problem of showing that the figure below is unsolvable. With one brilliant *coup* he doubles the wire along its length, (our next figure,) and transforms the puzzle into one continuous loop. The problem now is can this loop be manipulated to show clearly that the cord is round the loop? Mr Dawes shows a manipulation which transforms the wire into the shape of our third figure, with the cord presumably round the wire still.





DISSECTION PUZZLES

Jigsaw Puzzles

To dissect means literally to cut into pieces. Just about any chunk of material sawn into pieces becomes a sort of dissection puzzle. If done freely on the two-dimensional surface of a sheet of plywood, the result is the familiar jigsaw puzzle. A chapter of the Meras book (page 1) is devoted to jigsaw puzzles. Most jigsaw puzzles are not designed to exercise or perplex the mind, at least in the sense that most other types of puzzles do, and it is perhaps stretching the definition a bit to even call them puzzles. The definition given in the dictionary for the noun "puzzle" seems to have been purposely stretched so as to include what are really exercises in pattern recognition and patience. The definition given for the verb "to puzzle" contains no such connotation.

There are some clever jigsaw puzzles which go beyond the ordinary, such as those made by Stave (page 4). Especially interesting are three-dimensional jigsaw puzzles, such as those sawn on two faces of a rectangular block of wood or on two different axes of a wooden sphere. We mentioned some patents based on these (page 9).

Tangrams

If instead of cutting freely, the dissection is done according to some simple geometrical plan, an entirely different type of puzzle results. Many fewer pieces are required to create interesting puzzle problems. Two characteristics of such puzzles are that they often have more than one solution and usually assemble into many different puzzle shapes. The most familiar puzzle of this type, and one of the oldest puzzles known, is the popular seven-piece dissection of the square known as Tangrams. It is mentioned in nearly every puzzle book, and many thousands of problem shapes have been published such as symmetrical geometrical patterns and animated figures of every conceivable sort.

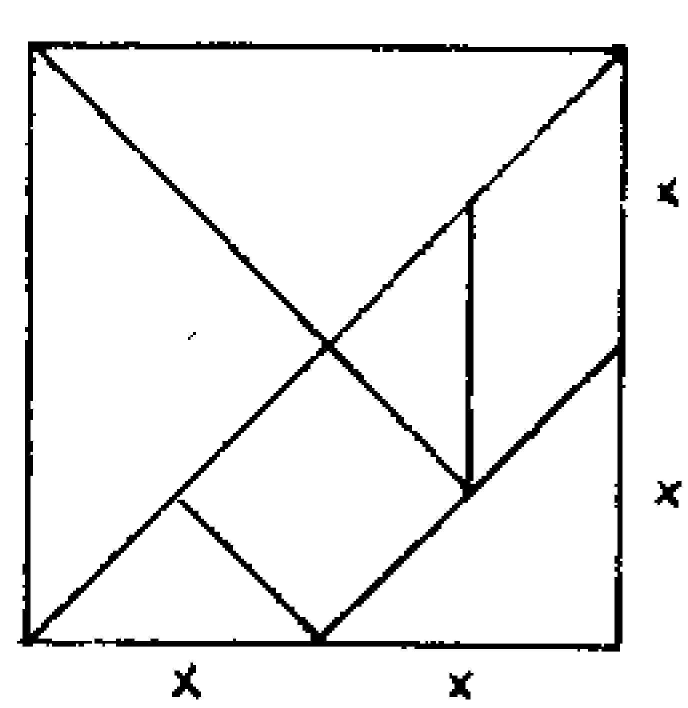
Sufficient information is given in the drawing below to enable one to lay this puzzle out on plywood and saw out the pieces to any scale one chooses, noting that one diagonal connects the midpoint of adjacent sides of the square.

Important note: Throughout Puzzle Craft unscaled drawings such as this are given for puzzle constructions. Many readers have complained that these drawings are useless because dimensions are missing. Some books do in fact include dimensions for such puzzles, both linear and angular. They are not included in Puzzle Craft for the following reasons:

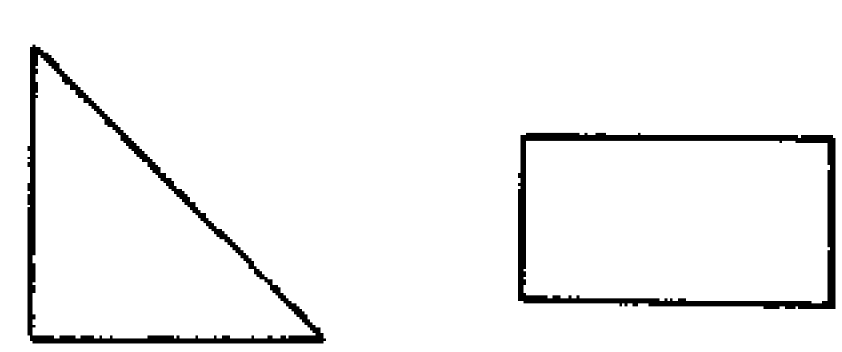
a. They are not necessary. It should be obvious that in Tangrams all the angles are 45 or 90 degrees.

b. Being unnecessary they simply confuse the picture. Anyone who would lay out the pieces for Tangrams by measuring each side of each piece has missed the whole principle of the puzzle.

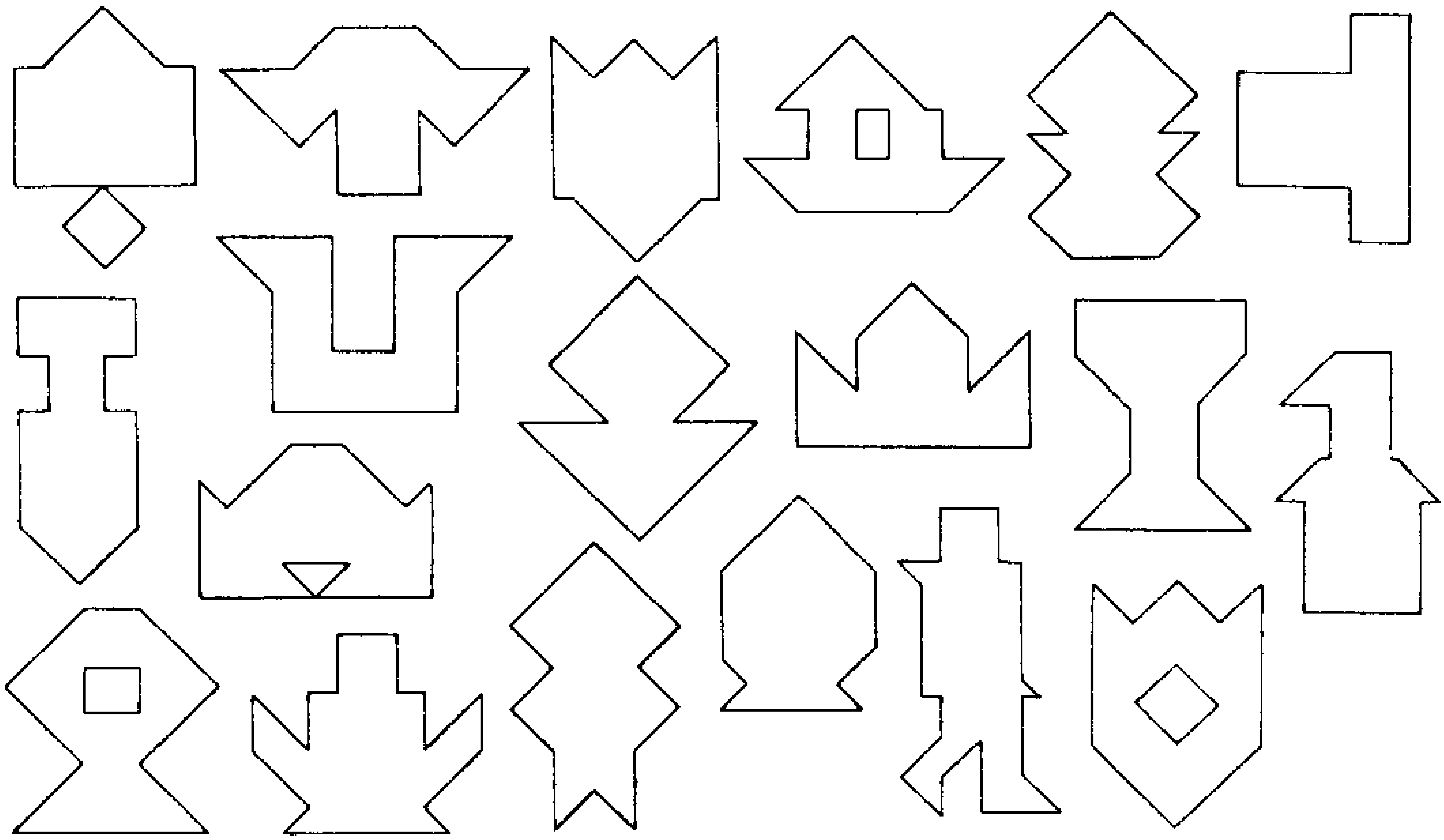
c. They are not as accurate as geometrical constructions. If the Tangram square is integral, all the diagonal measurements are irrational and can be expressed in sixteenths of an inch or whatever only by rounding off.



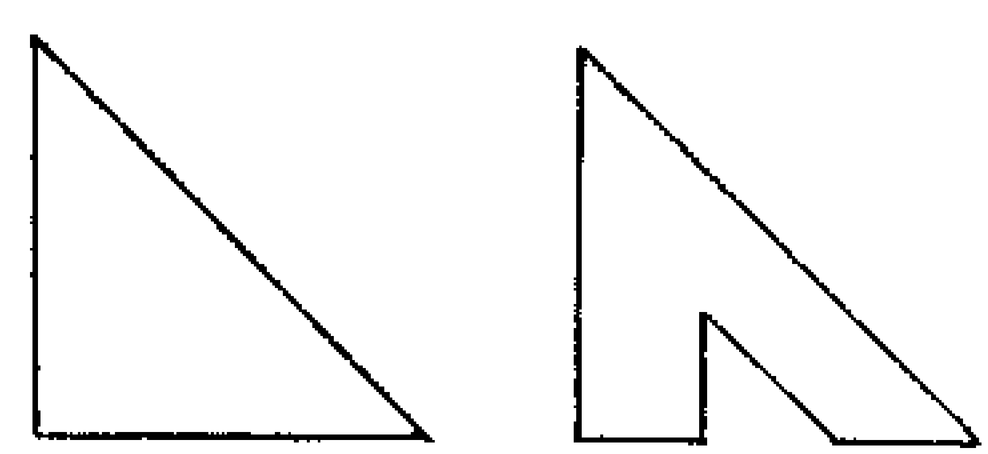
TANGRAMS



PROBLEMS
(NOT TO SCALE)



Two simple Tangrams problem shapes are shown on the previous page, and a typical sampling of more is shown above. All figures use all seven pieces. Obviously none can be very difficult, but that does not seem to have diminished the popularity of the puzzle - quite the contrary. Many so-called puzzles have appeal unrelated to difficulty. Intangible aesthetic qualities play a large role.

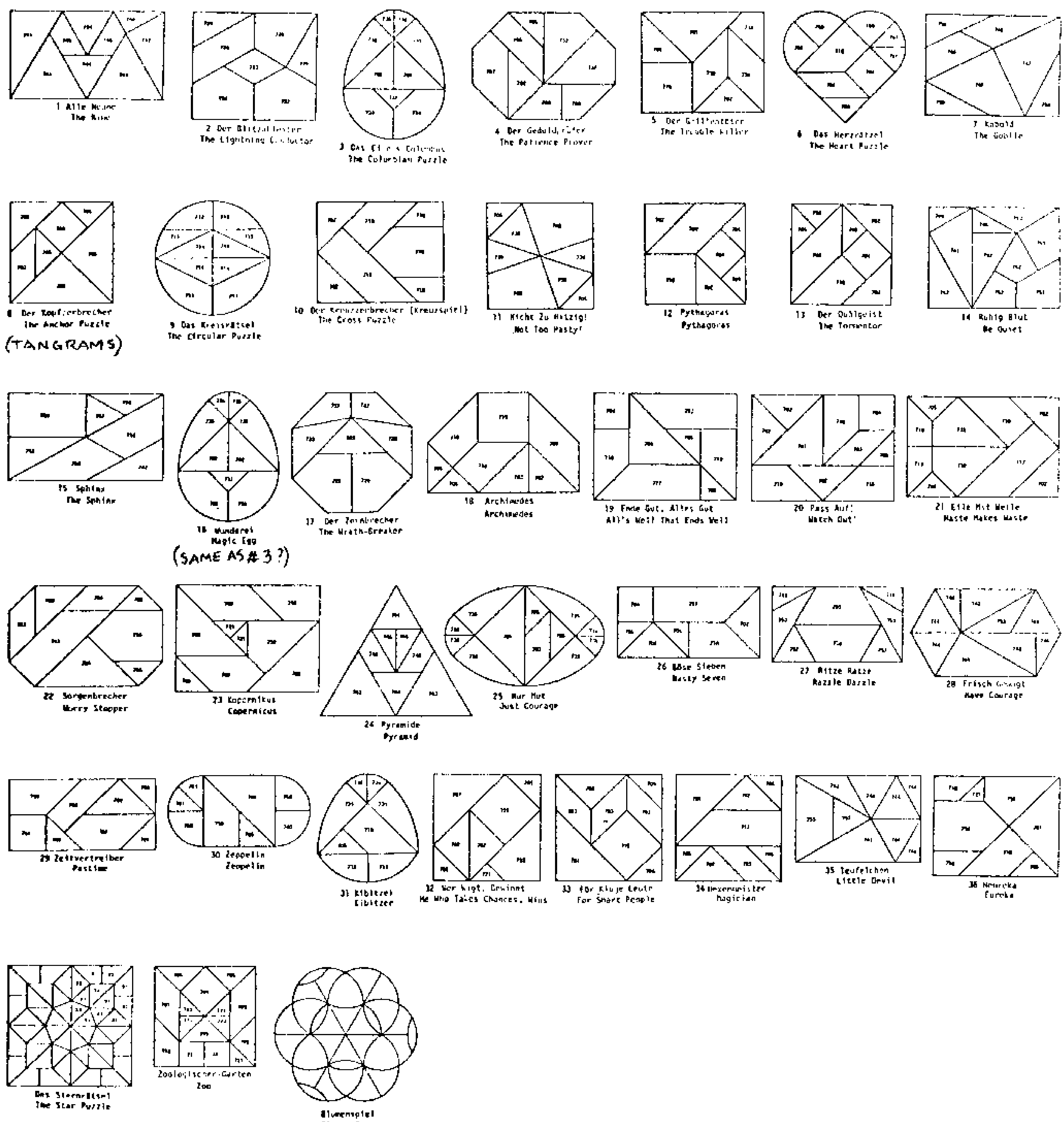


Note the two Tangram figures shown at right. One is a solid isosceles right triangle, and the other appears to have a piece missing, yet they both use all seven pieces. Therefore they must not both be drawn to the same scale. The trick in making these confusing pairs, in case you haven't already figured it out, is that the pieces are all rotated 45 degrees from one to the other, so that the overall dimensions are changed from an integral measure to some close approximation by some multiple of $\sqrt{2}$, or vice versa. Thus, in order to be entirely satisfactory, even simple puzzles such as this one should be accurately made of stable materials. If sawn directly out of a square of plywood, there will be noticable errors introduced by the kerf of the saw unless it is very fine. A more accurate way is to lay it out on cardboard, cut the cardboard with scissors, and use it as a pattern.

Richter "Anchor Stone" Puzzles

Over the years, there have been countless other puzzles like Tangrams, too numerous to even mention. Most notable were the Anchor Stone series produced by Richter and Company of Germany starting in the late 1800's and on into the early 1900's. These were of a brick red mineral composition compressed to the hardness of stone. Van Delft & Botermans devote several pages to them. Jerry Slocum of P.O. Box 1635, Beverly Hills, CA 90213, is a foremost authority on them and collector of them. Reproduced on the next page is a sheet supplied by Slocum showing 39 different designs.

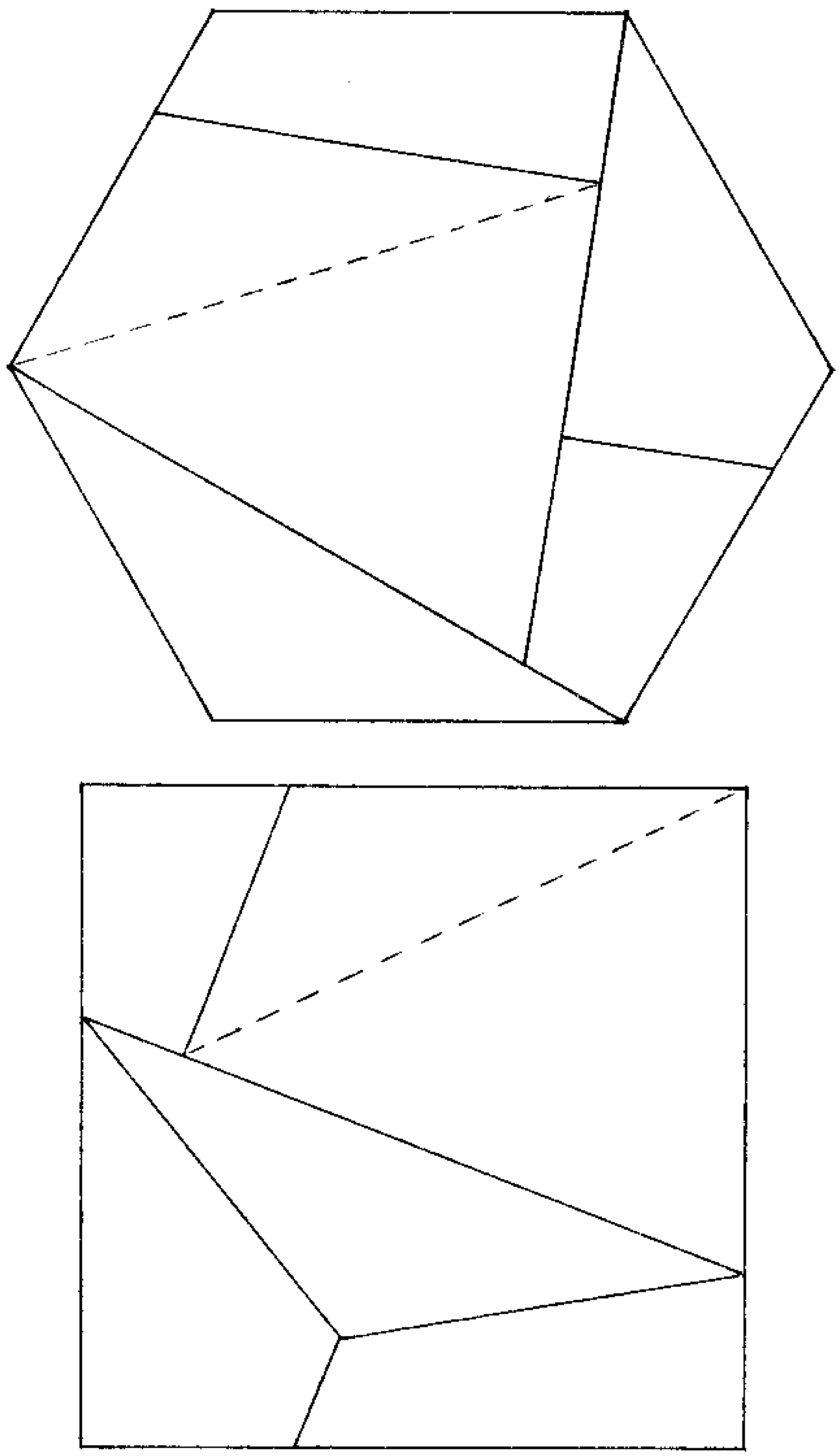
ANCHOR STONE PUZZLES by F. Ad. Richter & Co.



Geometrical Dissections

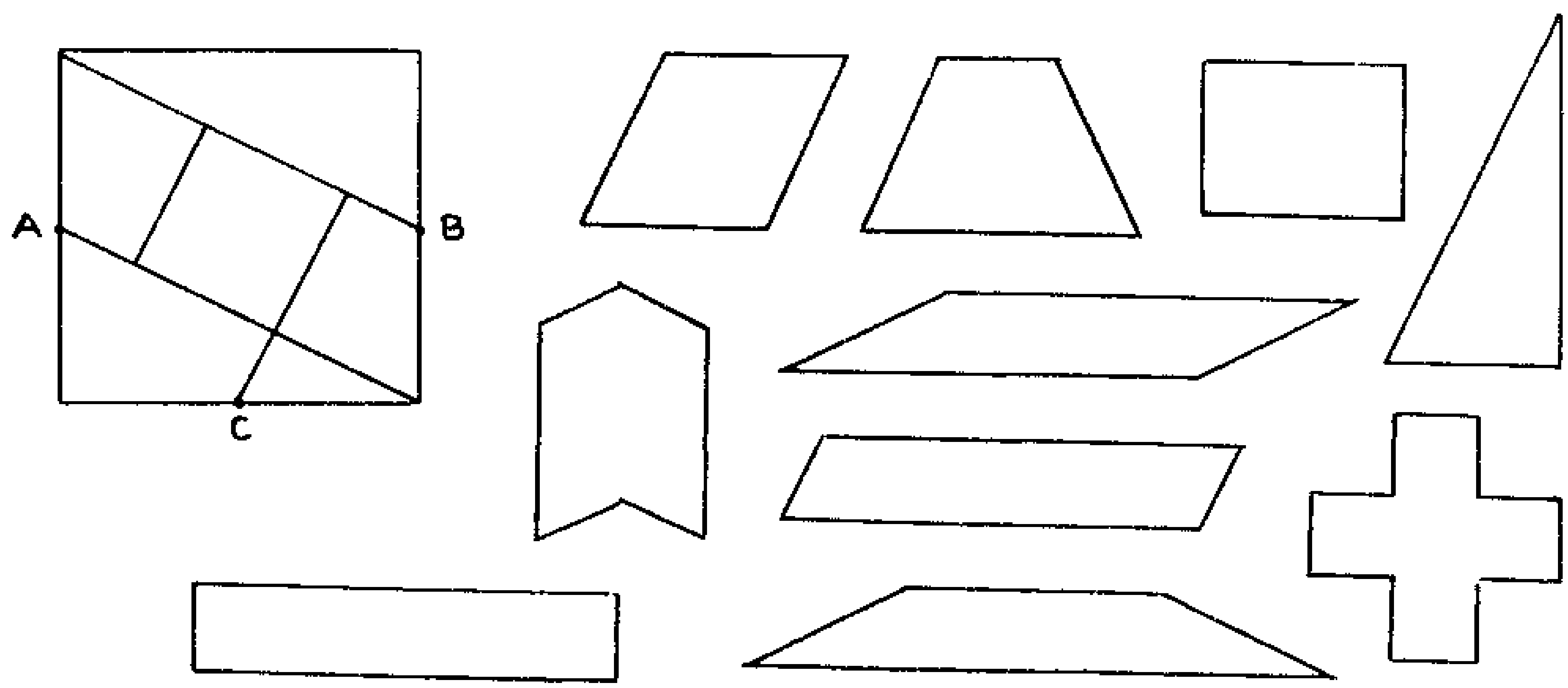
To mathematicians, the term "dissection" has a slightly more restrictive meaning. It usually refers to two (or more) different geometrical figures being formed from the same set of pieces. This is essentially a mathematical rather than a mechanical problem, and a minor branch of mathematics is devoted to it. The usual problem is to find the minimum number of pieces required to perform a particular dissection - an interesting problem but outside the scope of Puzzle Craft. Van Delft & Botermans have an excellent section on the subject, and Lindgren has produced an entire book on dissections (page 2).

One example of a geometrical dissection - that of the square and hexagon - is shown below in a scale sufficient to be used directly as a pattern for a small model. Being only five pieces, it is very easy as a puzzle. However, you can make it more difficult if you wish by further subdivision, such as is shown by the broken line. You can make a two-sided tray to hold the two solutions.



Geometric dissections of the type shown on the preceding page have never enjoyed much popularity as puzzles. Perhaps it is because the two solutions are quickly learned, and there are no more problems. Shown below is a simple six-piece dissection puzzle of my own design. It is really only a minor variation of a classic five-piece dissection of Sam Loyd, made by subdividing one of his pieces.

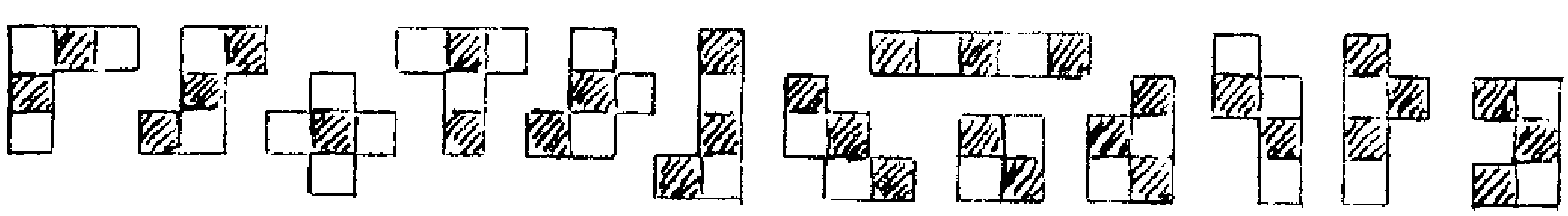
To construct a pattern for this puzzle of any size you wish on paper, refer to the drawing below. Start with a square. Locate midpoint of side at A and draw line from corner of square. Locate midpoint of opposite side at B and draw another line. Locate midpoint of third side at C and draw a line which would pass through a corner if extended. Draw one more short line which makes the center piece square.



This is just a small sample of geometric constructions possible. No doubt the reader can discover many more. Remember, all six pieces must be used in each problem.

Checkerboards

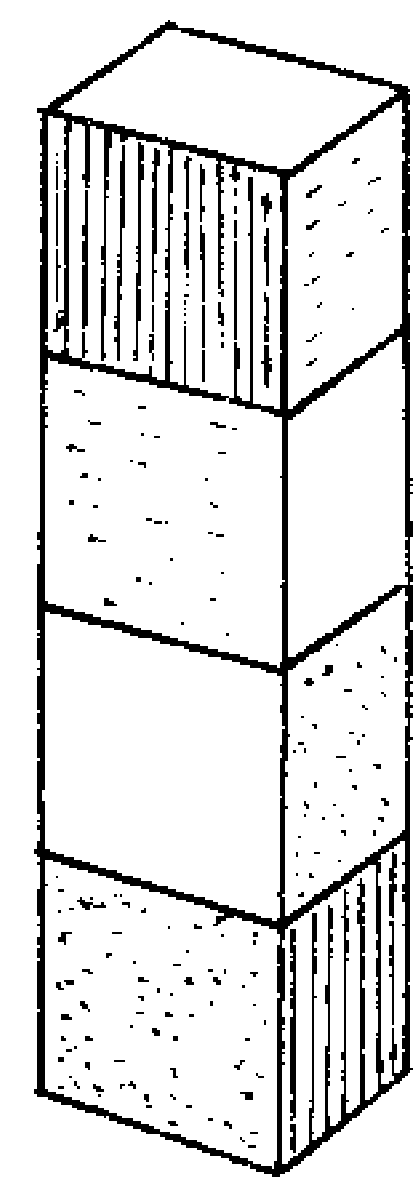
Many puzzles have been made simply by dissecting a checkerboard in various ways, and some of these are very difficult. Shown below is a 13-piece version taken from The Canterbury Puzzles, by H. E. Dudeney, Dover Publications. The number of solutions is not indicated, and is probably unknown unless someone has analysed it recently by computer. Many other versions have been published, but it is questionable how much thought went into the design of any of them. (The October 1978 issue of Puzzle World, an informal newsletter published for a short while by Dale Overy in England, shows twelve different versions.) None have become popular. The reader could just as well invent a new and original version rather than copy one. Can some new feature be incorporated to make the puzzle more intriguing instead of just plain hard? Different sizes and shapes of solutions? Different color patterns? Interlocking? Wouldn't fewer pieces be better?



COMBINATORIAL PUZZLES

The term "combinatorial puzzle" as used here denotes a type of puzzle having pieces which can be combined or arranged many different ways, only a few of which are the desired solution. The success or lack of it for any attempt at solution should not become apparent until most of the pieces are in place. Ideally, all the pieces are dissimilar and non-symmetrical, thus resulting in the maximum number of combinations for a given number of pieces. Maximum difficulty is achieved when only one correct solution exists. Since puzzles of this type can be made more difficult simply by increasing the number of pieces, the challenge facing the puzzle designer is to cleverly devise simple puzzles of this type having the fewest number of pieces and yet being intriguing and baffling.

Four Colored Cubes



Most combinatorial puzzles to be discussed here have pieces and solutions of various geometrical shapes. One notable exception is the popular four-color cube puzzle known as "Instant Insanity" and various other names.

Four cubes are colored as follows: R-B, W-R, W-G; B-W, R-R, G-R; B-W, G-G, R-B; B-W, G-W, R-G, where the letters denote four different colors (red, green, blue, white) or markings of some sort, and the hyphen indicates opposite faces. (Note that either one of a reflexive pair of cubes will satisfy the coloring as indicated; it does not matter which you choose.) There is essentially only one way of arranging them in a stack such that each of the four colors appears on each of the four sides of the stack. We have no information as to who first conceived of this puzzle, or who arrived at this particular coloring scheme, but it is very cleverly chosen such that one and only one solution exists.

The Difficulty Index

A very useful skill for the puzzle designer is being able to judge the difficulty of any given puzzle design. You could simply test it on all your friends, but there is a better way.

Since each cube may be placed face down on any one of its six faces, and then rotated to any one of four positions, there are 24 ways that each cube may be oriented. The stacking order may be ignored, so there are 24^4 or 331,776 ways of arranging the four cubes. Since the whole stack may be rotated or inverted eight possible ways, there are essentially 41,472 different combinations. Dividing this number by the number of correct solutions, which is one in this case, gives us a figure of 41,472 which I call the "difficulty index" for this puzzle.

On first encounter, this figure may not convey much. However, if one were designing other puzzles of this sort, say with different numbers of cubes or different colorings, the difficulty index of different versions should be a good indication of their relative difficulty.

Don't assume that a puzzle with a difficulty index of 41,472 must be terribly difficult. The size of the number is misleading. An intelligent systematic approach eliminates most wrong trials from even being considered. Most persons will solve this puzzle in a few minutes to half an hour.

Ways of Solving Combinatorial Puzzles

Although "Instant Insanity" never was one of my favorite puzzles, it is quite useful to us here because it illustrates so many interesting principles. There are many different ways you may attempt to solve puzzles of this sort.

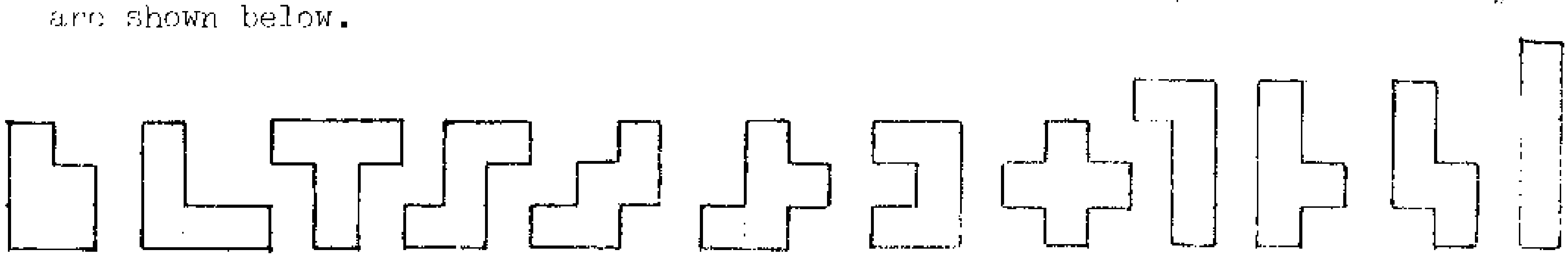
1. The first way is to just keep turning the blocks randomly until you stumble upon the solution.
2. A second way would be to manipulate the blocks systematically until all possible ways are tried. You have to devise a system, and you may need pencil and paper to keep track. When finished, you will not only know the solution, but you will know all the solutions.
3. A third way is to do the whole thing analytically on paper, given the coloring pattern as on the preceding page, without even having the actual puzzle pieces. "Instant Insanity" lends itself well to that approach.
4. A fourth way, which is becoming increasingly popular, is by computer. Usually the computer is used for problems which are too difficult to do practically any other way. "Instant Insanity" is certainly not in that category, but it might be a good one to practice with on a computer.

There are of course combinations of all of the above, plus probably other ways I have overlooked.

Pentominoes

The book Polyominoes by Golomb (page 2) discusses the many different ways that squares may be joined edgewise to form puzzle pieces, and how such pieces may or may not fit together. Although the book is oriented more toward the mathematical aspects, the application to mechanical puzzles is obvious. Taken as a whole, polyomino-type puzzles are quite popular, partly because it is such a large class of puzzle designs, and also because they are so easy to design and to make. The most popular have been the pentominoes.

There are 12 ways that five squares may be joined together, not counting reflections, and they are popularly known as the set of 12 pentominoes. They are shown below.



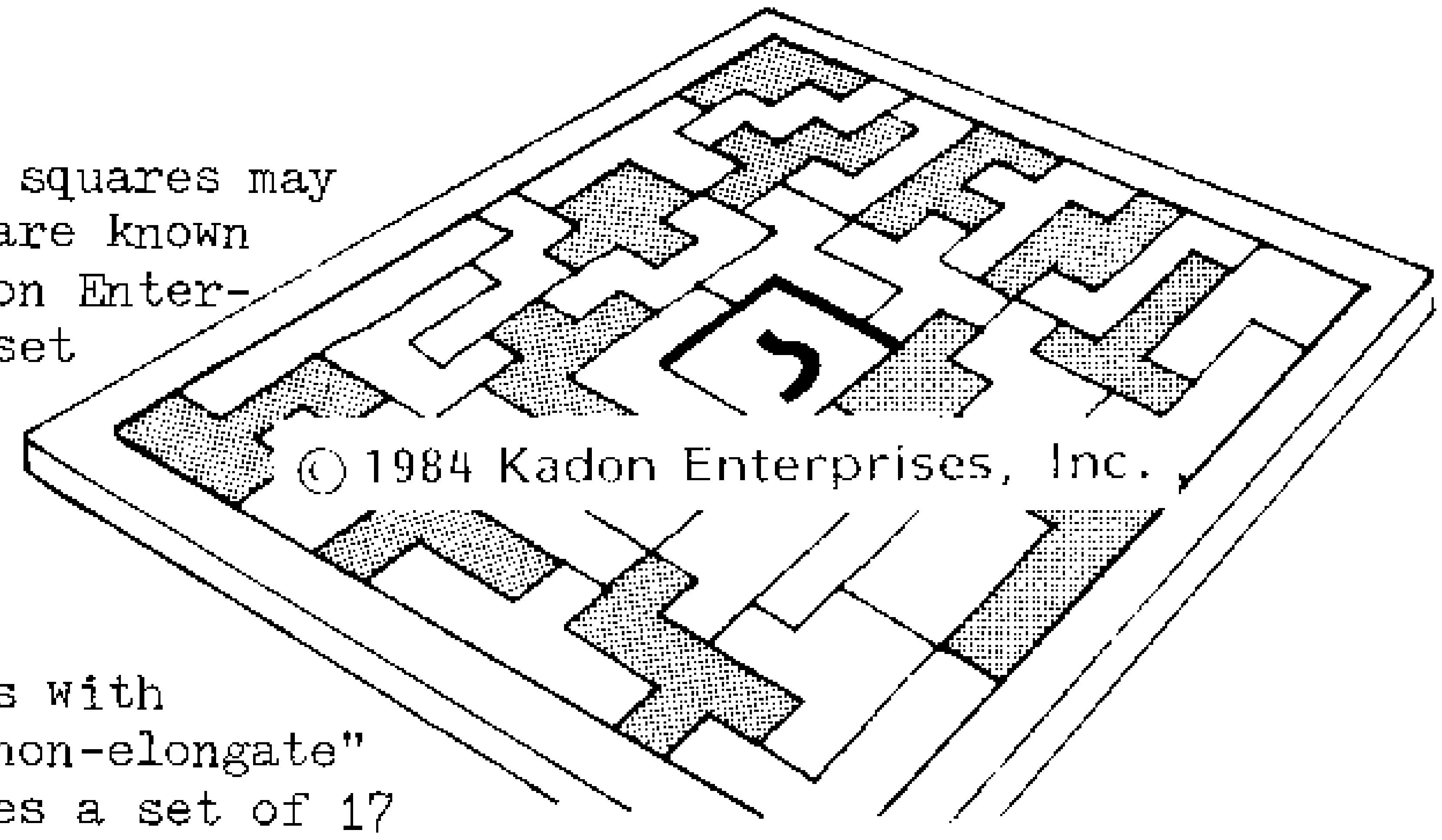
Note the similarity of these to the Dudeney puzzle on page 22. Why, you may wonder, was the Dudeney puzzle listed under "dissection" puzzles, and these under "combinatorial"? It is simply a question of method, not geometry. The Dudeney puzzle was created by cutting up a checkerboard. The pentominoes, on the other hand, were made by putting things together and then seeing what they will make. The distinction is not important. Many times the two terms are used interchangeably, and many puzzle classifications overlap.

It is not known who first came up with the idea of using the pentominoes as a set of puzzle pieces, but it is so obvious it may have occurred to several persons independently that they can be assembled to form the following rectangles: 3x20, 4x15, 5x12, and 6x10. According to an investigation by C. J. Bouwkamp using a computer, there are respectively 2, 368, 1010, and 2339 solutions to these. (Note: this was reported in the Journal of Combinatorial Theory 7, 278-280 , 1969. The numbers have since been confirmed by many others.)

Many puzzle companies have put out the set of pentominoes with a tray, usually 6x10, usually plastic. Kadon Enterprises (page 4) has done better. Theirs is well crafted of hardwood, with several new and original puzzle problems and games devised around a set of what is essentially the pentominoes.

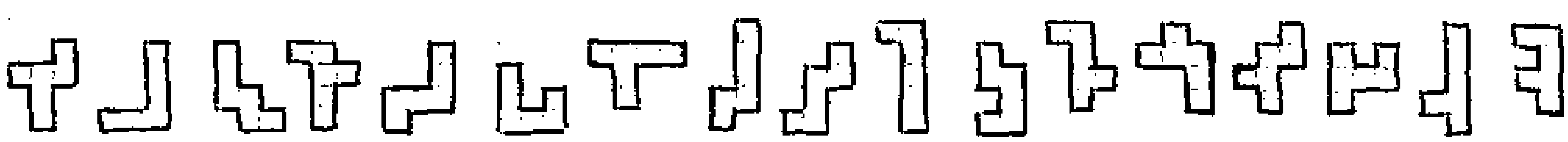
Hexominoes

There are 35 ways that six squares may be joined together, and these are known as the set of hexominoes. Kadon Enterprises produces a puzzle-game set based on them, made of acrylic and cut by laser.

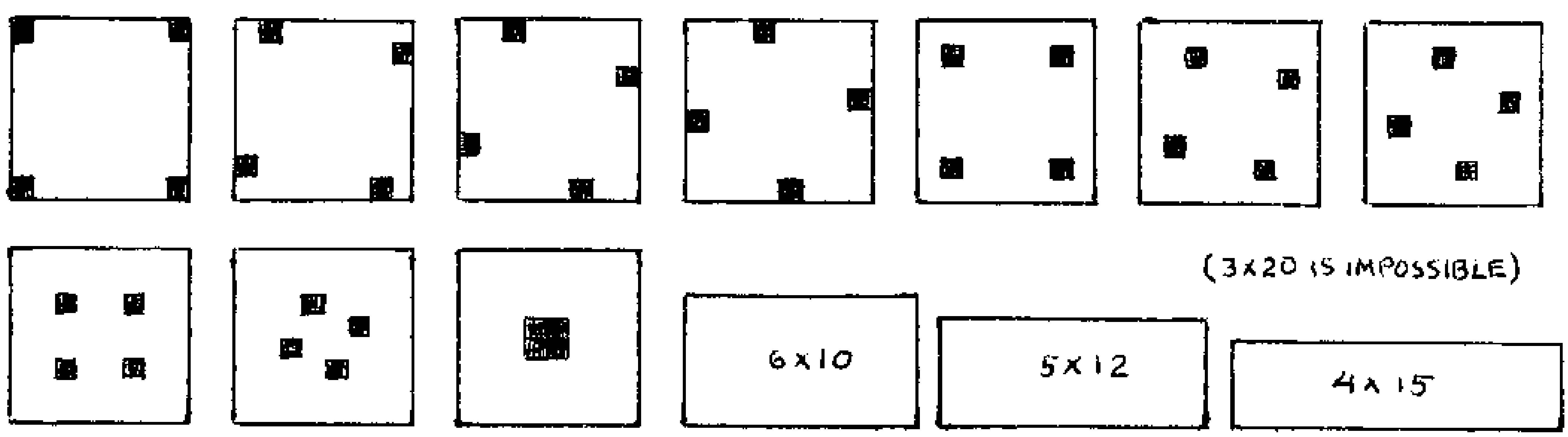


The Cornucopia Puzzle

Eliminating hexomino pieces with symmetry and those which are "non-elongate" (containing a 2x2 square) leaves a set of 17 pieces. These are shown below:



Is it possible to select a subset of ten pieces from these 17 which will assemble into any of the symmetrical patterns shown below?:



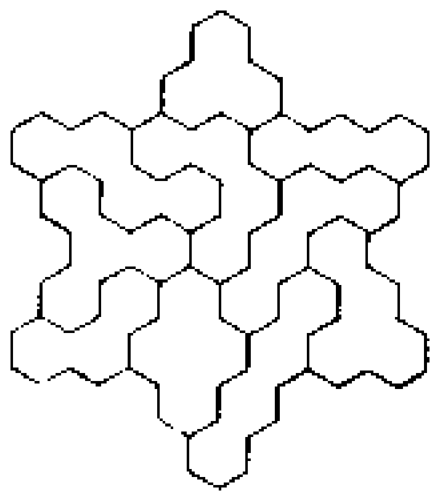
The answer to the above question is decidedly yes. As this edition of Puzzle Craft goes to press, the matter is being investigated by Mike Beeler, assisted by a computer. There are in fact so many thousands of possible subsets, all of which would make fine puzzles, we are considering the possibility that every puzzle set sold could be a limited edition of one!

Hexagonal Tiles

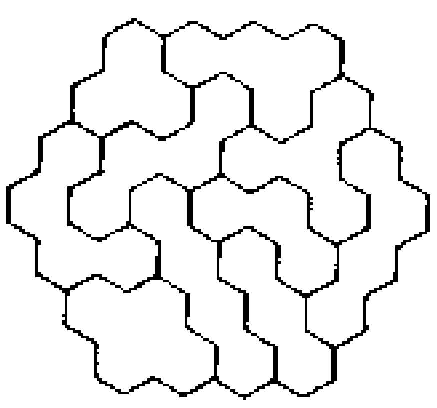
Given the popularity of puzzle pieces made up of squares, it does not require too much imagination to realize that triangles or hexagons might also be used as building blocks for combinatorial puzzles. Indeed, there are many such now on the market.

There are three ways in which three regular hexagons may be joined, and seven ways that four may be joined. The resulting ten pieces with 37 hexagonal units just happen to assemble into shapes having hexagonal symmetry, as well as many other interesting shapes. My SNOWFLAKE puzzle is based on this set of pieces. Reproduced on the next two pages are portions of the instruction booklet which came with this puzzle. Mike Beeler has analysed some of the problems by computer - there are 12,290 solutions to the HEX pattern and 167 for the SNOWFLAKE.

SNOWFLAKE™

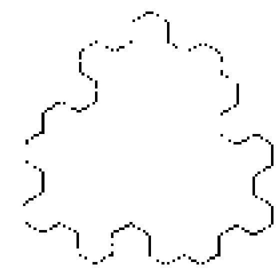


SNOWFLAKE PATTERN

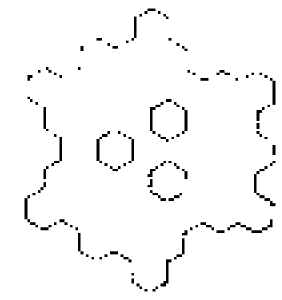


HEX Pattern

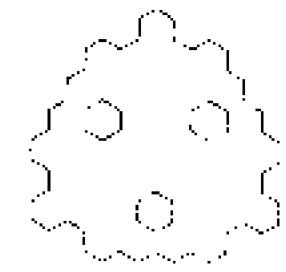
Puzzles 3-5 - Find at least one solution for each of the three numbered triangular patterns shown below. (How many others can you find?)



3

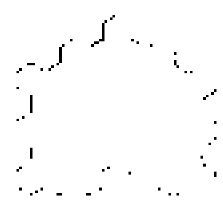


4

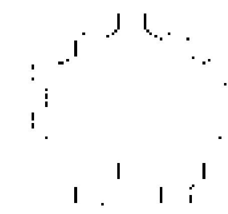


5

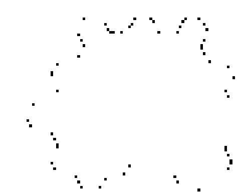
Puzzles 6-13 - Find at least one solution for each of the reflexive patterns shown below.



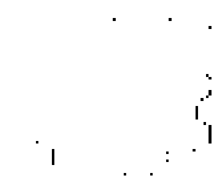
6 HOUSE



7 IGLOO

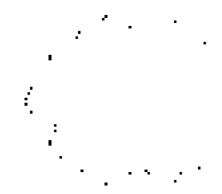


8 SUNRISE

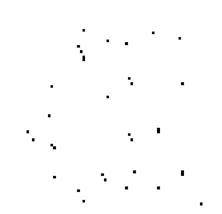


9 KETTLE

10 ACORN



11 EGG

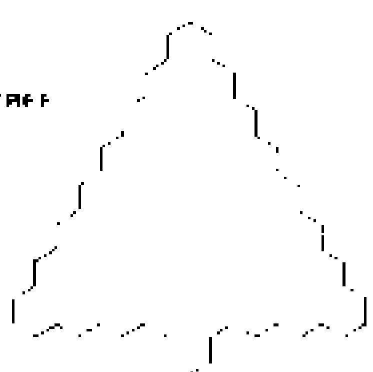


12 SMILE

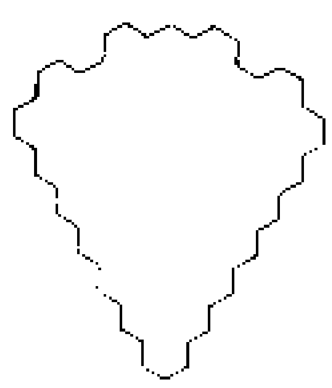
13 FAT PIG

PATTERNS WITHOUT THE BASE

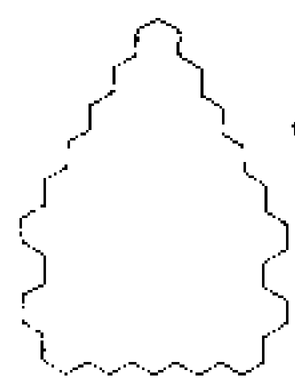
Puzzles 14-25 - Do not use the Base for the symmetrical patterns shown below and on next page.



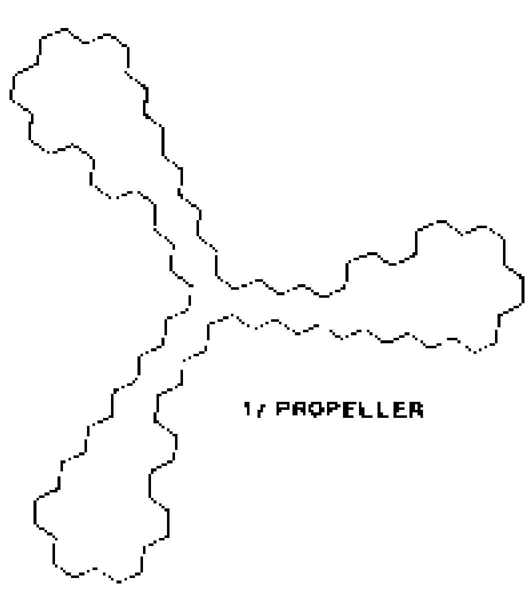
14 XMAS TREE



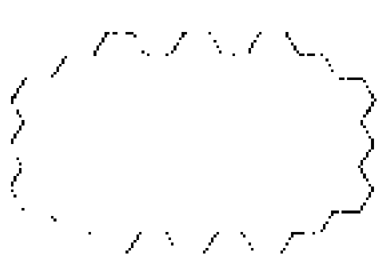
15 TOP



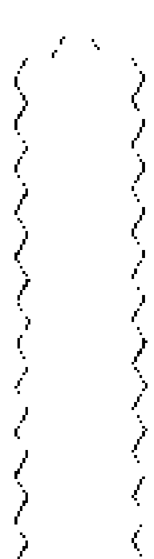
16 CHURCH



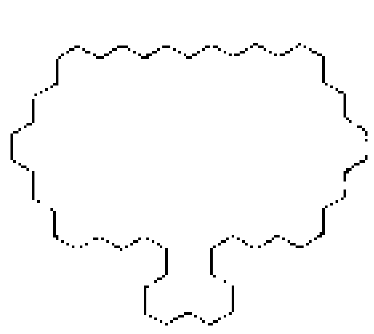
17 PROPELLER



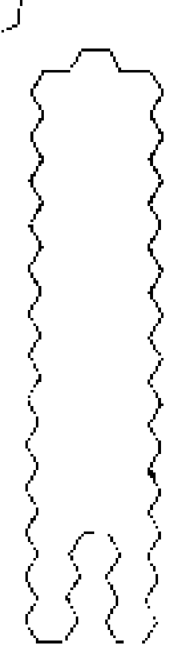
18 WATERMELON



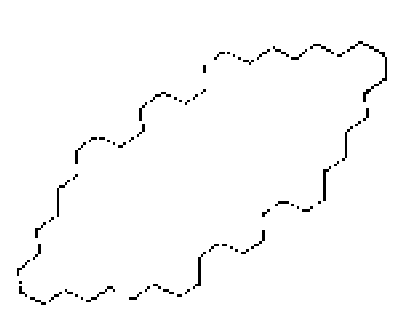
19 TOWER



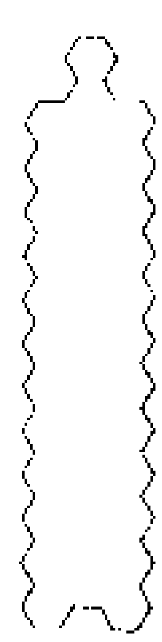
20 SHADE TREE



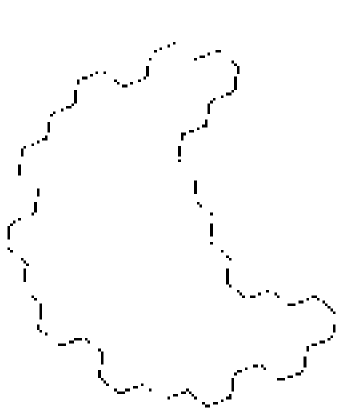
21 ROCKET



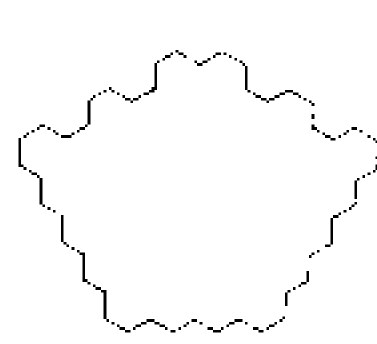
22 U.F.O.?



23 CANDLE



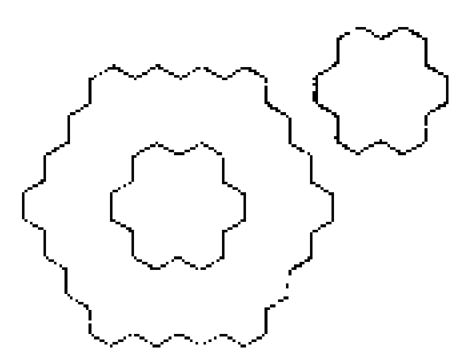
24 MOON



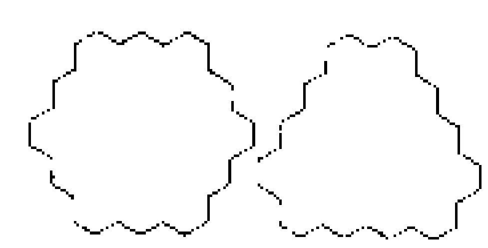
25 BASKET OF FRUIT

DOUBLE PATTERNS - One set of pieces makes both figures.

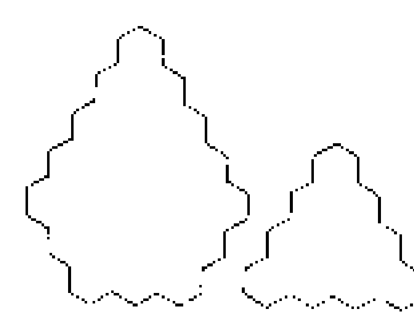
Puzzles 26-28 - Solve these three Double Patterns -



26 WREATH and SNOWBALL



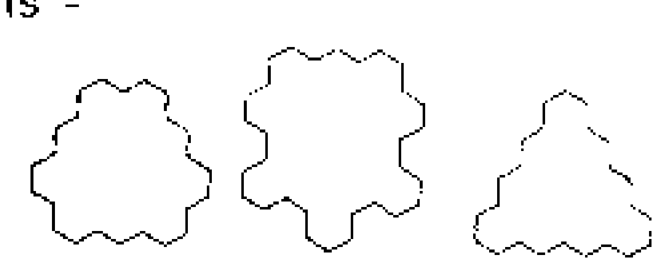
27 HEXAGON and TRIANGLE



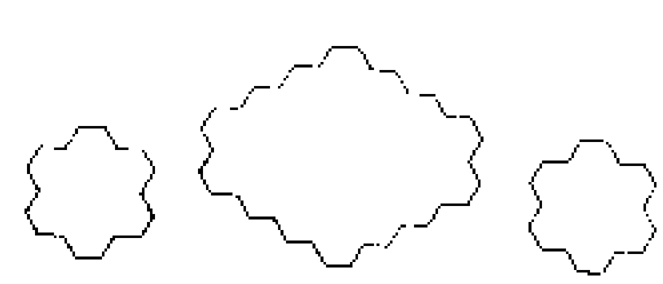
28 SPRUCE TREES

TRIPLE PATTERNS - One set of pieces makes all three figures.

Puzzles 29-30 - Solve these Triple Patterns -



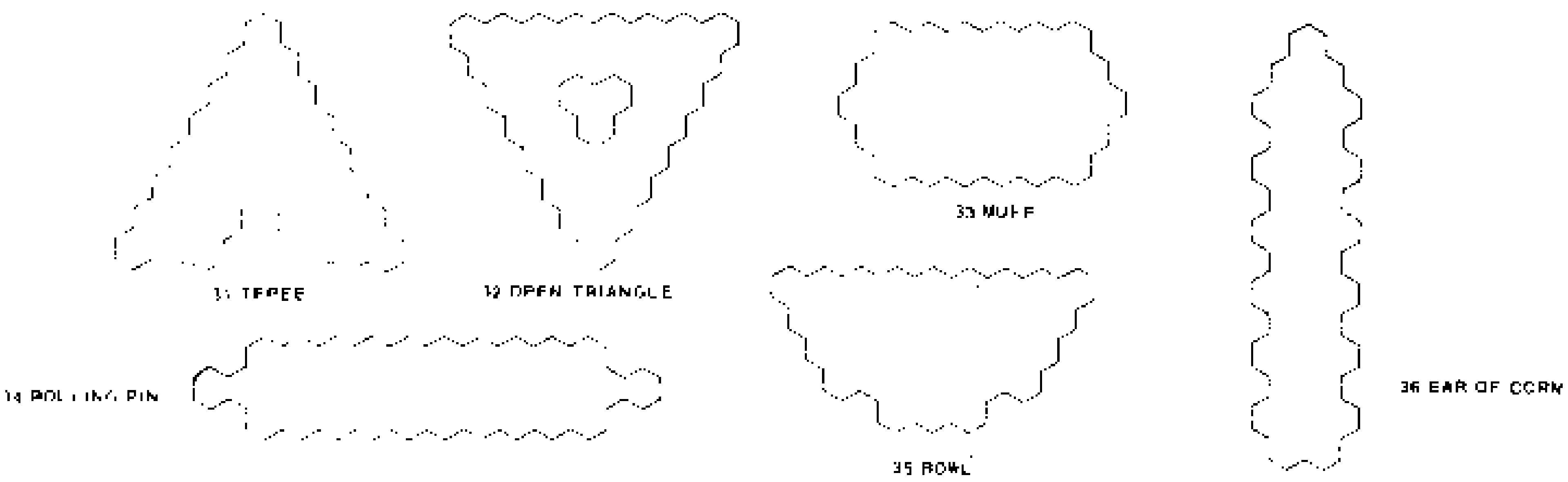
29 SHRUBS



30 BASEBALL - FOOTBALL - TENNIS BALL

PATTERNS WITH PIECES OMITTED - (Which ones?)

Puzzles 31-36 -Solve each of the problems shown below by omitting one or more pieces. Which piece do you omit to make OPEN TRIANGLE? Don't leap to a conclusion.



31 TEPEE 32 OPEN TRIANGLE 33 MUFF 34 ROLLING PIN 35 BOWL 36 EAR OF CORN

IDENTICAL DOUBLE AND TRIPLE PATTERNS - It is impossible to make identical Double or Triple Patterns using all the pieces, because the total number of hex units - 37 - is not divisible by 2 or 3. By omitting one or more pieces, however, some are possible

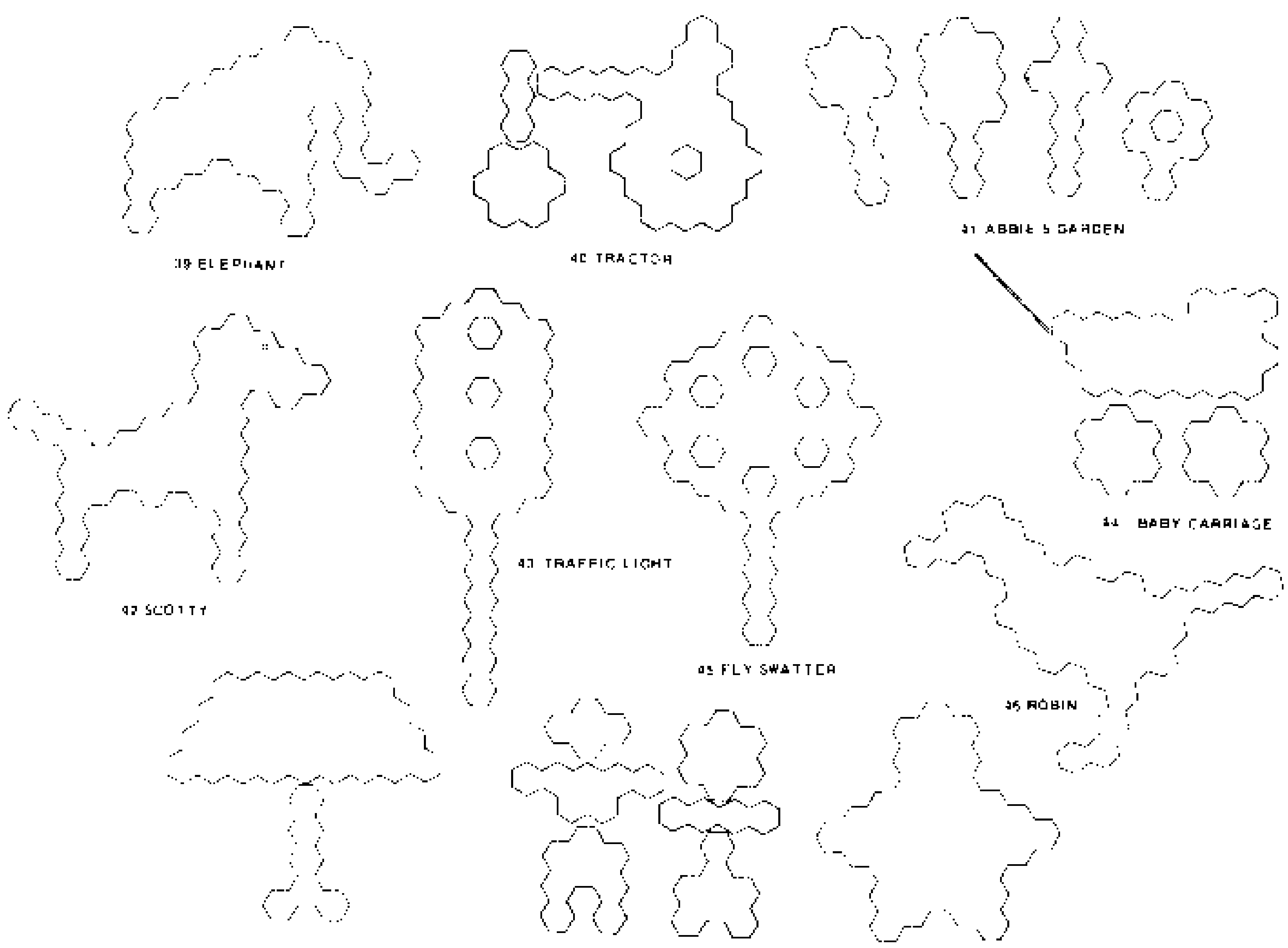
Puzzles 37-38 - Solve these two Identical Triple Patterns -

37 THREE BOTTLES

38 THREE SNAILS

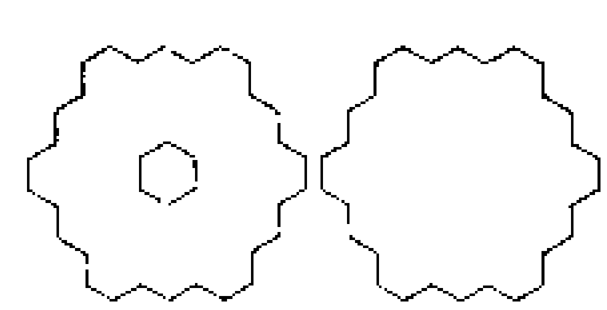
DESIGNS

Shown below are but a few of the myriad pictorial figures which can be made with this set. Detailed directions are not needed. Turn your imagination loose; see what new and original designs you can discover.



39 ELEPHANT 40 TRACTOR 41 ABBIE'S GARDEN 42 SCOTTY 43 TRAFFIC LIGHT 44 BABY CARRIAGE 45 FLY SWATTER 46 ROBIN 47 LAMP 48 SENOR and SENORA 49 GINGERBREAD MAN

Challenge: The appealing double pattern, **DONUT and POPCORN BALL**, shown at right, has not been proven impossible, but has foiled all attempts at solution. Can it be done? (Probably not.)



DONUT and POPCORN BALL

Design Comment

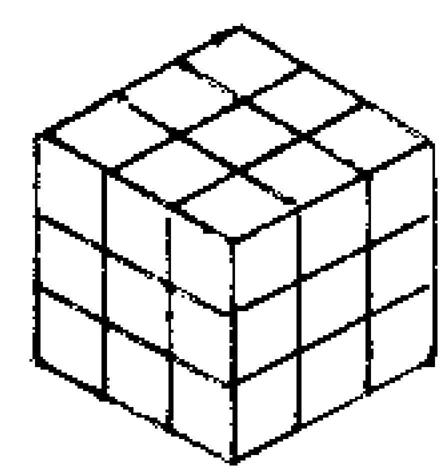
Since *Puzzle Craft* is intended primarily as a design resource, there is a point which is appropriate to make here:

I first discovered the set of Snowflake pieces in a column by Martin Gardner in *Scientific American*. I sawed a set of pieces out of Masonite, worked out a few of the patterns shown on the preceding pages, called it "HEXMAS," and started showing it to manufacturers, through an agent. There was no interest in it, to my disappointment. I thought it was *so* clever. A few months later, I cast the same pieces accurately in solid, brightly colored epoxy one-half-inch thick, improved the base, and changed the name to "Snowflake." What a difference that made, and soon it was in production.

The point is simply this: No one knows exactly what factors go into the design of commercially successful puzzles. Every time we think we know, we get a surprise. Aesthetics plays a large part - color, size, materials, texture and feel, workmanship and accuracy. Even the name and the packaging can be important. One thing we know for sure - cleverness of design is one of the least important factors.

Solid Block Puzzles

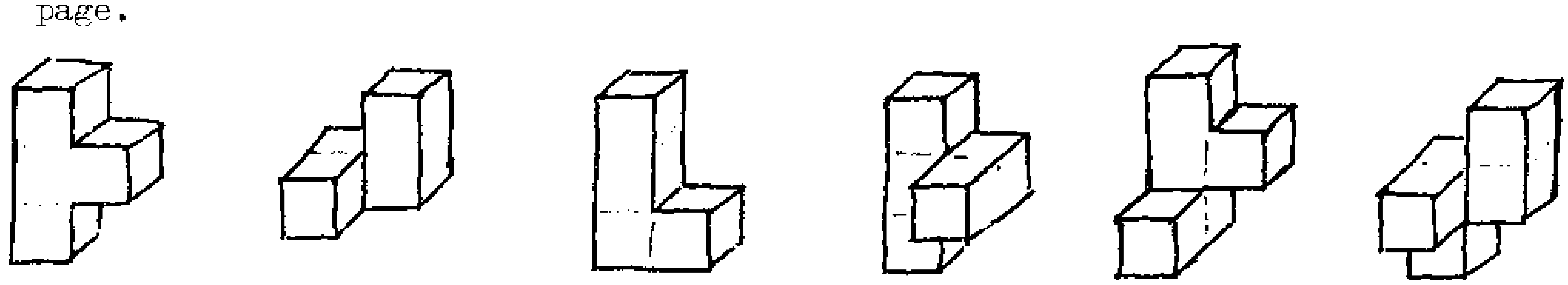
The obvious next step in the development of polyomino-type puzzles was to make the building blocks cubic, and the constructions three-dimensional. The smallest practical size for a puzzle of this sort is 3x3x3.

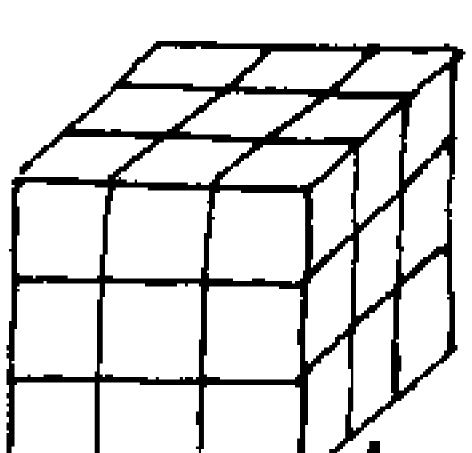


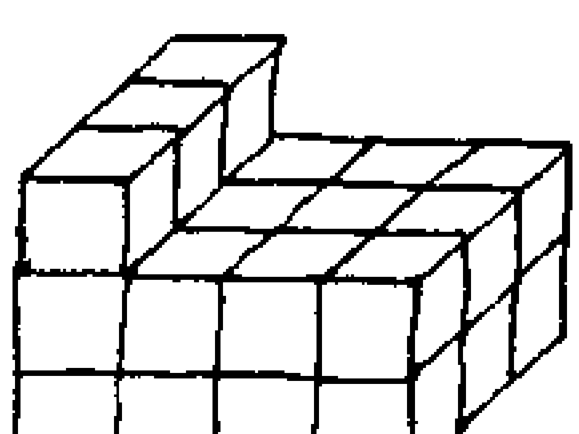
Nearly everyone is familiar with Piet Hein's SOMA CUBE, a puzzle which has had great commercial success. The seven pieces form a 3x3x3 cube 240 different ways, and construct many other solid figures shown in the instructions. There have been many variations, including checkered or numbered pieces, pieces with pins or magnets, and so on.

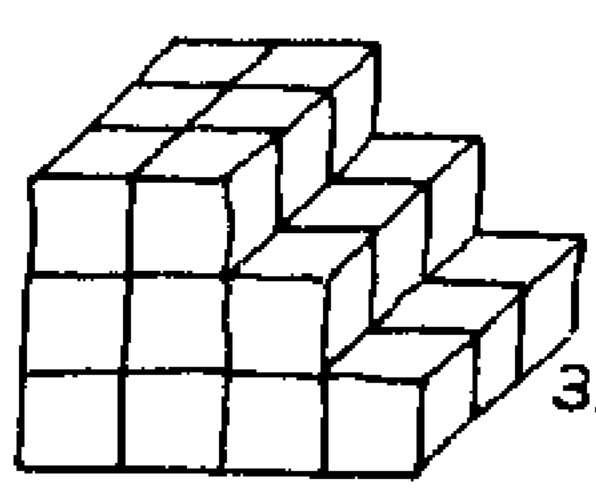
Half-Hour Puzzle

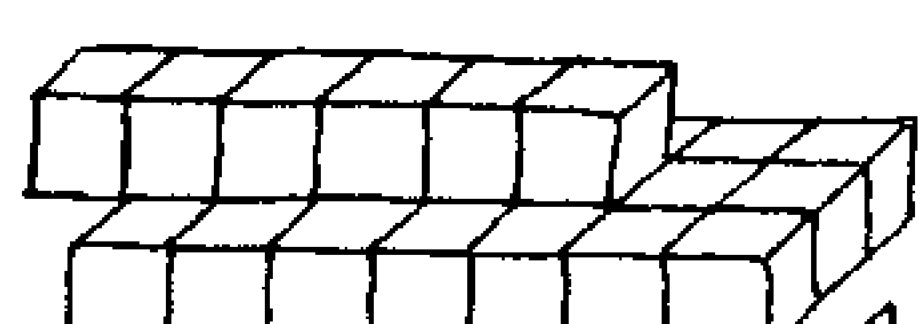
I designed a six-piece version of the 3x3x3 which I produced at one time under the name "Half-Hour Puzzle." Quite a bit of analysis went into its development, and I thought it was a distinct improvement over all previous designs. Alas, I fear it is destined for obscurity. The "Half-Hour Puzzle" has only one 3x3x3 solution, all the pieces are dissimilar, and they have the maximum amount of dissymmetry possible, making it surprisingly difficult. Yet it makes hundreds of other geometrical shapes. Hans Havermann of Toronto contributed the first 20 shapes, and these were printed on a supplementary instruction sheet. David Barge of Oneonta, N.Y. has come up with many more - over 700 by the latest count. Some of these are shown below and on the next page.

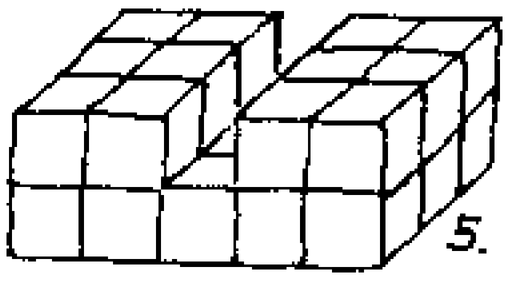


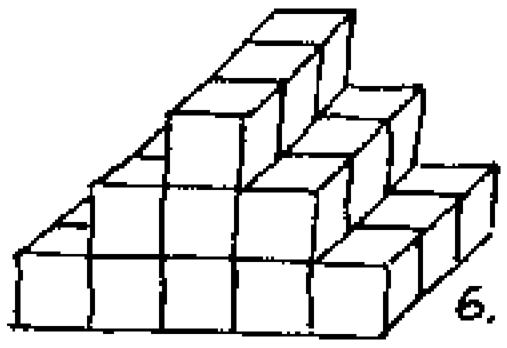

1.

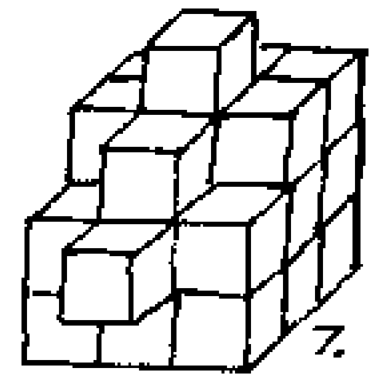

2.

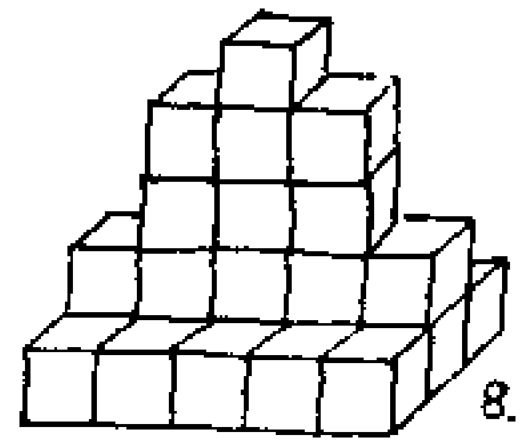

3.

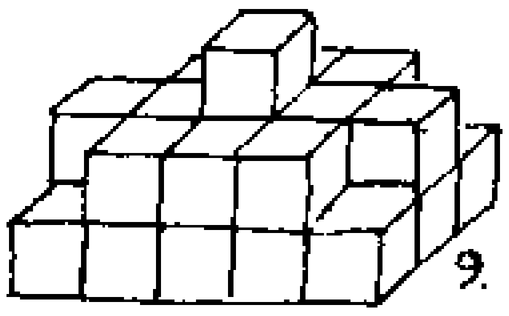

4.

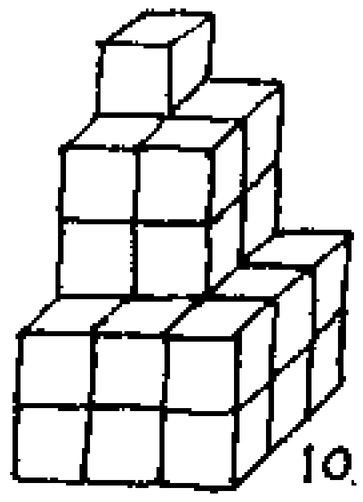

5.

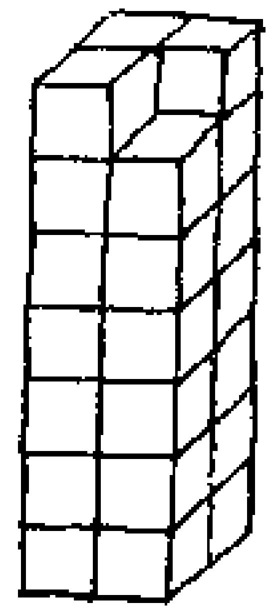

6.

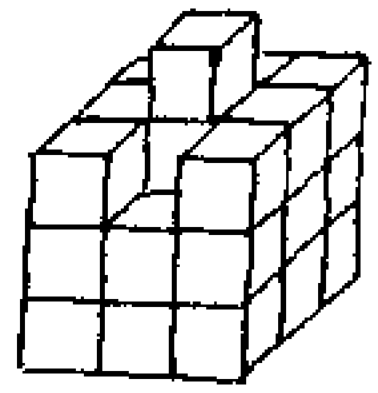

7.

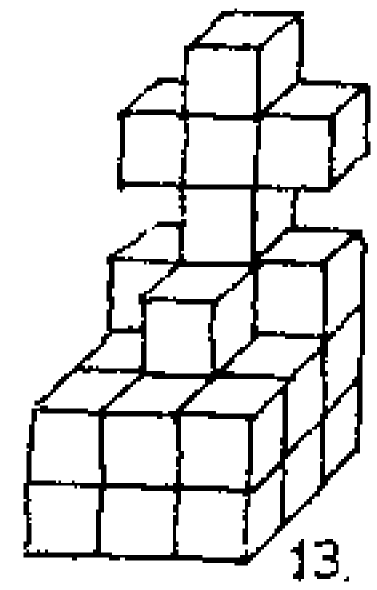

8.

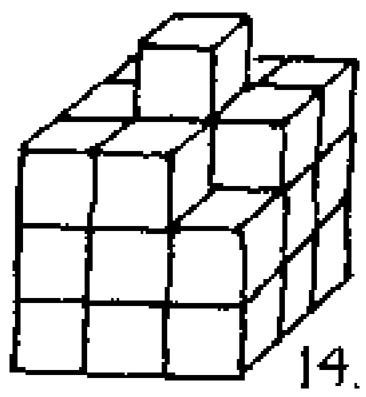

9.

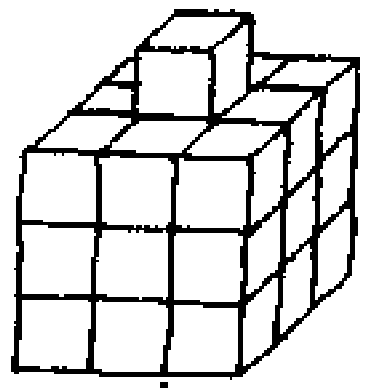

10.


11.

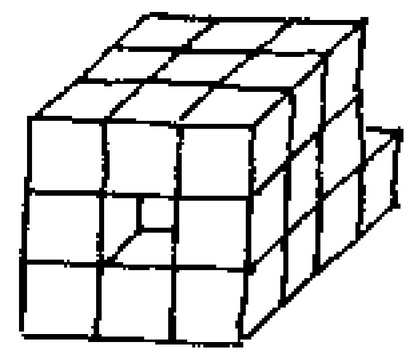

12.

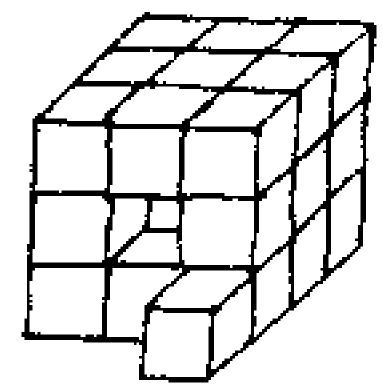

13.

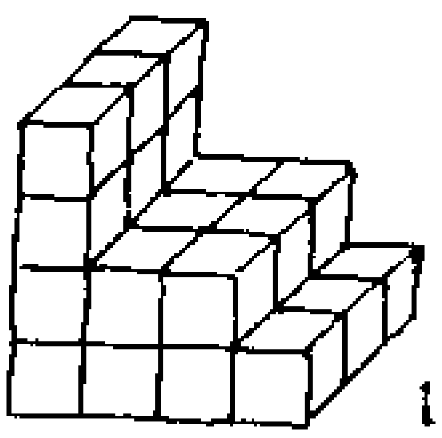

14.

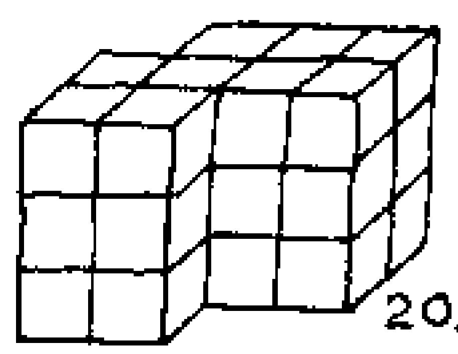

15. BOTTOM CENTER BLOCK MISSING

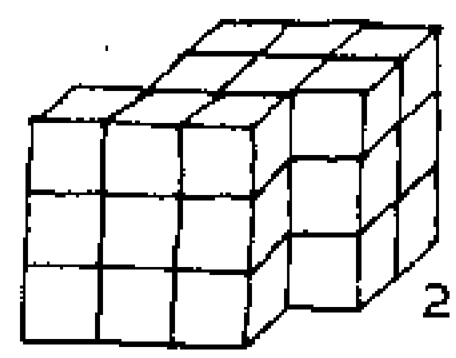
16. SAME, BUT INTERNAL CENTER BLOCK MISSING

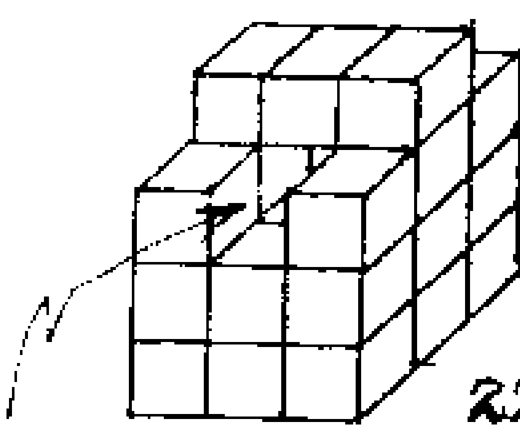

17.


18.

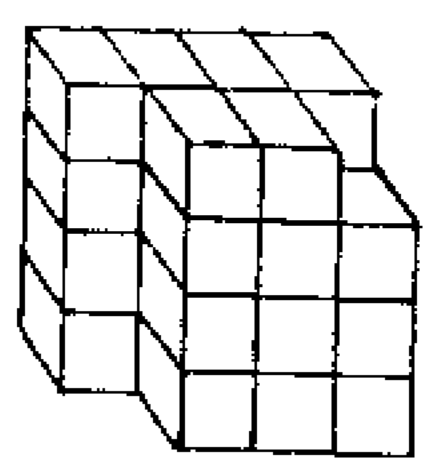

19.

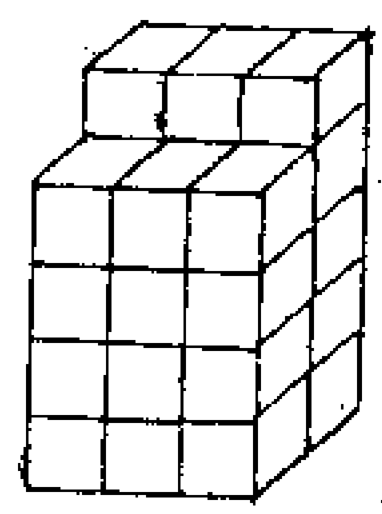

20.

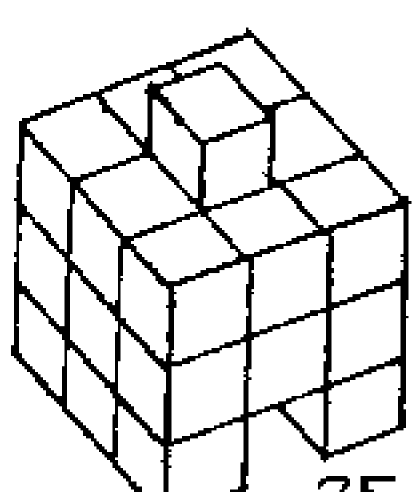

21.

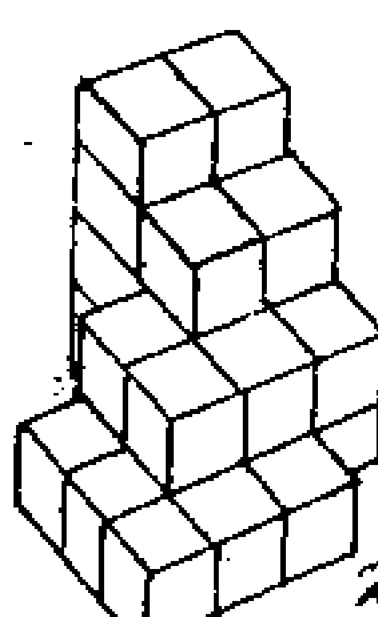

SLOT ST. THRU

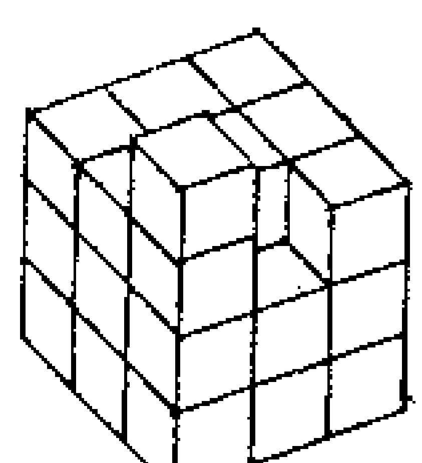
22. (BRIEFCASE)

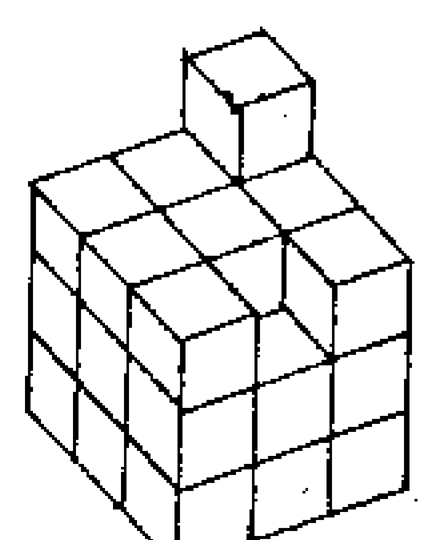

23.

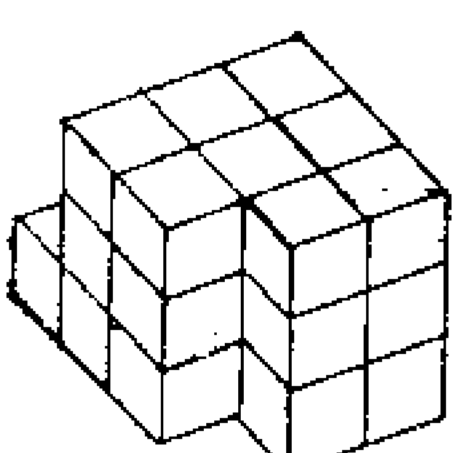

24.

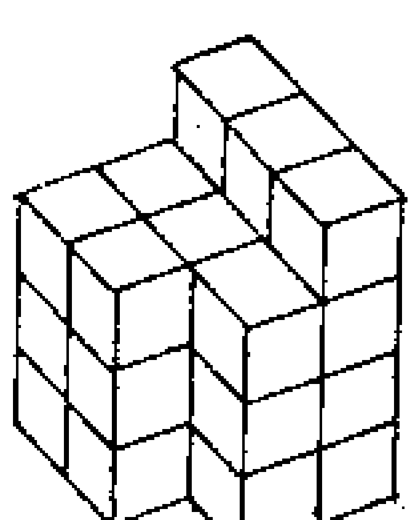

25. (HOUSE)

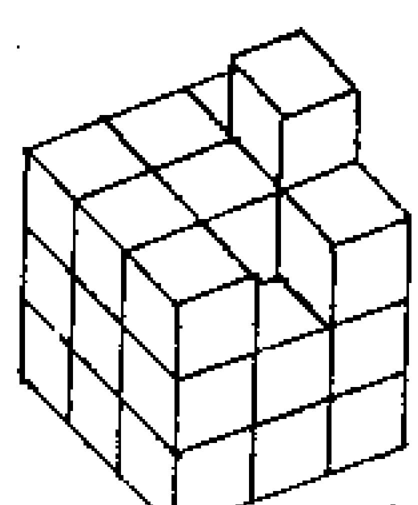

26. (HABITAT)

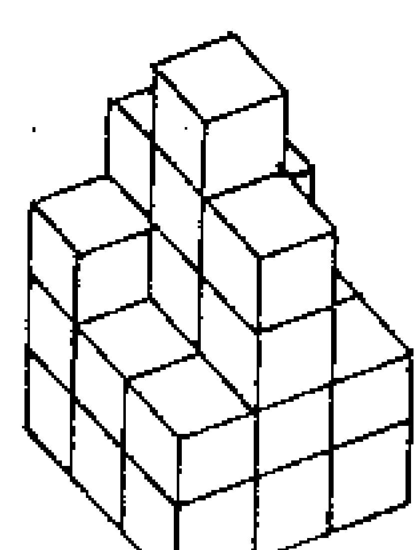

27.


28.


28.


30.

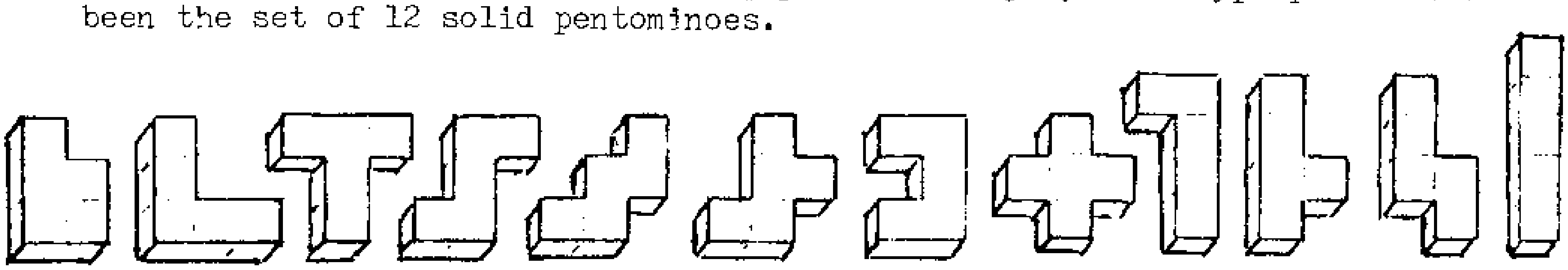

31.


32.

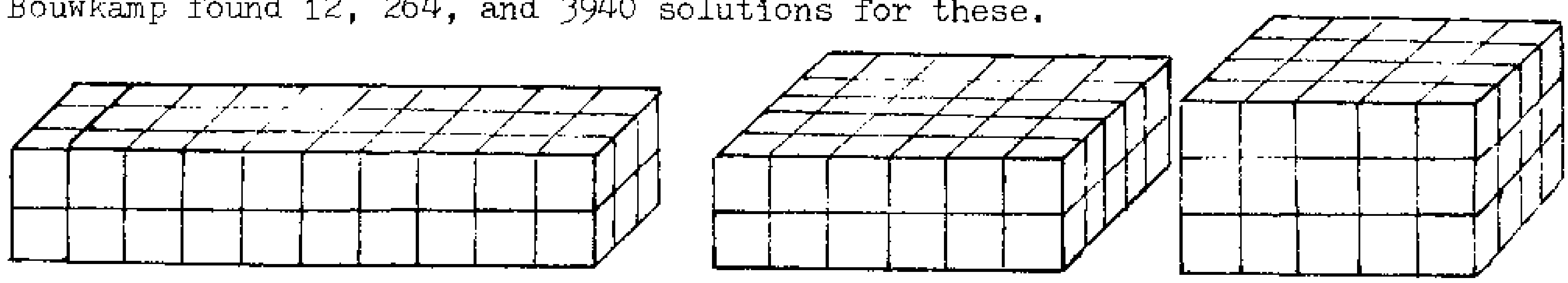
plus many more

Solid Pentominoes

After the 3x3x3, the next most popular solid polyomino-type puzzle has been the set of 12 solid pentominoes.



They pack into the following rectangular solids: 2x3x10, 2x5x6, and 3x4x5. Bouwkamp found 12, 264, and 3940 solutions for these.



You might think that with 3940 solutions, the 3x4x5 would be easy to solve, and if so you are in for a surprise.

Several puzzle companies sell the set of 12 solid pentominoes. Kadon's are accurately cut out of hardwood using a laser.

Sivy Farhi, 815 S. California Unit B, Monrovia, CA 91016, is an expert on puzzles of this type and publishes booklets about them.

Checkered Solids

Any polyomino-type puzzle, solid or plane, can be checkered for added novelty. This may make it easier or more difficult, depending on the circumstances. One example will be given here:

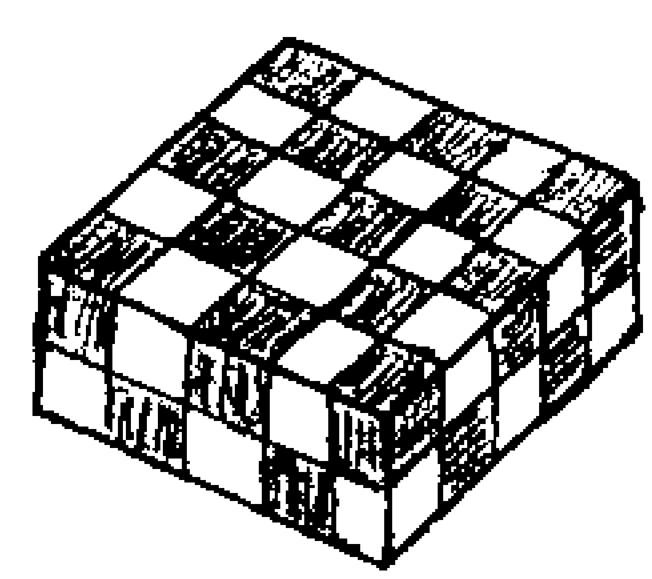
If you take all the ways that five cubes may be joined and exclude those which lie flat (the solid pentominoes), those with an axis of symmetry, and those which fit inside a 2x2x2 box, you end up with a set of ten puzzle pieces. These assemble into a 5x5x2 box 19,264 different ways, according to Beeler. We decided to try checkering this one to make the puzzle more interesting. Out of all the 512 different possible ways of checkering the ten pieces, Beeler found that there was <u>one and only one</u> way which produced a unique solution. This amazing discovery is given in the diagram below.

G	G	G	I	I
B	B	A	E	D
A	A	A	E	E
C	J	J	E	F
J	J	H	H	H

BOTTOM

G	B	I	I	D
G	B	I	D	D
C	B	A	D	F
C	C	H	E	F
J	C	H	F	F

TOP



Summary: 2x5x5 random color - 19,264 solutions - easy
2x5x5 checkered - 1 solution - very hard
2x4x5 checkered - 5 solutions - fairly hard (omit 2 pieces)
2x3x5 checkered - 15 solutions - fairly easy (omit 4 pieces)
2x4x5 checkered - 1 solution if the 2 pieces having a plane of symmetry are omitted - hard

Packing Problems

There is a branch of mathematics which deals with the question of whether or not certain geometrical solids can be packed into certain boxes. It is the sort of thing you are apt to find in the recreational math books and journals, to wit: "Filling Boxes with Bricks," by N. G. de Bruijn, American Mathematical Monthly, Jan. 1969; "Brick-Packing Puzzles," by David A. Klarner, (Stanford University), Journal of Recreational Mathematics, Vol. 6, No. 2.

Occasionally mathematical solutions to packing problems become materialized in the form of wooden blocks and a box into which they pack - a puzzle. One of the more familiar is the so-called "Slothouber-Graatsma Puzzle," which calls for three 1x1x1 cubes and six 1x2x2 blocks to be packed into a 3x3x3 box. There is only one solution and it is fairly difficult.

Another is known as "Conway's Puzzle" after its inventor, mathematician John Conway of England. It calls for packing three 1x1x3 blocks, one 2x2x2 block, one 1x2x2 block, and thirteen 1x2x4 blocks into a 5x5x5 box. It is extremely difficult unless you happen to be an expert in this particular branch of mathematics.

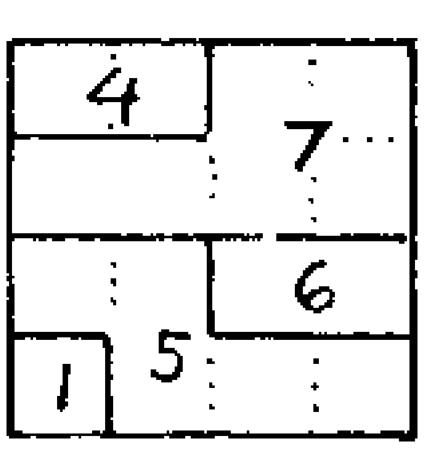
Rubik's Cube

While on the subject of cubes, we will take the opportunity to dispose of Rubik's Cube. It was not mentioned in the first edition of Puzzle Craft, and many have asked why. Anyone in the puzzle business these days must endure being asked incessantly if they sell Rubik's Cube, if they make it, and if not, why not? Would they make one out of rosewood? Would they show someone how to solve it? Etc., etc. This book is mostly about puzzles you can design and make. I have never taken a Rubik's Cube apart to see how they are made because I never was interested in knowing. I have never seen any made in a home workshop, and I would assume it is not very practical to hand-craft. It should have been mentioned in the section on patents, but was overlooked. There is a Hungarian patent on it by Rubik,Ernő, #170062, 1978. There is a U. S. patent on a similar puzzle using magnets by Larry D. Nichols, #3,655,201, 1972. Recently there was a multi-million dollar patent infringement case trying to establish who invented it first.

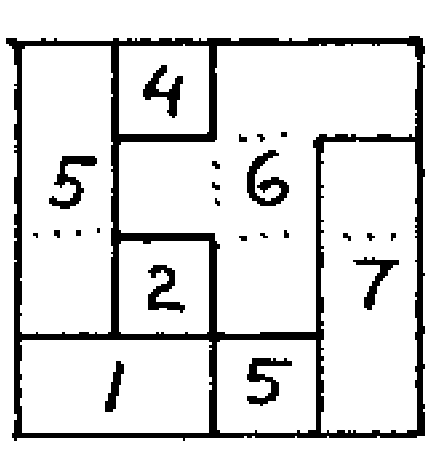
The Convolution Puzzle

If packing bricks into a box does not excite you, you might try gluing some of them together to make more complicated and interesting puzzle pieces. You may even be able to make them interlocking so that you no longer need the box. For added amusement, perhaps you can come up with an arrangement which can only be assembled in one particular order. Finally, try to make all the outside faces symmetrical and identical in appearance for aesthetics.

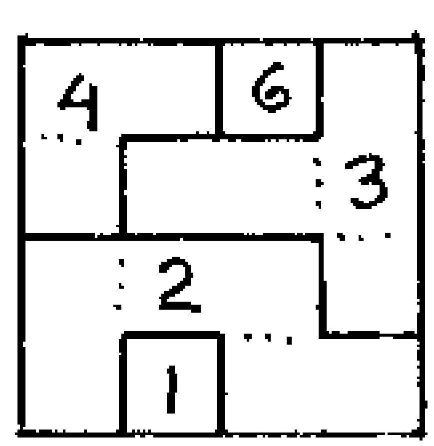
Here is one for an example: My "Convolution" puzzle is made up of twenty-four 1x1x2 blocks and eight 1x1x1 cubes, which you see on the outside, plus eight more cubes in the center. The design is indicated in the diagram below, and hints for making it are given in the section on woodworking. It has one peculiar step in assembly involving a rotation, which Bill Cutler has shown by analysis to be impossible unless two edges are rounded ever so slightly.



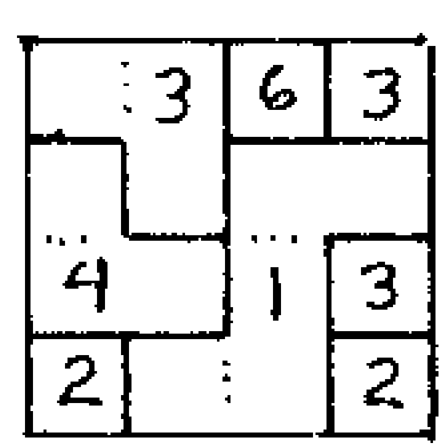
TOP LAYER



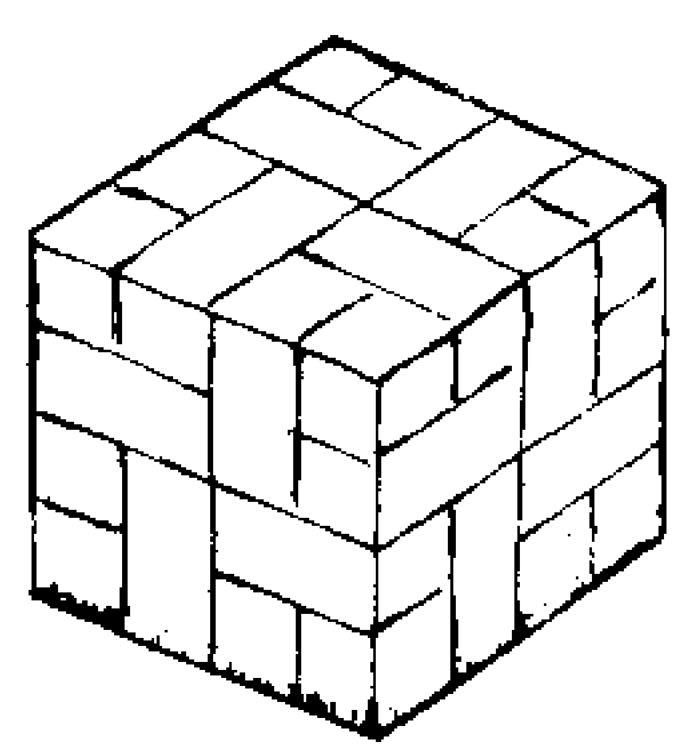
SECOND



THIRD



BOTTOM



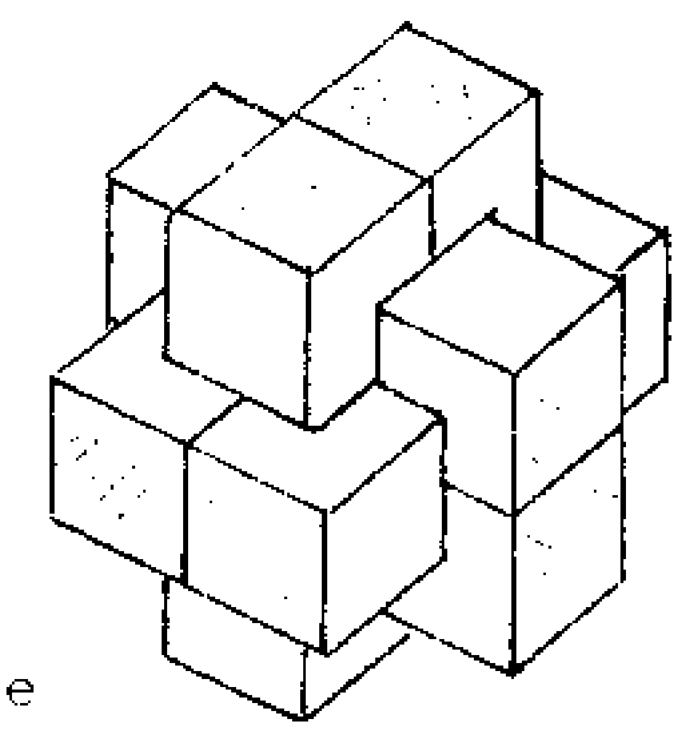
Part 2 - Burrs and Polyhedral Puzzles

BURRS

Taken as a whole, the notched stick or burr-type puzzles are probably the most familiar of all mechanical puzzles. The family is a large one, and being added to all the time. Nearly every general puzzle book or article mentions them. The directions which have been published for making simple burrs are too numerous and redundant to list. One of the best and most accessible is Puzzles in Wood by Wyatt (page 1). Since the theme of Puzzle Craft is to publish new information that is not available elsewhere, we will just review the basics and then carry on where most of the others leave off.

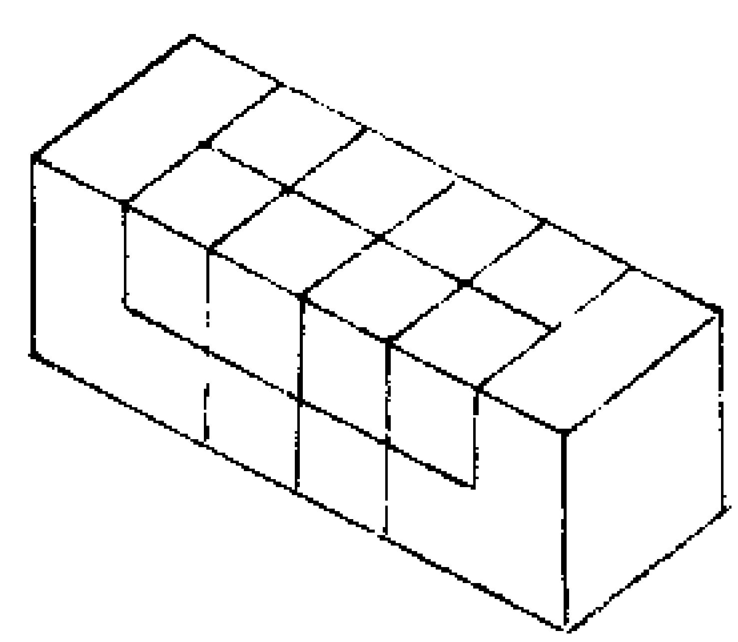
The Standard Six-Piece Burr

This is the king of puzzles. Its origin is unknown, but it is ancient by puzzle standards, meaning 18th century or possibly earlier. In my selection of the ten best puzzles, it is near the top of the list. The problem is, it has now been established that there are well over 100,000 versions of the standard six-piece burr, so which one do we choose?



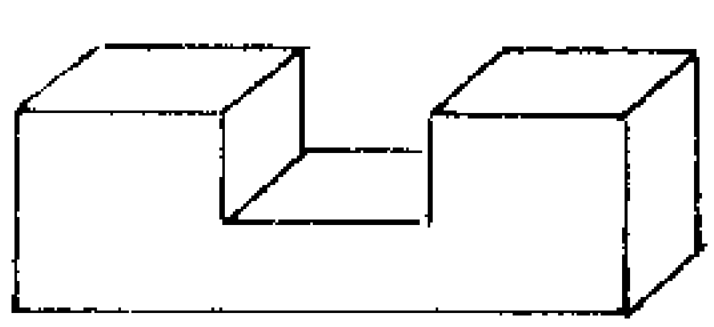
The puzzle consists of six notched square sticks, which form an interlocking structure of three mutually perpendicular pairs. When assembled, all the notches are hidden inside, so the puzzle has apparent total symmetry. In other words, if spun about, there is no way you can tell by the geometry if the same piece is still on top or a different one. This is basic to all totally symmetrical puzzles.

Since each stick intersects with four others, one or the other must be notched. All notches are in discrete units one-half the size of the sticks. In other words, if the sticks are one-inch square, the notches are all one-half inch deep, and one-half inch wide or some multiple. You can think of notching the sticks in terms of removal of cubic blocks. There are a total of 12 cubic blocks in each piece which are candidates for removal. If the puzzle has no internal voids when assembled, a total of 40 cubic units must be removed from the six pieces.

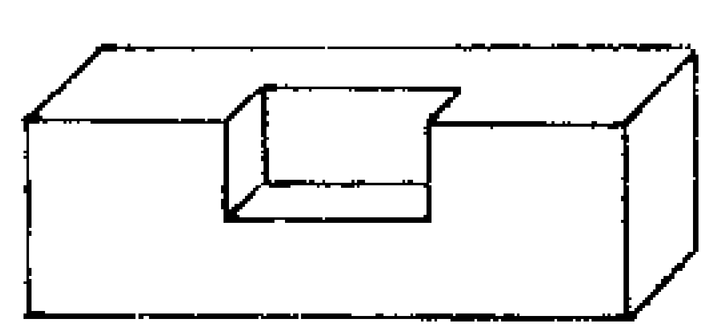


Over the years, many puzzle designers and analysts have taken an interest in the six-piece burr. Van Delft & Botermans devote several pages to it. To simplify things for a start, we will consider only pieces which can be notched on a table saw, rather than those which have blind corners and inside edges which must be chiseled out. Furthermore, we consider only pieces which can be assembled into a puzzle with no internal voids. There are 25 such pieces - they are known as the set of notchable pieces and are shown on the next page.

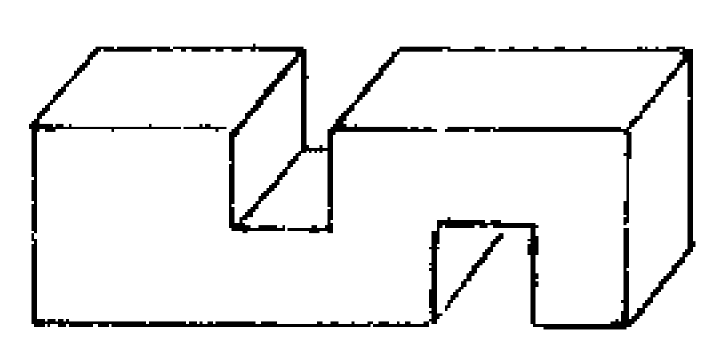
In the diagrams below, piece A is notchable. Piece B is not notchable. Piece C can be made with a saw, but cannot be assembled without voids, so is not included in the set of Notchable Pieces.



A

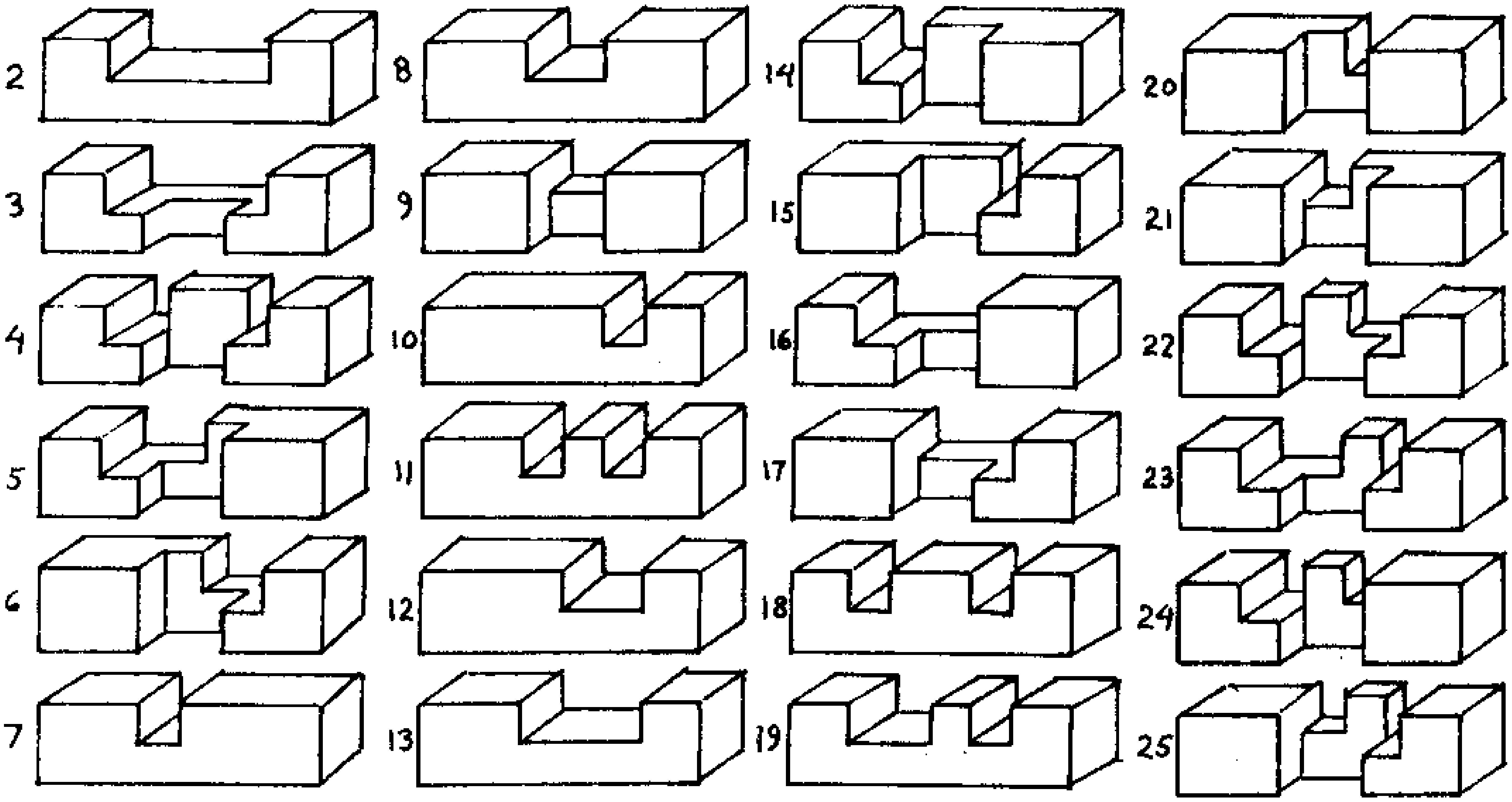


B



C

1 HAS NO NOTCHES



THE 25 NOTCHABLE PIECES

In anticipation of the many readers who will write to say that these drawings are useless because the dimensions are missing, please note the following: Start with square sticks of any arbitrary size - 3/4-inch to one inch would be the most popular sizes. They can be any length not less than three times the width, (those above are $3\frac{1}{2}$ times). The depth of all notches is exactly halfway (i.e. 3/8-inch or 1/2-inch). The width of the basic notch is exactly the same as the depth, and wider notches are made up of smaller ones side-by-side in exact multiples. You can scale these drawings to see where the notches come. (If you are using 3/4-inch sticks, these drawings are half scale. So, dimensions are unnecessary.

In order to assemble all 314 burrs with this set, you will need duplicates of pieces 4, 5, 6, 9, 10, 12, 14, 15, 16, 17, 19, 22, 23, and triplicates of pieces 2 and 3, for a total of 42 pieces. Helpful hints on making them will be found in the section on woodworking.

Burr #305

The most common version is one in which piece #1 with no notches is the key piece. Some authors assume that it is the only version. Only 158 are of that type. Of the other 156, most have two notched pieces which come out together as a key pair, and a few slide apart in halves. These latter are clearly the most intriguing. If we eliminate all those which use two or more like pieces, which use symmetrical pieces, which have more than one solution, or come apart in ways other than just in two halves, we find there is only one burr (and its mirror image) which satisfies all these requirements. It is Burr #305 in Cutler's list. It uses pieces 6, 12, 14, 21, 22, and 23. Most persons will not find it especially easy. I think it is my favorite of all burrs.

Unnotchable Burrs

Cutler next investigated solid six-piece burrs using any kinds of pieces, notchable or otherwise. He found there were 369 usable pieces, and they go together 119,979 different ways! It is possible that a process of elimination like that described for Burr #305 might lead to some interesting combinations in this lot, but I am not aware of anyone having attempted it.

Higher Level Burrs

All of the 119,979 burrs discussed thus far are known as level 1, meaning that in the first step of disassembly, one or more pieces slide straight out. All solid burrs must be of this type if they are ever to come apart at all.

You may wonder what is so special about burrs with no internal voids. No one really seems to have an answer. There may be some subtle aesthetic symbolism involved here in being solid and complete. For puzzle analysts before the computer age, limiting their analysis to solid burrs certainly made the job more manageable. One author has stated that burrs with voids tend to rattle and fall apart. I have not found that to be the case at all. On the contrary, I find the ones with sliding key piece #1 to be the least satisfactory in that regard because there is nothing to seat the key piece in place.

Burrs with voids can be much more complicated, interesting, and challenging than those without. In particular, the first step of disassembly may involve the shifting back and forth of one or more pieces within the assembly before the first piece or group of pieces is released. Cutler uses the term "level" to count the number of shifts required. Curiously, there seems to have been no published information on burrs of this type or their manufacture until quite recently.

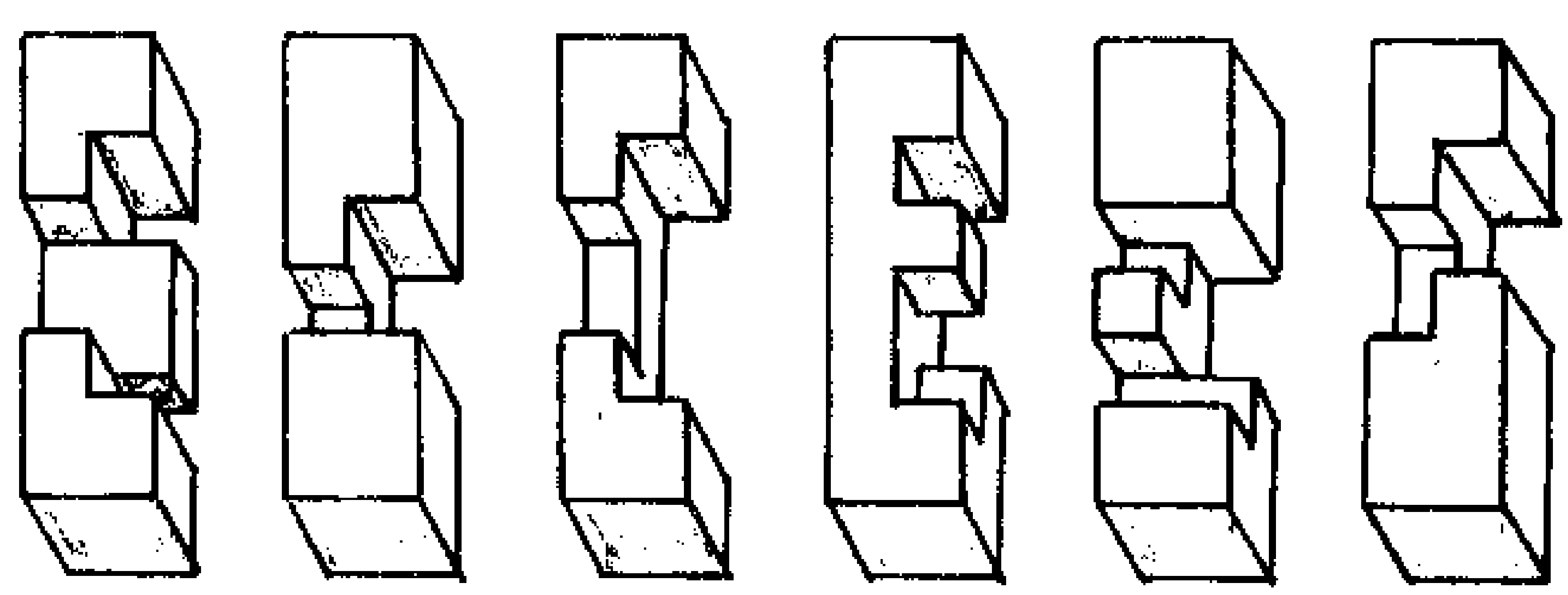
My design No. 36, "Coffin's Improved Burr," (1979) is Level 2-3, meaning that the first piece is removed with two shifts, and three more shifts are required to release the next piece.

My design No. 40, "Interrupted Slide," (1979) has two solutions, one of which is Level 3-2-2, and the second is a separation into two halves with Level 3.

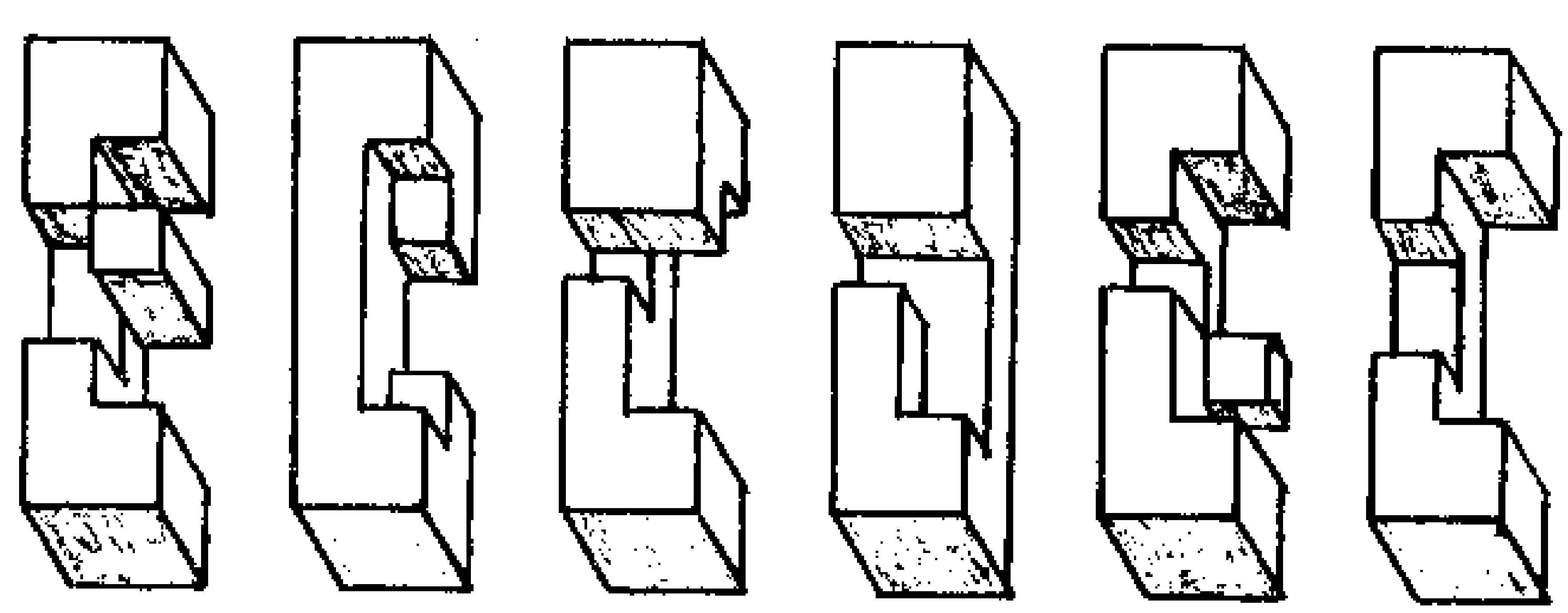
Bill Cutler recently discovered a superb new burr design of Level 5 which he calls "Bill's Baffling Burr."

Just as this goes to press, an extremely clever new burr design from Israel has come to my attention, of Level 7-4. I expect someone is now hard at work looking for a Level 8 design. It is hard to say where this will lead, except that we can expect many more really clever designs, probably even more baffling and entertaining than those listed here.

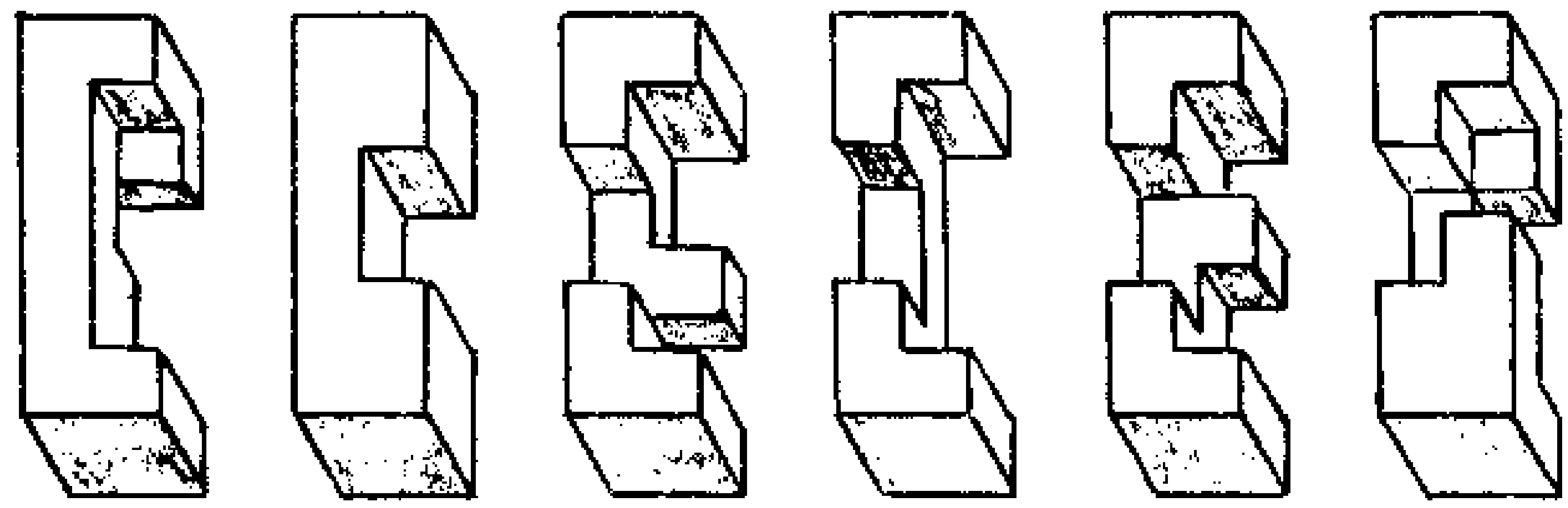
COFFIN'S IMPROVED BURR



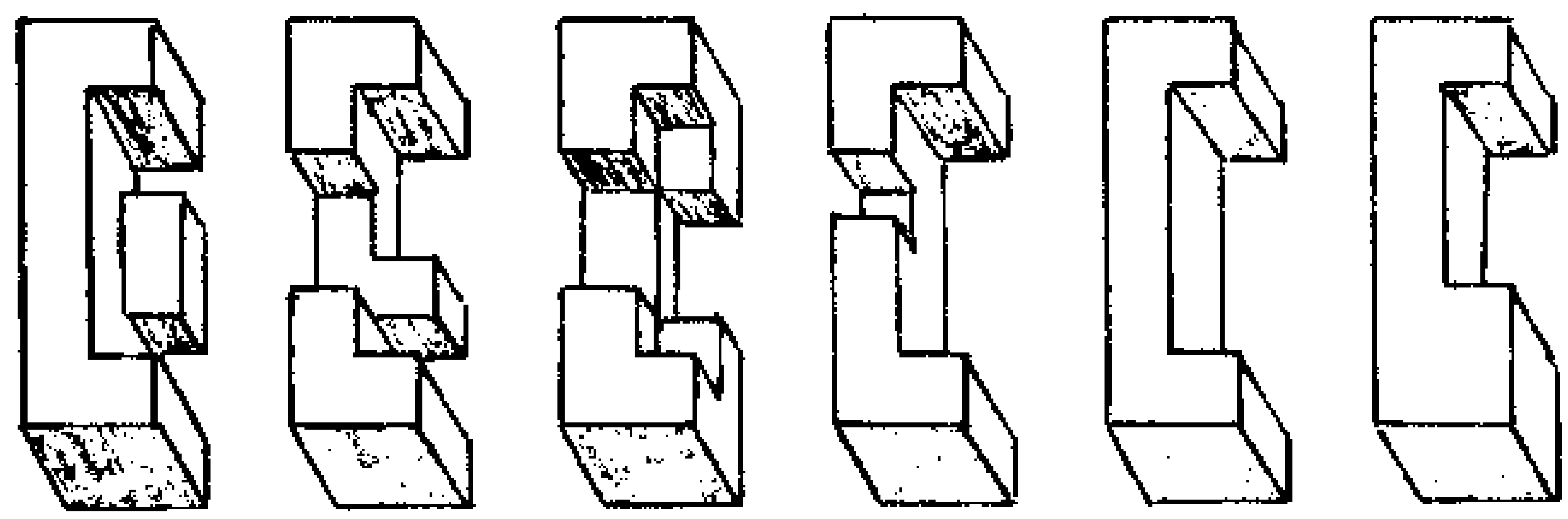
INTERRUPTED SLIDE



BILL'S BAFFLING BURR



ISRAELI BURR



On page 33, we stated that the sticks could be any arbitrary length not less than three times the width. We will now qualify that statement. If you scale the drawings above, you will find that the sticks are slightly shorter than the others shown. They are exactly three times the width. This is important. If they are any longer, the puzzle <u>cannot be assembled</u>. With most burrs, including "Coffin's Improved," the length does not matter. The "Interrupted Slide" is an interesting case - with the length shown, only one solution is possible, but if the sticks are shortened to three times the width, the second solution (3-2-2) becomes possible.

Persons interested in making burrs for sale please note that the two shown above may be proprietary. In this section, I have avoided using the word "invent" for this reason: Given the rules, there are only a finite number of possible six-piece burrs. Cutler's computer program has already discovered all 119,979 of the solid ones, and the ones with voids will probably also be calculated sometime. The puzzle designer's task then becomes simply a matter of selection. Does that qualify as invention? I don't know the answer. (There is an interesting analogy here in the discrete notation system commonly used in musical composition.)

<u>The Difficulty Index As It Applies To Burrs</u>

On page 23, we introduced the idea of a "difficulty index." Let's see how it applies to burrs. Think of the six positions of the pieces in the assembled burr as being: bottom, top, left, right, back, and front. Select any piece at random for the bottom. For the back piece, you have a choice of five, assuming they are all dissimilar. Any piece can go either end to, so unless the piece is symmetrical, you have a total of ten choices to try. Then eight, six, four, and two. Total - 3840 choices. If there is only one solution, then the difficulty index is 3840. Identical pieces, symmetrical pieces, and multiple solutions all decrease the difficulty index. Usually you can tell which side of the piece should face the center of the puzzle, but there are exceptions, and these delightful pieces are known as the "ambiguous" pieces." Notchable piece #7 is one example. They increase the difficulty index. The difficulty index idea works pretty well for the simple burrs such as the 314 notchable ones. For the more complicated ones like those above, it does not work because it does not take into account the really tricky business of getting all the pieces together.

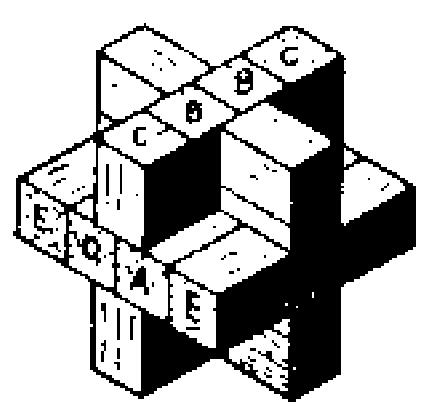
Variations on the Standard Six-Piece Burr

We mentioned some of these in the section on patents - those with tapered pieces or rectangular sticks, non-integral notching, rotating keys, hidden pins, etc. They all lack the simple elegance of the standard version, and we will not waste space on them here. Let's hope someone had fun dreaming them up.

More Complicated Burrs

Several of these were mentioned under "patents." The Wyatt and the van Delft & Botermans books contain a good selection. Several puzzle companies make and sell them, including Johnson Smith, Pentangle, and Ray Rylander. Bill Cutler (1020 Augusta Ave., Wausau, WI 54401) designs very complicated ones and produces a few for sale, as do probably many other part-time home workshop operations.

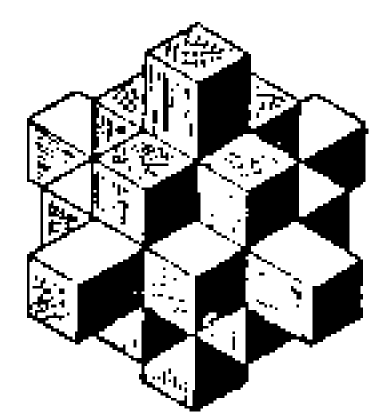
The illustrations below, which are quite representative of the type of puzzle we are talking about here, are taken directly from Rylander's brochure:



THE CROSSBURR

12 Pieces

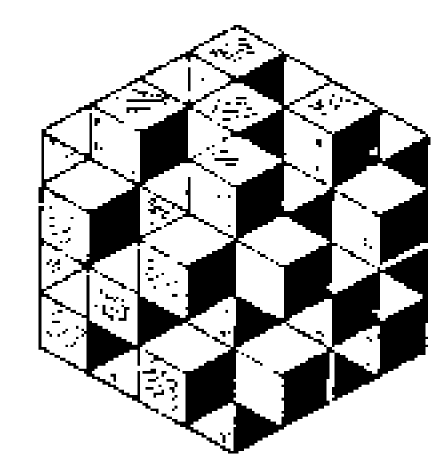
An expanded variation of the 6-piece Burr.



THE MINISTAR

9 Pieces

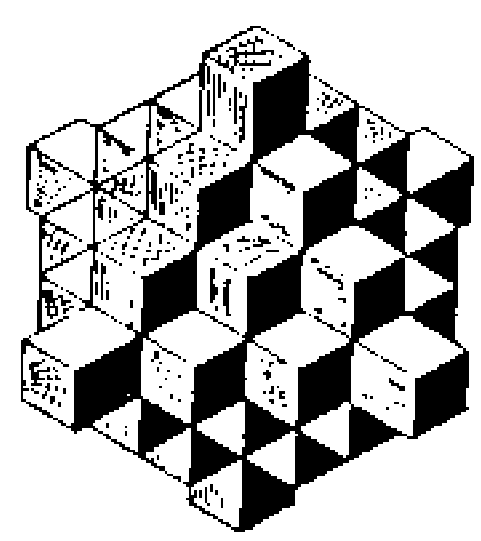
A simplified version of the Star.



THE POLYCROSS

15 Pieces

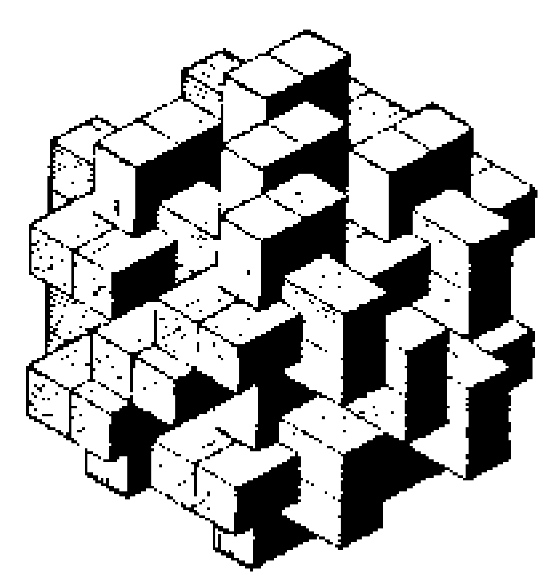
That's a simple 3-piece Cross in each corner.



THE STAR

"But it had to grow thataway!"

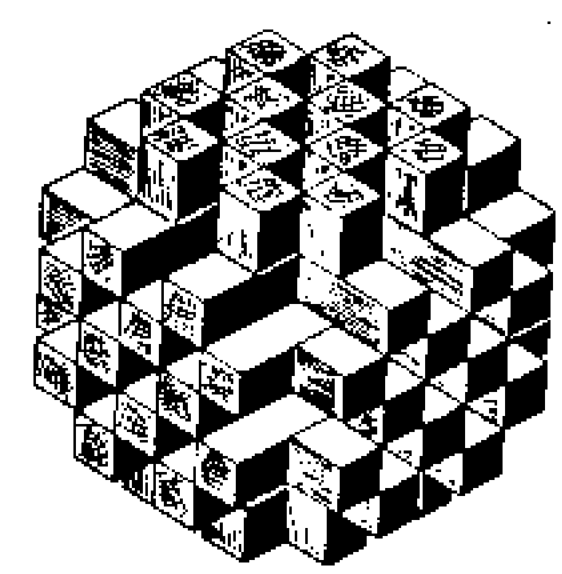
Comes in both 15 and 19 piece versions.



THE POLYBURR

In both 24 and 30 piece versions.

Note the simple 6-piece Burr in each corner.

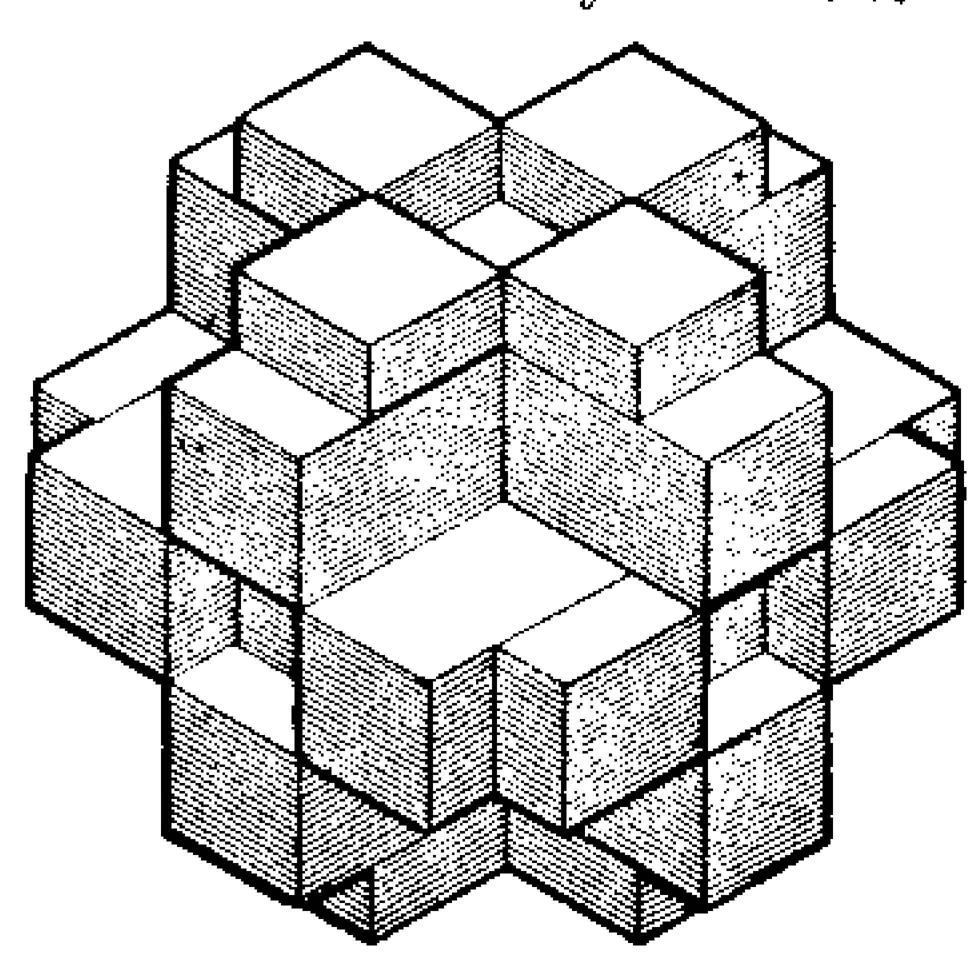


THE 36 - PIECER

"Holy Jeehosiphat!!!"

Good directions for making most of these will be found in the Wyatt book.

The Altekruse Puzzle



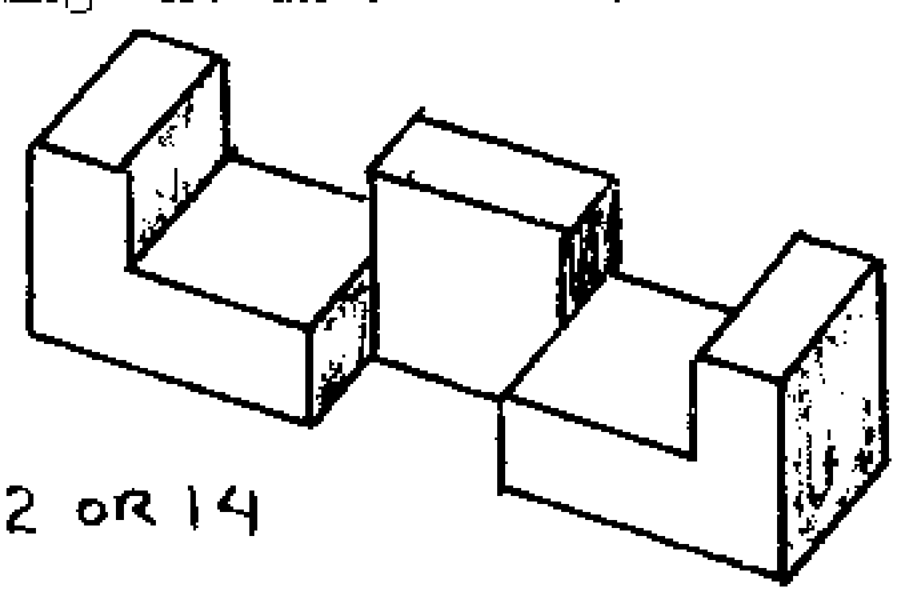
Of the prolific family of larger burrs, Puzzle Craft will be concerned only with the unusual Altekruse Puzzle and its many variations. This puzzle was patented by W. Altekruse in 1890. Its origin is unknown. Since the name means "old cross" in German, you wonder, but apparently it was just coincidence. The Altekruse family is of Austrian-German origin. William Altekruse came to America in 1844 as a young man to avoid being drafted into the German Army, but whether he was the grantee of the patent, or perhaps his son, is unknown.

The puzzle has several unusual features: All twelve pieces are identical. The mechanical action of the solution is quite unlike any of the other common burrs, and can be quite confusing to the unknowing. There are three different solutions, depending on whether this action can occur along one, two, or all three axes. (If minor variations of the first two are counted, there are a total of six distinctly different solutions.) When Altekruse drew up the patent, apparently he was aware of only the simplest one-axis solution.

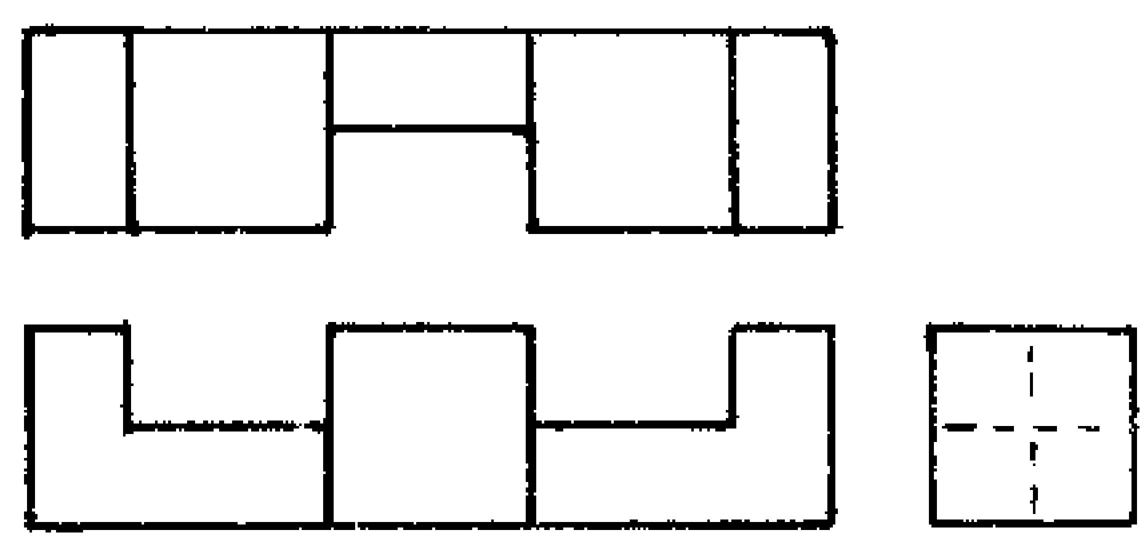
I used to make this puzzle in three contrasting fancy woods, one wood for each axis. Once when exhibiting at a craft show, I watched with considerable interest as a young girl named Marjorie Hoffman was amusing herself at my booth by trying to put one together in a strange new configuration. Later I completed it and found to my surprise that it required fourteen pieces rather than twelve.

The puzzle is easy to make. Start with 12 or 14 square sticks of any length, but not less than four times the width. Like practically all proper burrs, the depth of the notches is exactly to the center. The notches are twice as wide as they are deep, so if you are using the same notching tool that you used for the six-piece burr, you will have to make two notches side-by-side, or else halve the depth and use half-sized sticks. Or use another notching tool twice as wide. Directions will be found in the books already mentioned, and also the Meras book. Helpful hints will be found in the section on woodworking.

The drawing below is on quadrille paper, so exactly half scale if you are using one-inch stock.

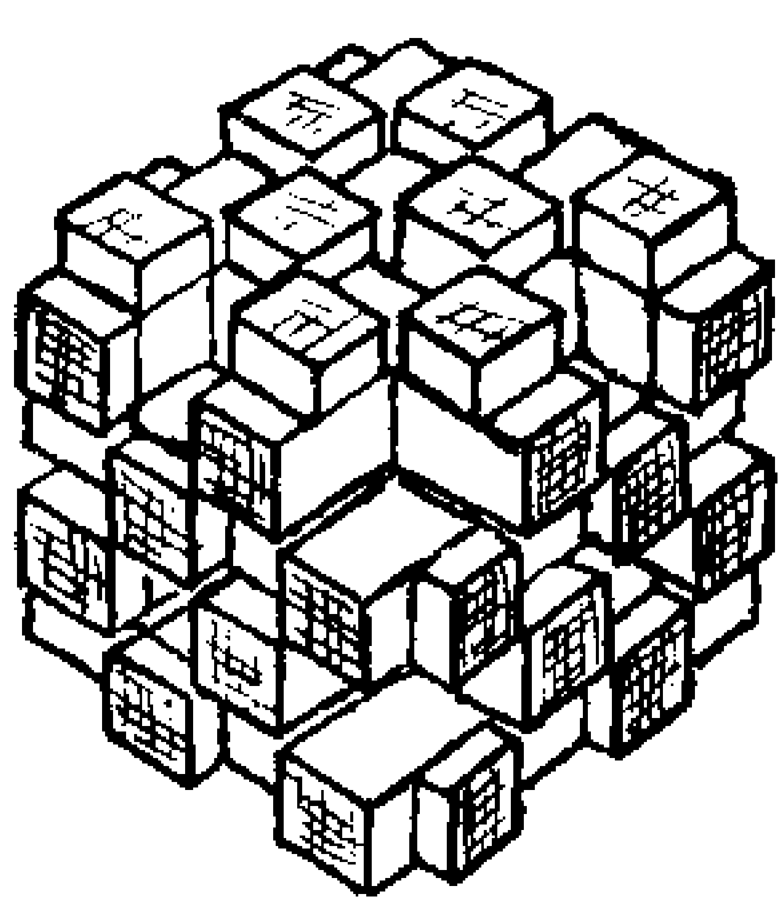


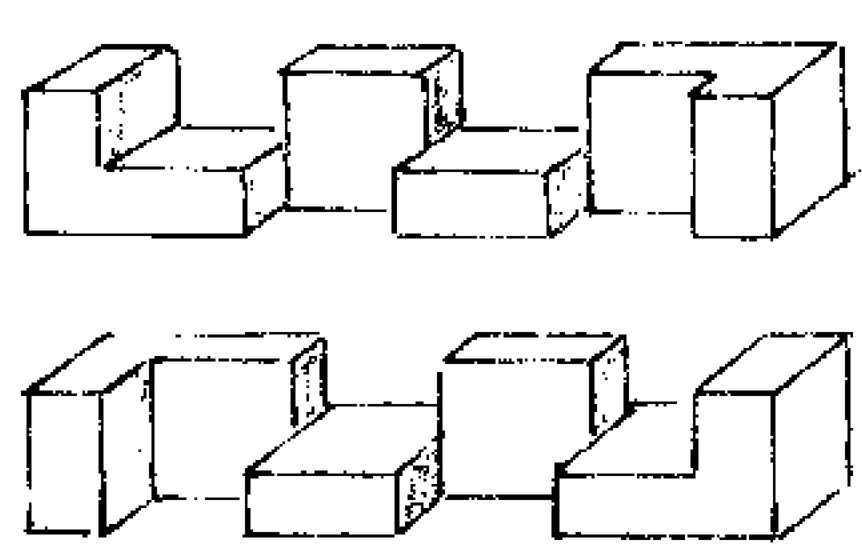
12 OR 14



Variations of Altekruse

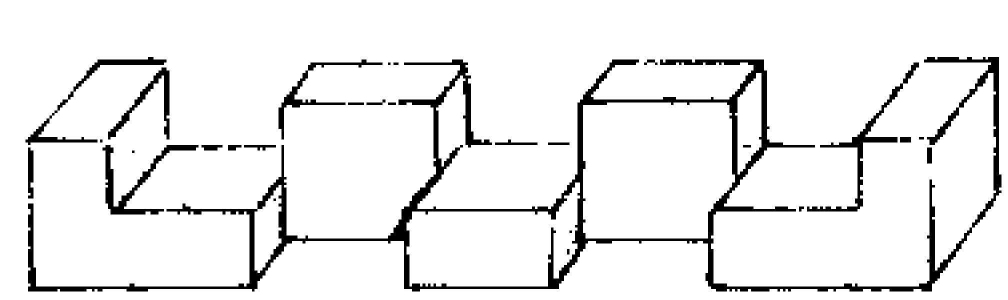
The Altekruse puzzle has spawned a large family of closely related designs. If we think of it as having somewhat the form of a 3x3x3 array, there is a 4x4x4 version having 24 pieces - 12 right-handed and 12 left-handed (below). There is a 5x5x5 version of 36 or 38 pieces, and so on, (the 36-piece version is one of Rylander's, preceding page). There are rectangular versions in even greater number.





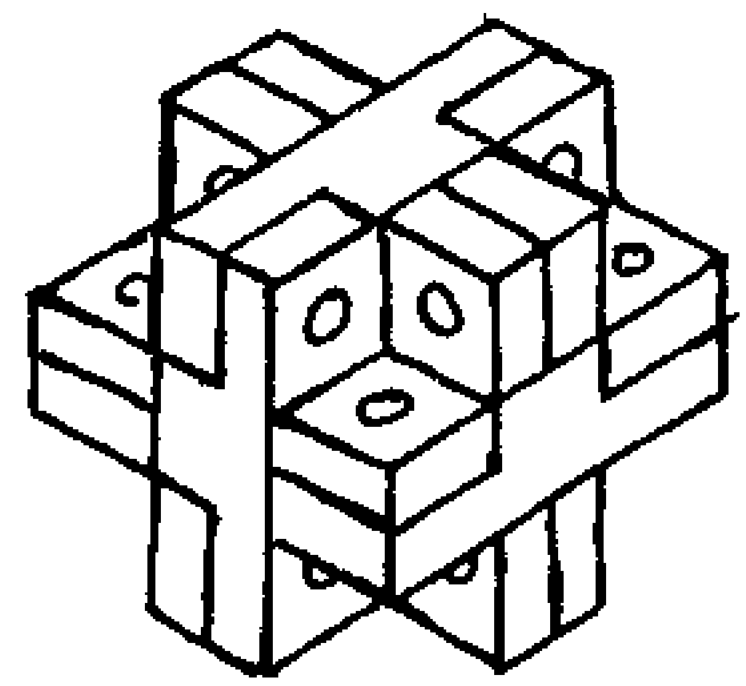
12
+
12

36 OR 38

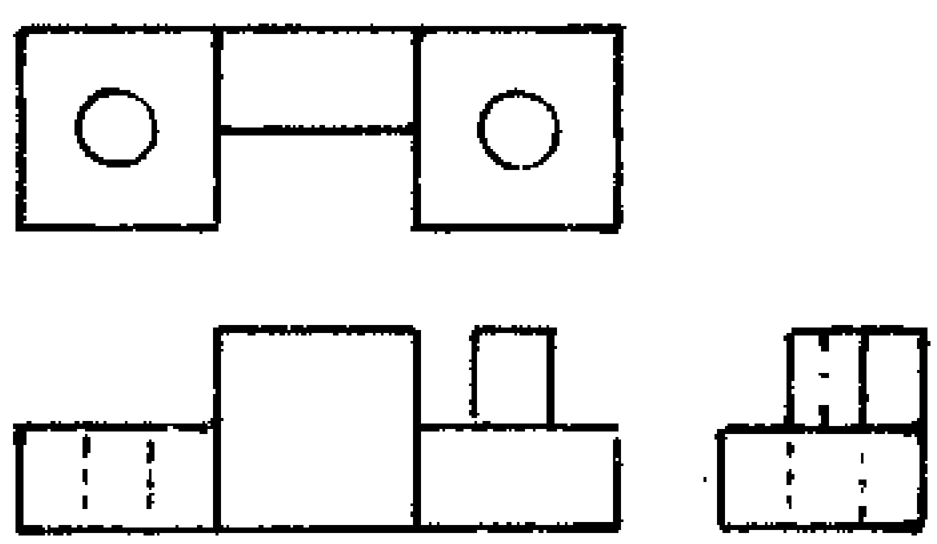


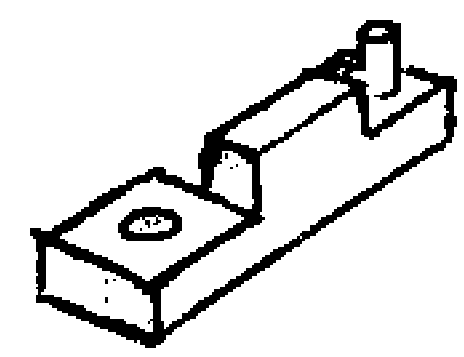
Frantix

Another interesting variation of the Altekruse puzzle has pins and holes instead of notches. A poorly made plastic version of this was for a while made by 3M, and later Avalon Hill, with the name of "Frantix." A better made wooden version is shown on the cover of Puzzle Craft. The wooden version has extra pins and holes in the center to make it more interesting. It is made of one-inch square stock, the dowels are 7/16-inch, and the holes are 15/32-inch. The holes must be centered accurately for a good fit. This puzzle has the unusual property of extended construction in all directions if you have a large enough supply of pieces.



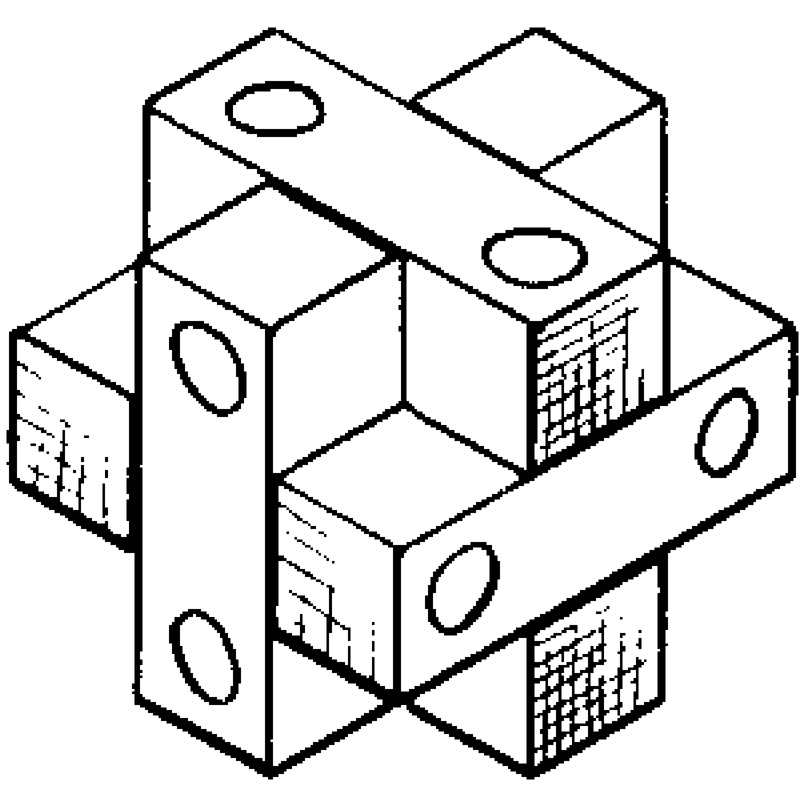
6 right-handed and
6 left-handed pieces
required - i.e. with
pin and hole reversed





The PIN-HOLE Puzzle

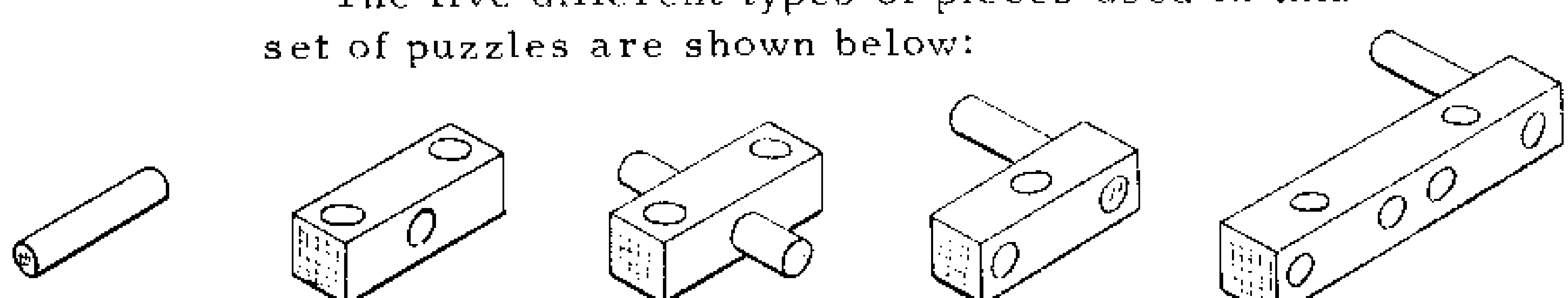
This simple puzzle is best explained by reproducing part of the instruction booklet which came with it. I made them of one-inch square cherry with 7/16-inch dowels and 15/32-inch holes. The pins were anchored with a brad.



The PIN-HOLE Puzzle

Copyright 1976
S. T. Coffin

The five different types of pieces used in this set of puzzles are shown below:



PIN BAR CROSS ELBOW LINK

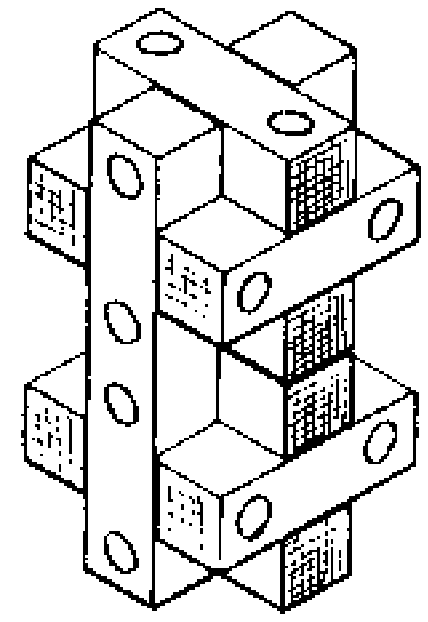
The BASIC puzzle (illustrated on the cover) consists of: 1 PIN, 1 BAR, 2 CROSSES, and 3 ELBOWS.

The first step of disassembly is to remove the locking pin. The six remaining pieces then come out one by one. There is only one solution, and it is rated moderately easy.

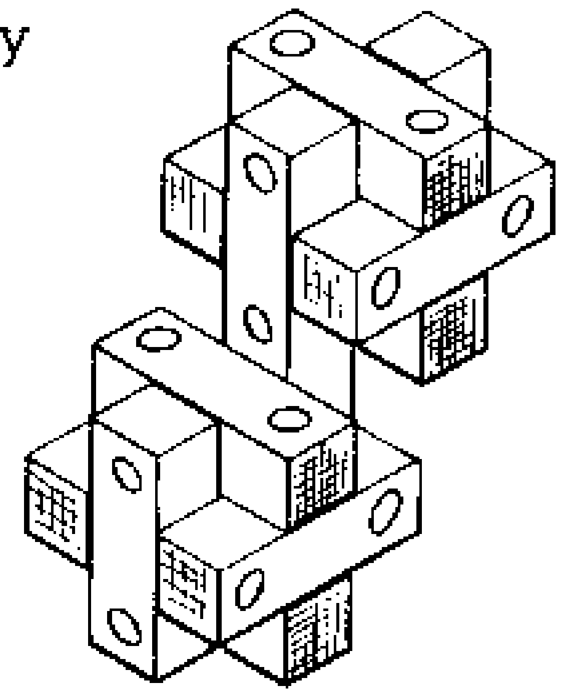
All of the more advanced problems are made up essentially of two or more of these basic modules joined together.

Next in order of difficulty are the DOUBLE and the OFFSET PAIR. They each require: 2 PINS, 1 BAR, 4 CROSSES, 5 ELBOWS, and 1 LINK. The DOUBLE has several slightly different solutions.

There is an alternate version of the DOUBLE which requires: 2 PINS, 4 CROSSES, 4 ELBOWS, and 2 LINKS.



DOUBLE

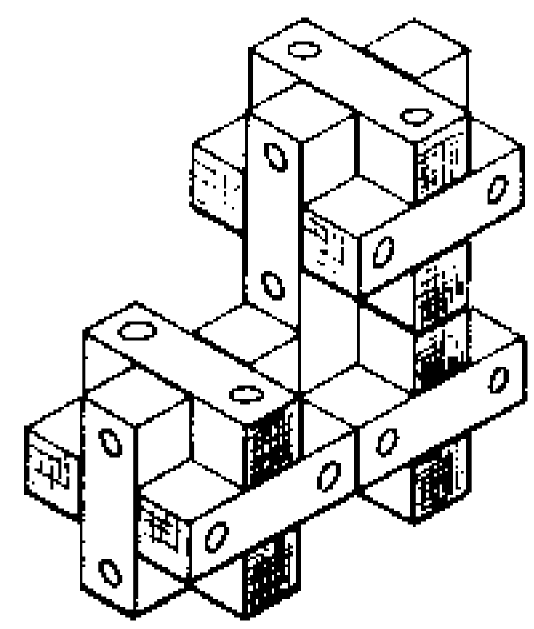


OFFSET PAIR

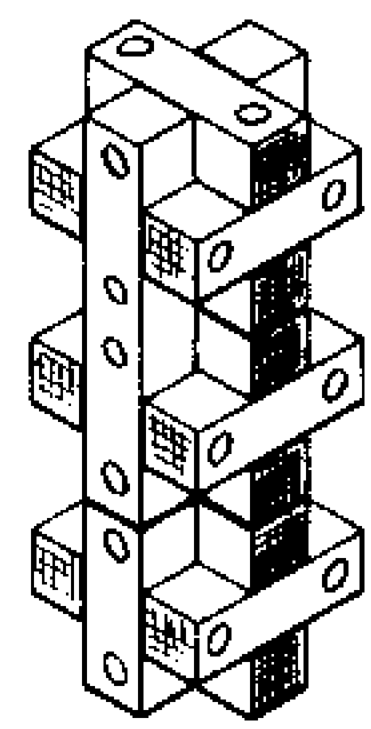
The TRIPLE and the RIGHT ANGLE are more difficult. They each require: 3 PINS, 1 BAR, 6 CROSSES, 7 ELBOWS, and 2 LINKS.

There is basically only one solution to the TRIPLE. Once discovered, the same principle can be used to add on more sections without limit. Each new section will require: 1 PIN, 2 CROSSES, 2 ELBOWS, and 1 LINK.

The RIGHT ANGLE has basically one solution with several minor variations.



RIGHT ANGLE

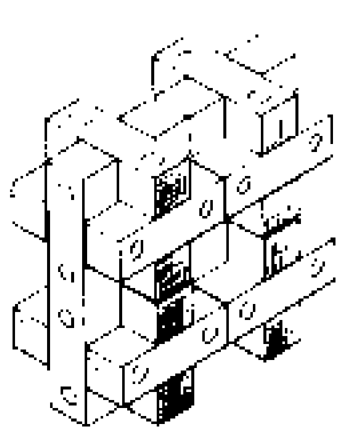


TRIPLE

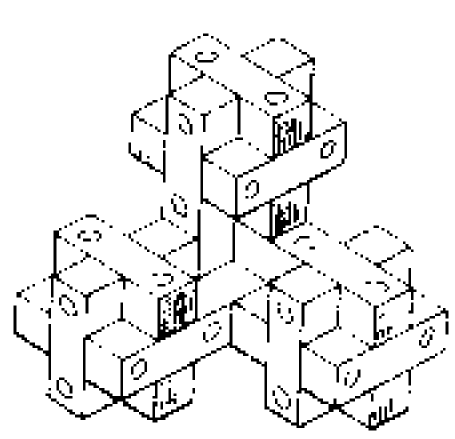
There is an alternate and more difficult version of the RIGHT ANGLE which uses: 3 PINS, 6 CROSSES, 6 ELBOWS, and 3 LINKS.

All of these shapes are made with the SQUARE set, consisting of: 4 PINS, 1 BAR, 8 CROSSES, 9 ELBOWS, and 3 LINKS.

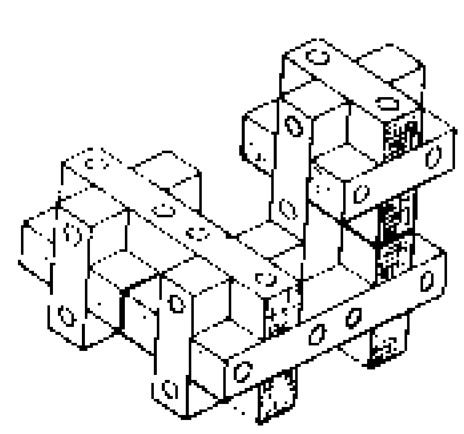
There are alternate and more difficult versions of all these which require: 4 PINS, 8 CROSSES, 8 ELBOWS, and 4 LINKS. The required extra LINK is included with each set.



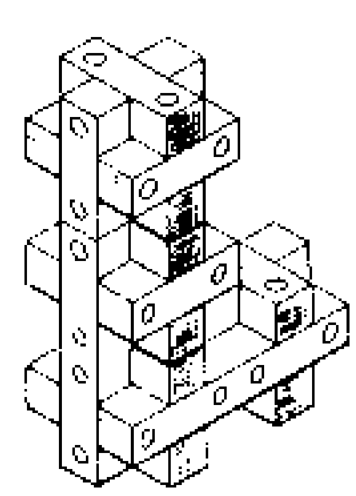
SQUARE



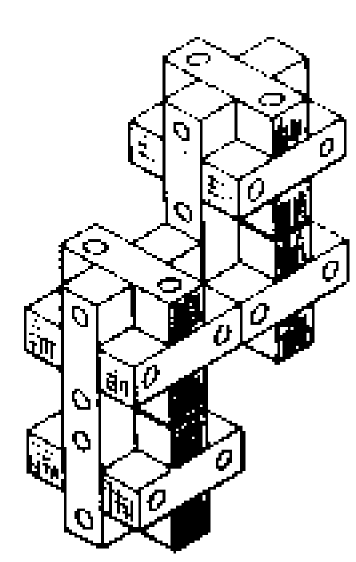
CORNER



TWIST



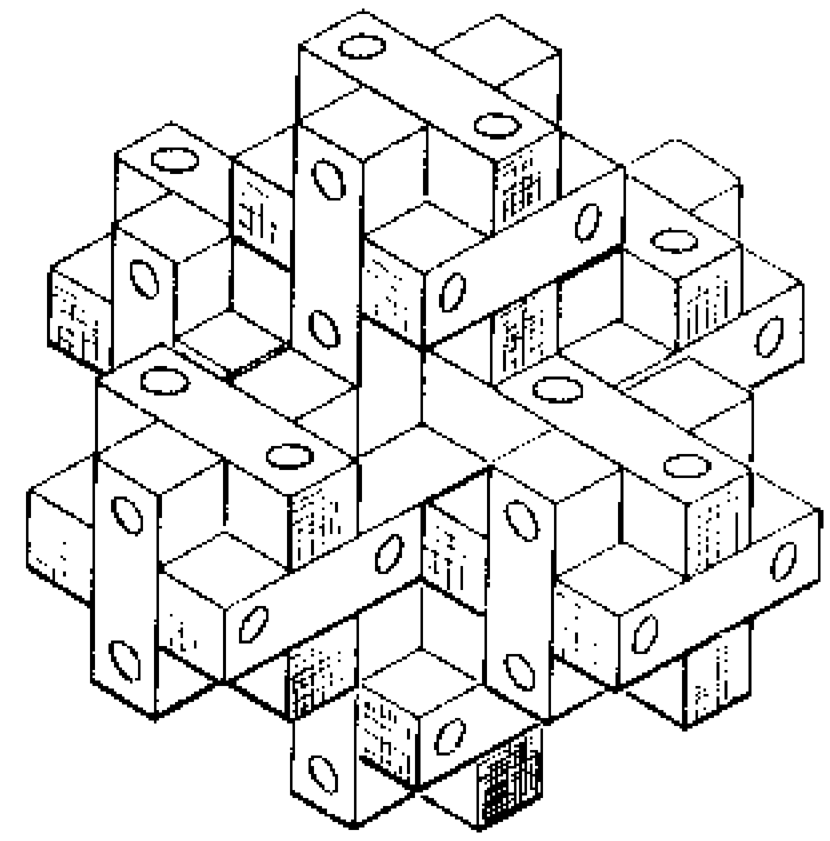
ELL



ZIGZAG

(And so on... up to the GRAND CROSS!)

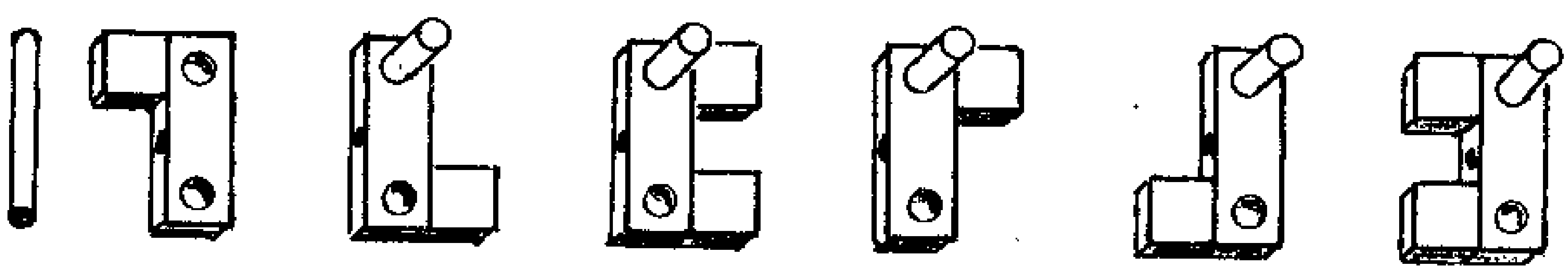
The seven-module GRAND CROSS requires: 7 PINS, 1 BAR 12 CROSSES, 17 ELBOWS, and 6 LINKS. It too has only one solution, and is difficult. Its shape is that of a jackstraw, i.e. a central cube, with one module attached to each of the six faces.

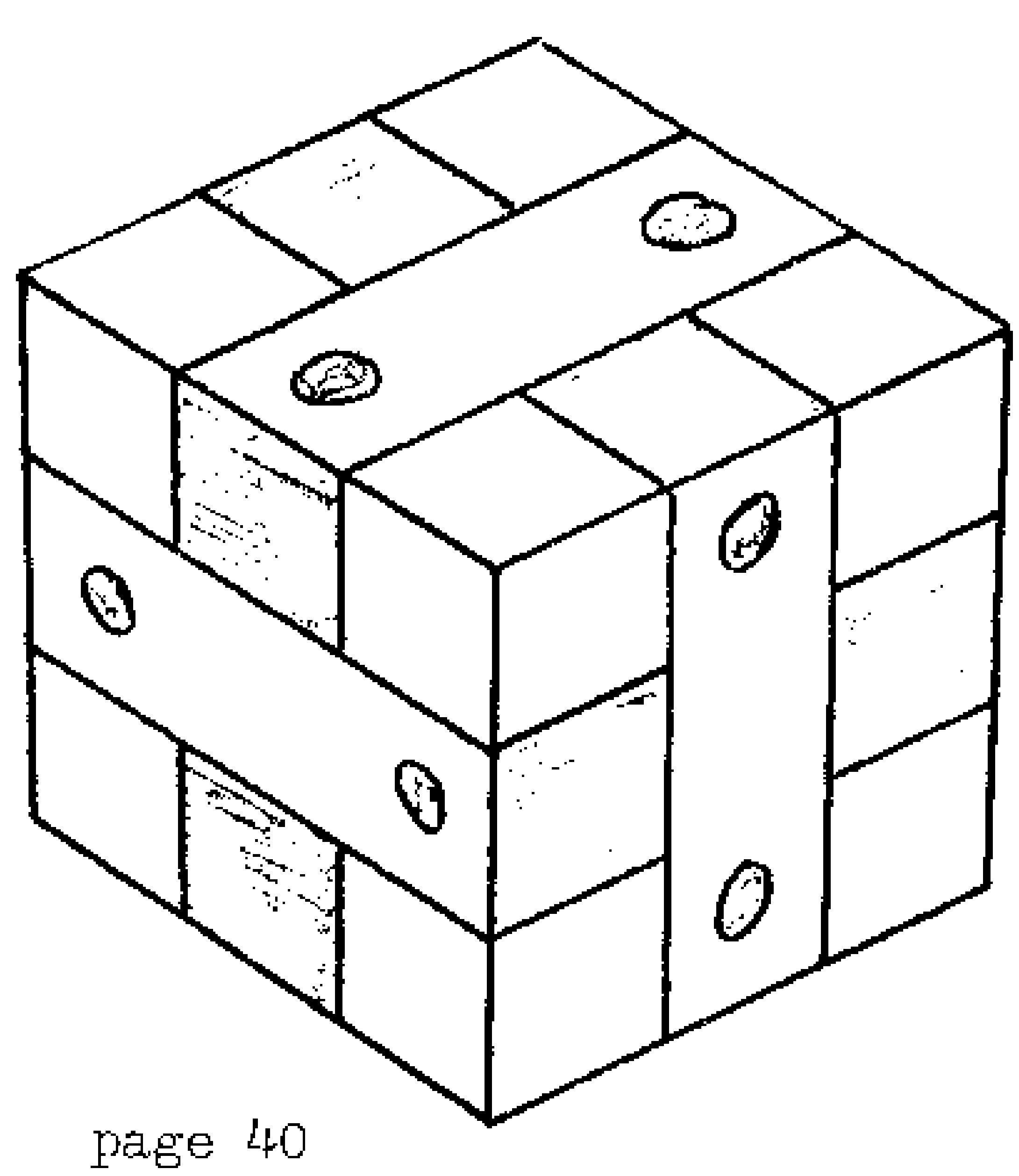


The Corner Block Puzzle

The Basic PIN-HOLE Puzzle is frankly not very challenging. It does have an interesting variation, however, known as the "Corner Block Puzzle." Start with a variation of the "Basic" made up of one PIN, one BAR, and five ELBOWS, (page 38), and glue cubic blocks in each of the eight vacant corners. Since each corner presents a choice of three faces to glue to, there are 3^8 or 6561 possible variations. The object was to find one which produced six dissimilar non-symmetrical puzzle pieces and only one solution. A laborious trial & error search extending over several years failed to produce the long sought combination, mostly because the solutions always seem to occur in pairs for some unknown reason. Finally, just recently a fairly satisfactory design was discovered which has essentially one solution with one minor variation. It is shown below. Further investigation of this interesting problem is encouraged.

The model shown on the cover is in zebrawood and purpleheart, a nice wood combination for this type of puzzle.





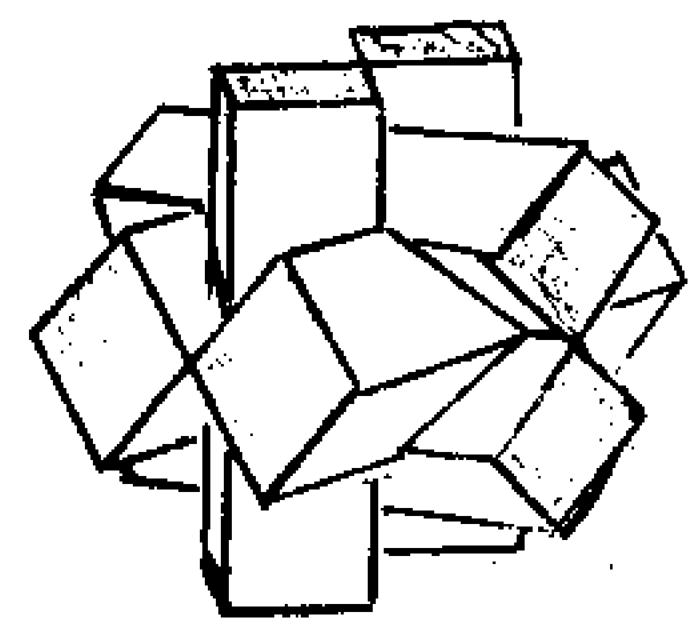
POLYHEDRAL PUZZLES

All of the solid puzzles discussed thus far have been made in the tradition of square stock and right-angle cuts. They are certainly the easiest to make, and the easiest to describe and illustrate for someone else to make.

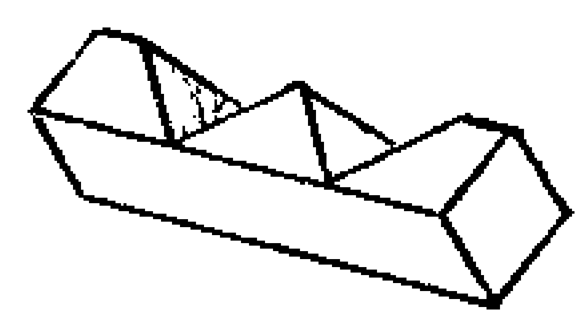
When I first became interested in puzzles as a business, around 1969, I decided to concentrate on new and original designs of my own (if there is such a thing). This led me to explore the fascinating new world of non-orthogonal (non-right-angle) spacial symmetries and interlocking solids. The timing was right, and from our first craft show at De Cordova Museum in 1970, it was apparent that the public (and our children) were as fascinated by it as I was. That was when we coined the term "Polyhedral Puzzles" and the slogan "AP-ART - the sculptural art that comes apart."

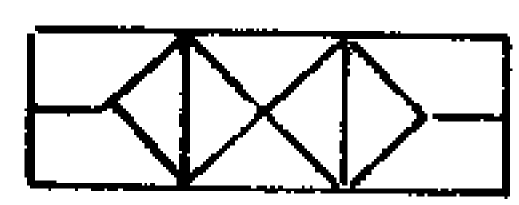
The Six-Piece Diagonal Burr

This is one of the oldest and most familiar puzzles of this type, and one of the simplest, so a good one to start with. Its origin is unknown. It was patented by Ford in 1905 (#779,121). It is apparent from the patent description that Ford was unaware of the usual simple assembly technique of mating two halves. The basic design was known in the late 1800's if not earlier. I have heard an unconfirmed rumor that it was known to the American Indians.



The puzzle consists of six identical diagonally notched square sticks of arbitrary length. The notches go exactly to the center. The puzzle is not as easy to make as you might think, for if the notches are the slightest bit too large, the puzzle rattles and falls apart. If the slightest bit too tight, it will be impossible to work in humid conditions. The notches can be whittled, routed, sawn by hand, or on a power saw using a jig.

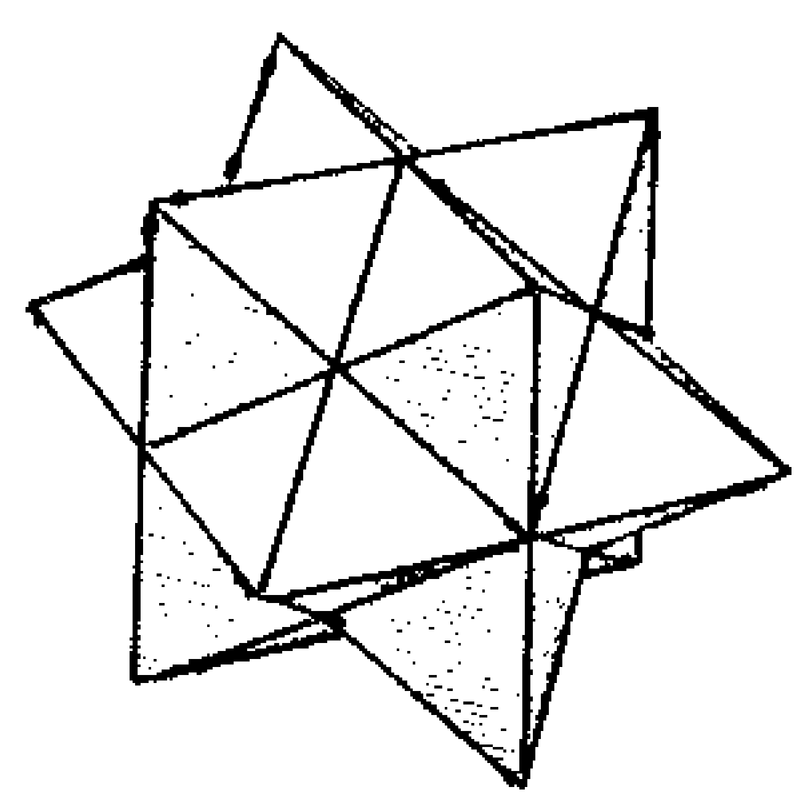




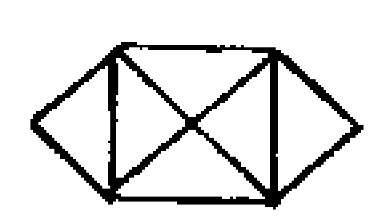
There are some simple variations, such as having one unnotched piece as a sliding key (or more properly pseudo-key), with extra notches in two other pieces, (see patents, page 7).

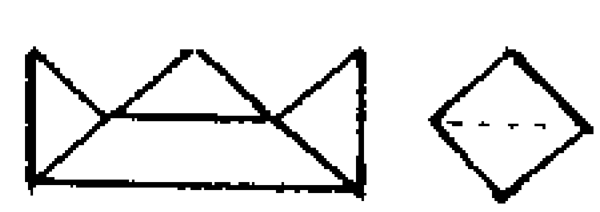
The STAR Puzzle

If the ends of the sticks in the above puzzle are beveled at 45 degrees, it is transformed into the intriguing first stellation of the rhombic dodecahedron. This version is even more familiar, and has been on the market for many years in both plastic and wooden versions, usually with the name "Star" or something like that.



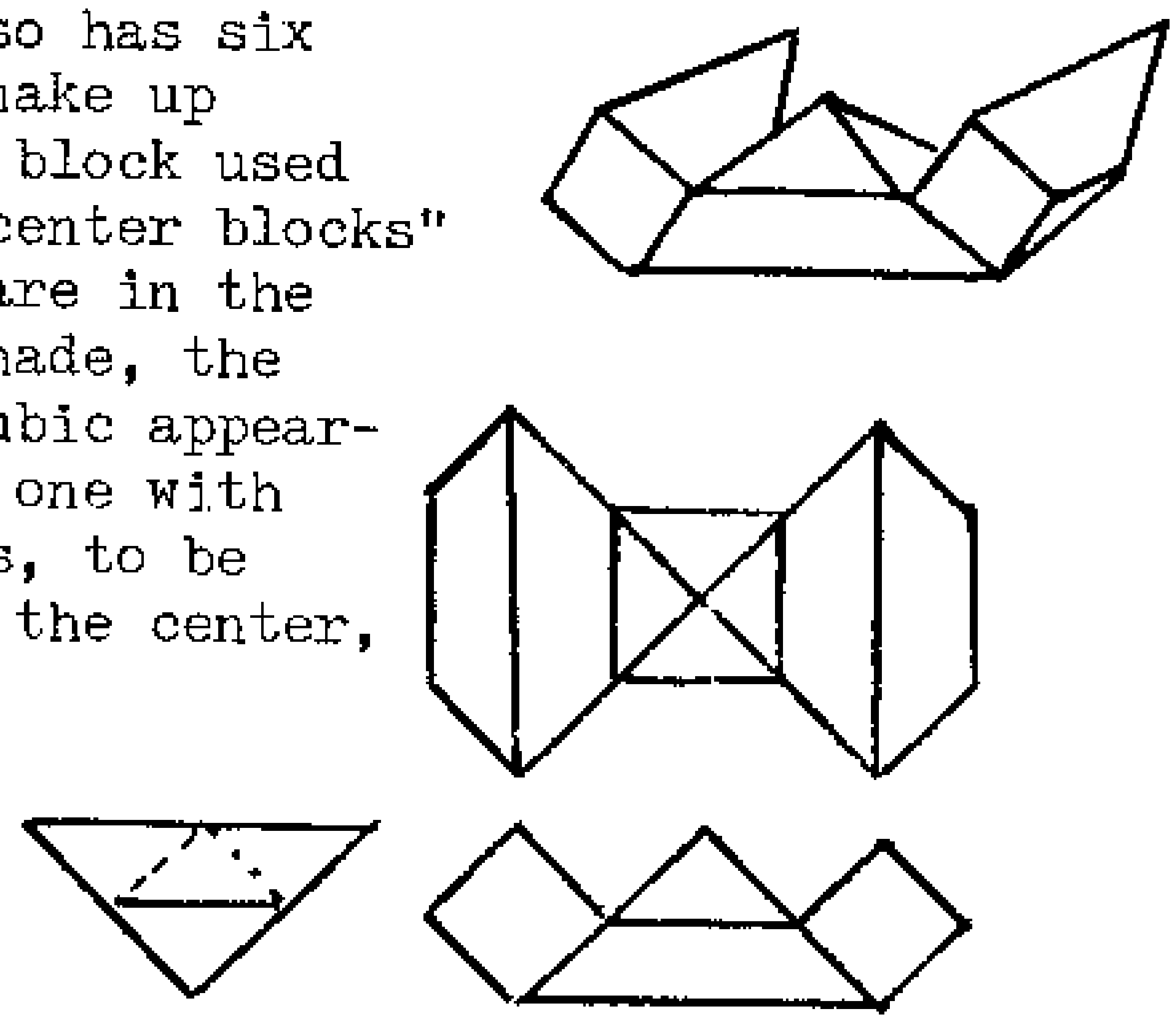
One disadvantage of the wooden version is that the sharp points on the ends of the pieces are across the grain and easily broken. One of my first "AP-ART" puzzles was a wooden version in which this problem was overcome by gluing up each piece of three blocks. It also used three contrasting woods, so the puzzle could be assembled two different ways with color symmetry. Directions for making it will be found in the section on woodworking.

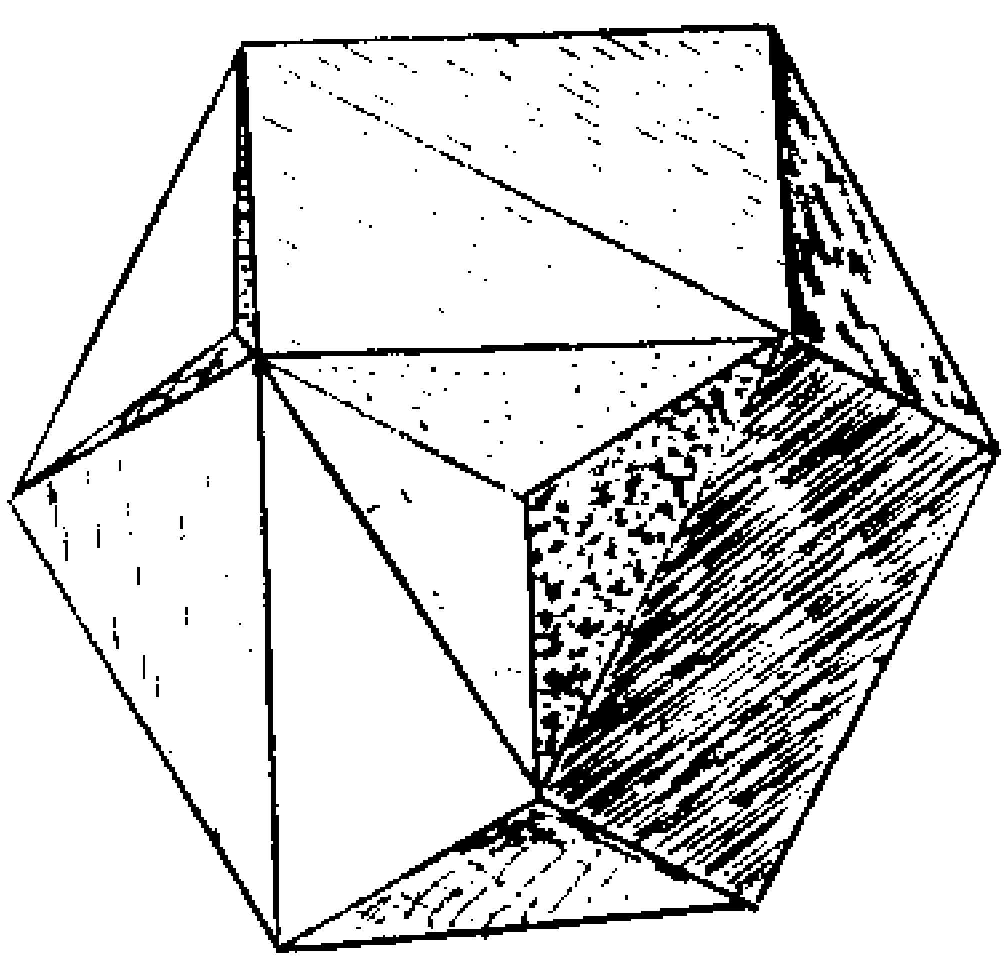


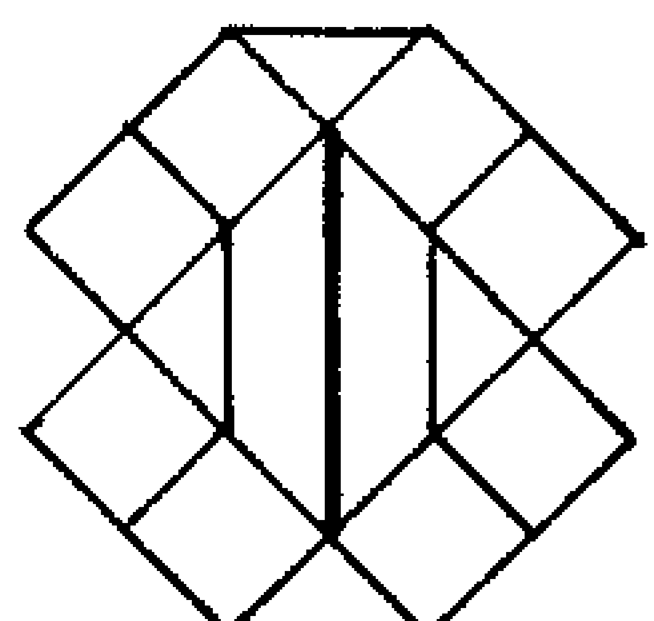


The Seven Woods Puzzle

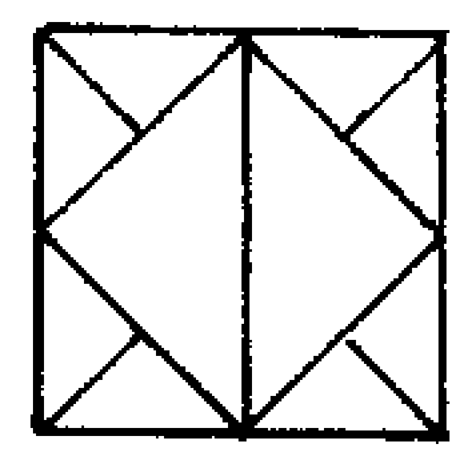
A simple puzzle similar to the STAR also has six identical pieces. The three blocks which make up each piece are all identical to the center block used in the STAR. These are called "six-sided center blocks" and directions for sawing and gluing them are in the woodworking section. After the puzzle is made, the six sides can be sawed down to give it a cubic appearance. One of my earliest puzzles was this one with six different woods used for the end blocks, to be matched in assembly, and a seventh wood in the center, hence the name "Seven Woods Puzzle."







before truncating



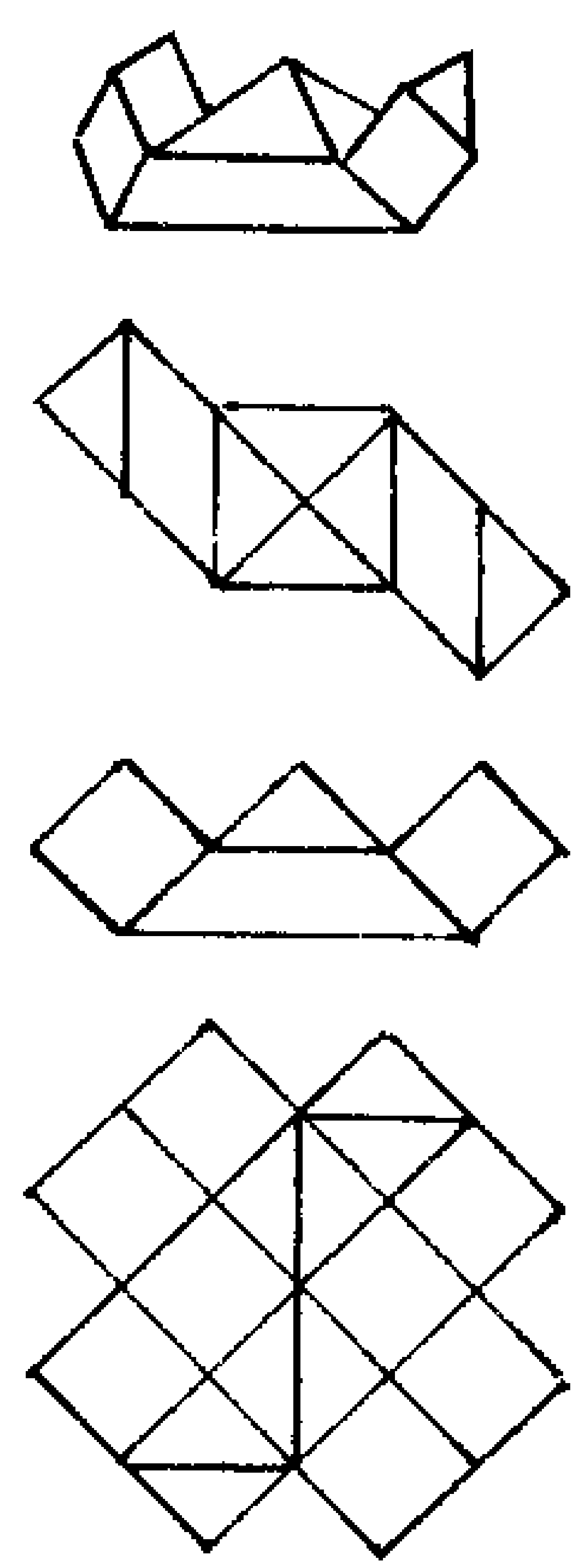
after

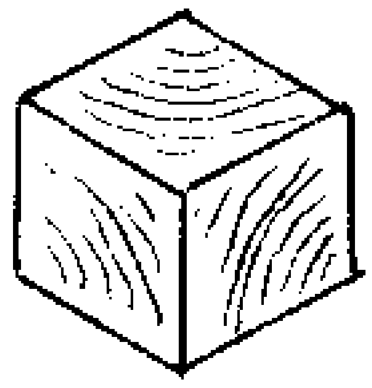
The Four Corners Puzzle

Once you get going in this business, one design just leads to the next. The Four Corners Puzzle is only a slight variation of the above. The six-sided center blocks are again used, but with a pair of end blocks called the "Four Corners end block." The woodworking section tells how to make them, and they are a lot easier to make than to describe.

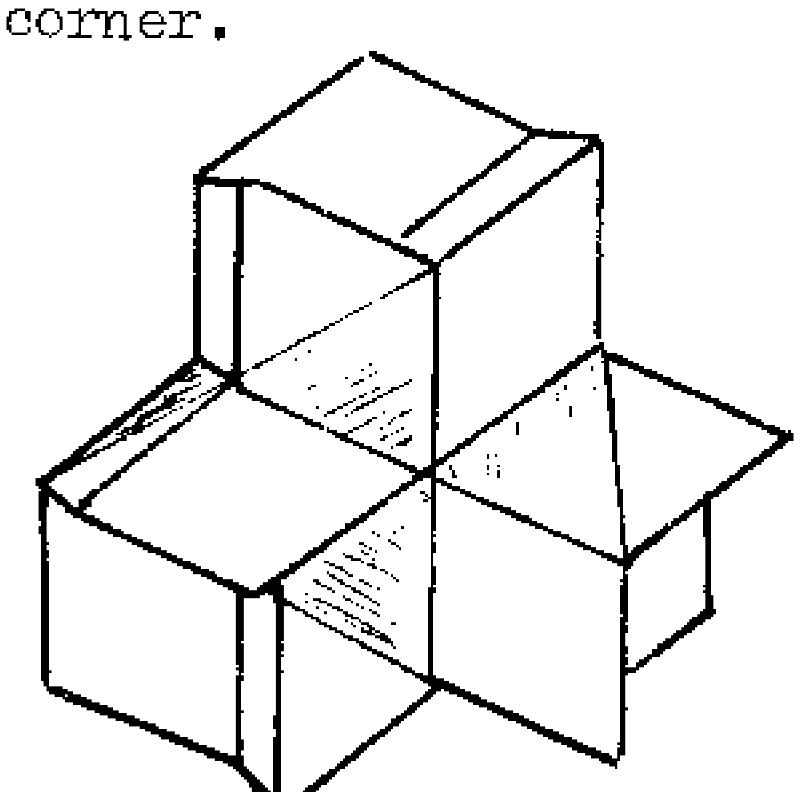
The six pieces of this puzzle are identical in shape, the assembled puzzle has tetrahedral symmetry, yet the final step of assembly is the mating of two quite dissimilar halves.

The puzzle is made in four contrasting woods, plus a fifth for the center. When assembled in the preferred way, each corner is one kind of wood. By taking a little extra trouble, symmetrical grain patterns will appear in each corner.





WOOD GRAIN

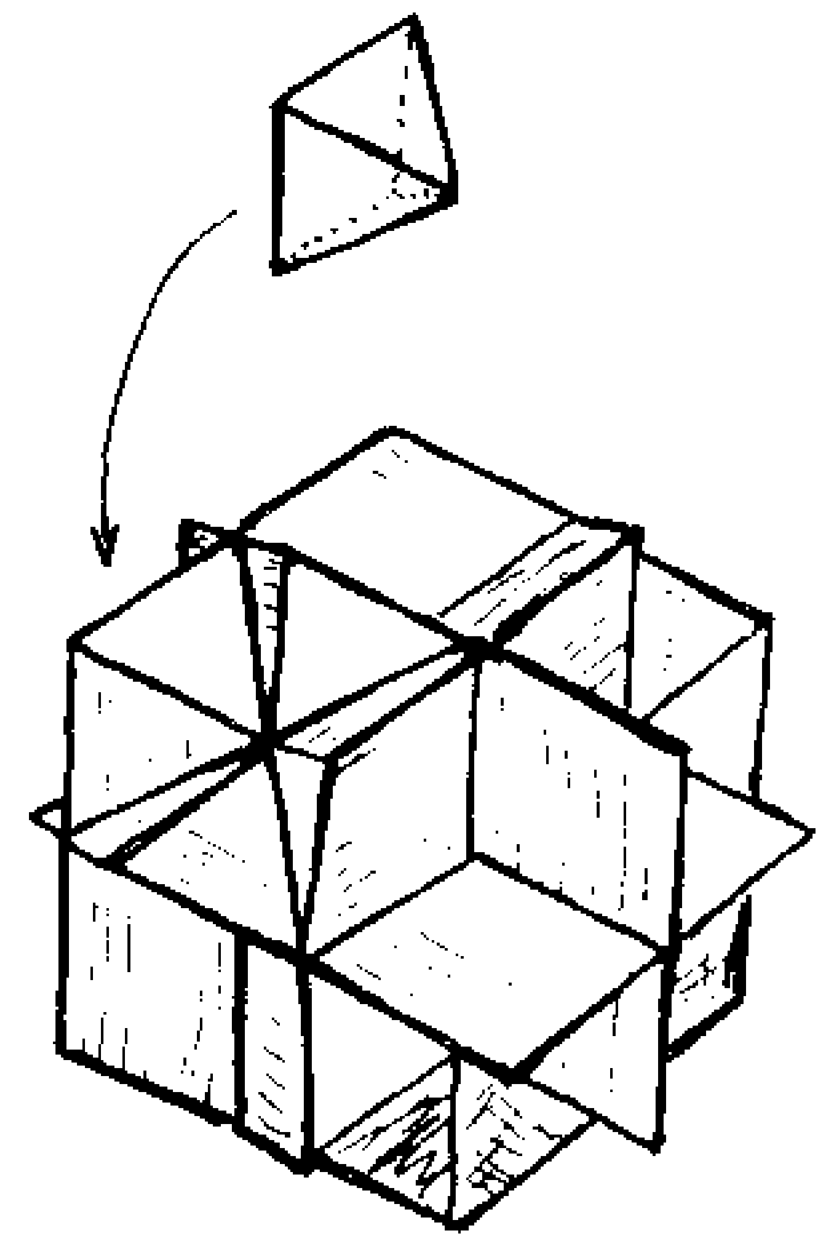


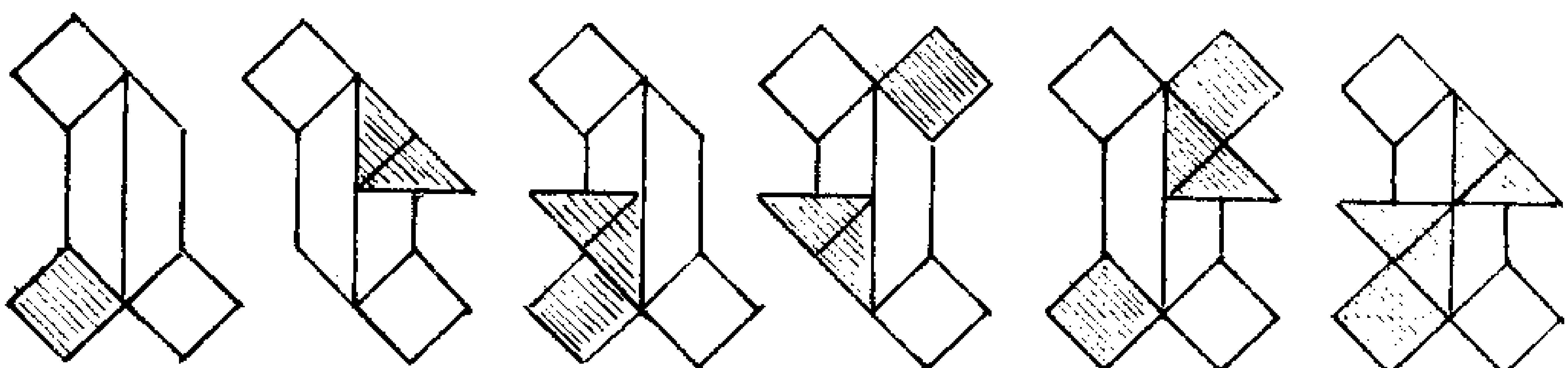
The Second Stellation Puzzle

Thus far we have described polyhedral puzzles in which all six pieces are identical in shape. These may be intriguing geometrically, but there is no way they can be very challenging as puzzles.

The Second Stellation is altogether more interesting. Start by making a Four Corners puzzle (preceding page) and twelve rhombic pyramidal blocks (woodworking section). With the Four Corners puzzle assembled, glue the twelve blocks around the outside to form the second stellation of the rhombic dodecahedron. For each block, you have a choice of two different surfaces to glue to. If you do it the one and only right way, no resulting puzzle piece will be symmetrical, and no two will be alike. The diagram below may help.

The puzzle has two solutions and is of medium difficulty. The one shown on the cover is Honduras mahogany.



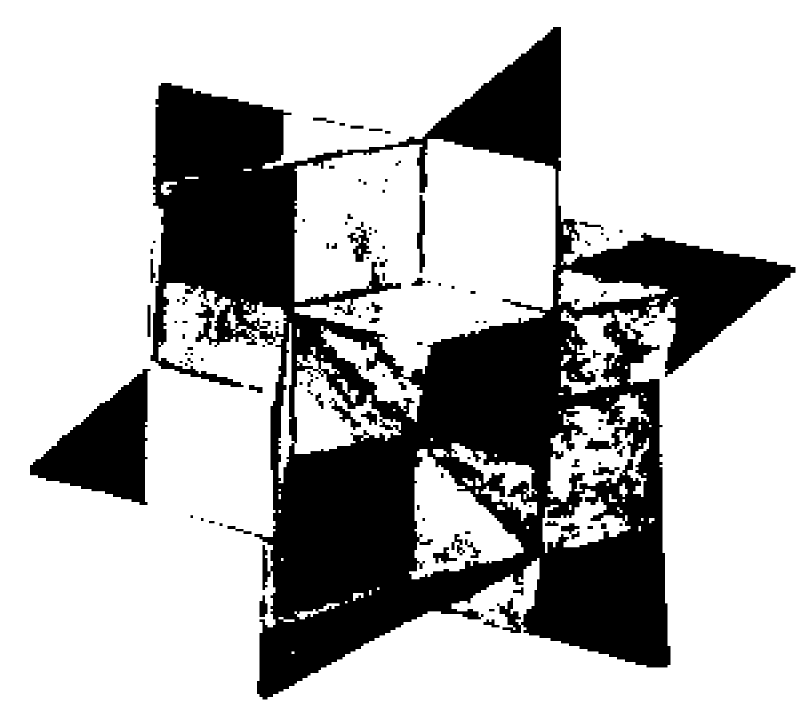


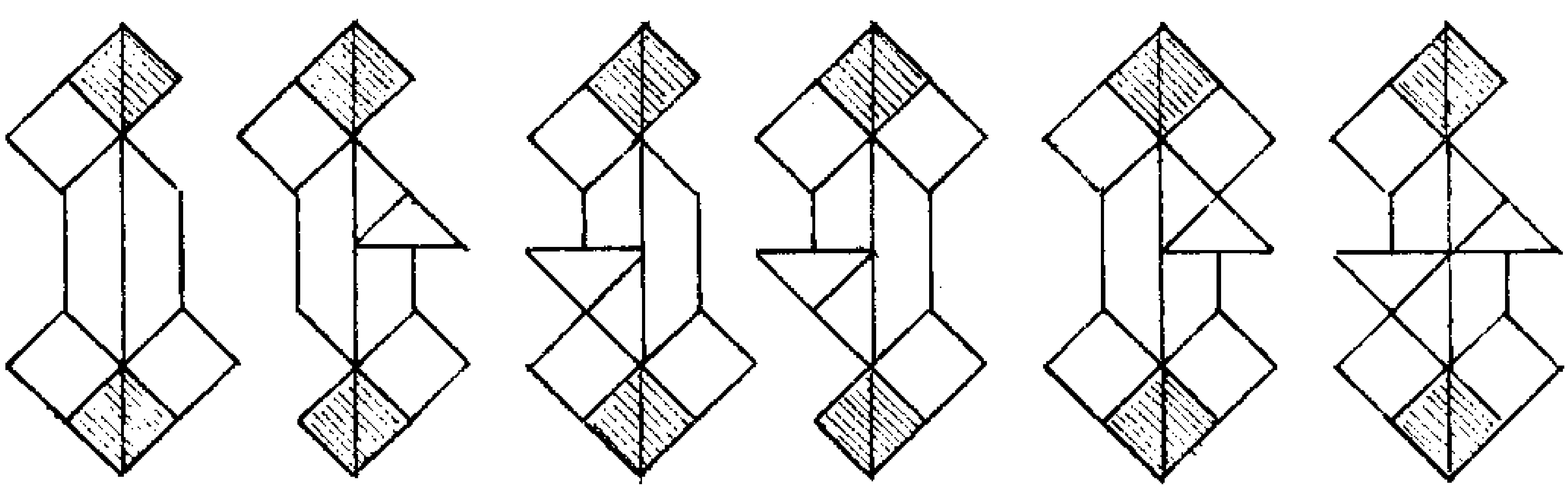
the twelve added blocks are shaded

The Twelve Point Puzzle

The Twelve Point puzzle is easily made by adding twelve more rhombic pyramidal blocks to the Second Stellation puzzle, one at each end of each piece according to the diagram below, while the puzzle is assembled. This makes a more interesting puzzle, as there is now only one solution and only one axis along which the two halves can be assembled or disassembled.

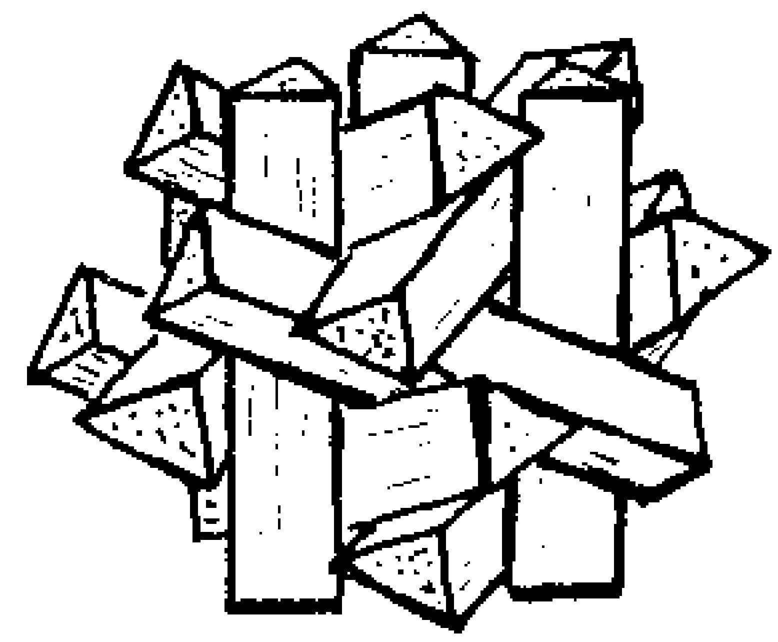
The model shown on the cover is in cherry, with end blocks of walnut for contrast.





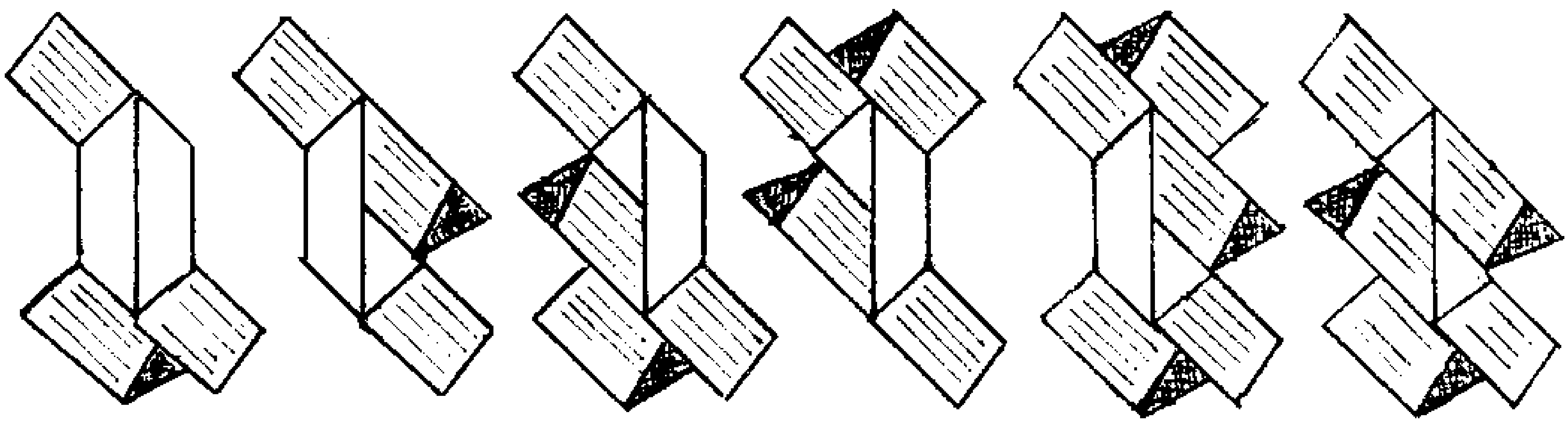
Broken Sticks Puzzle

Broken Sticks is made in exactly the same way as the Second Stellation, except that it uses triangular sticks instead of blocks attached to the standard six-sided center block. Twelve long triangular sticks and twelve short ones are used.



When you try to assemble or disassemble Broken Sticks the same way you would the Second Stellation, you find there is interference between the ends of the sticks such that it will go together one way only. Thus it is the same degree of difficulty as the Twelve Point puzzle.

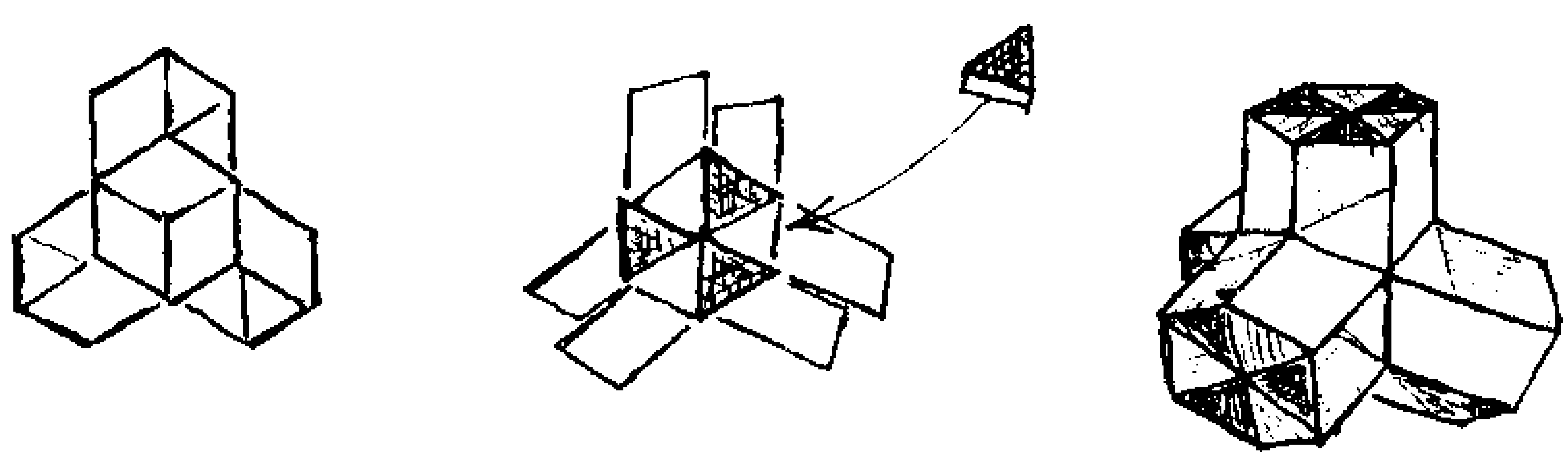
The model shown on the cover is Honduras mahogany.



Hexagonal Prism Puzzle

The construction of the Hexagonal Prism puzzle is best explained by referring to the drawings below. On the left is shown the Four Corners puzzle looking straight down on one of the "corners," which appears hexagonal. The center drawing shows the partially completed Hexagonal Prism in the same orientation, with short triangular stick segments glued in place, twelve in all. Twelve more sticks are required to fill in the empty spaces and complete the puzzle. These are glued in such that no pieces are symmetrical and all are dissimilar. The puzzle has only one solution and comes apart only one way.

The one shown on the cover is Honduras mahogany, Brazilian rosewood, and primavera.



Triangular Prism Puzzle

If you can figure out how to make the Hexagonal Prism puzzle, your reward is that you will have no difficulty at all making the intriguing Triangular Prism puzzle. As the drawing indicates, you simply add twelve more triangular sticks in the appropriate places.

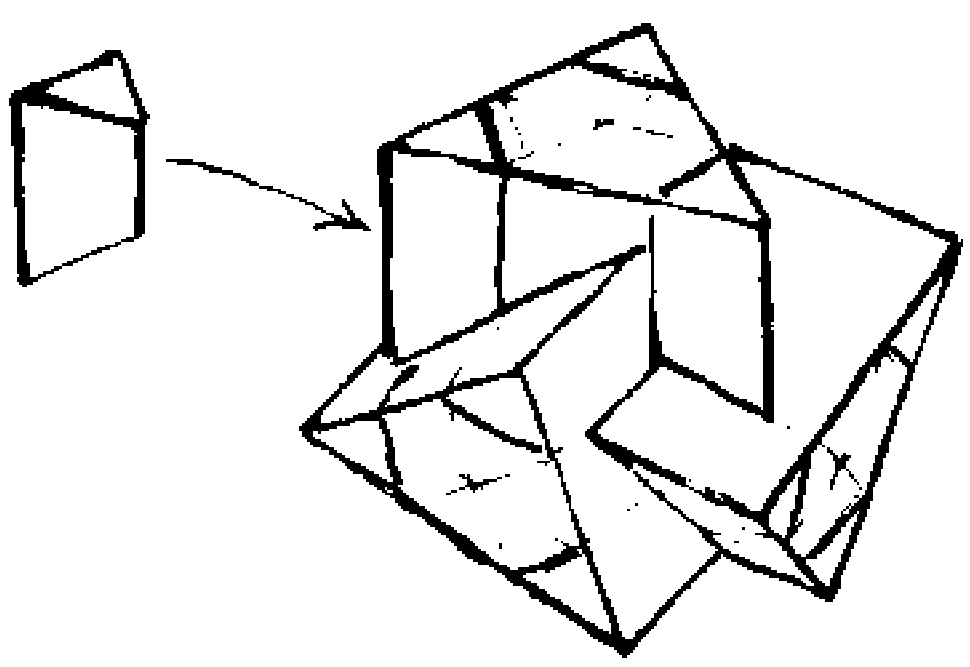
Once again we should explain the absence of detailed shop drawings with dimensions for all these puzzle parts and pieces. Giving detailed plans and directions for every puzzle covered in Puzzle Craft is not really the main purpose of this book. Some are a lot easier than others. These prism puzzles are not too tough to make, but very difficult to explain to someone else. I think the best we can do is describe them so that at least you will know what they are and what is involved. There is not enough space in this book to give detailed directions for everything, and I would rather use the space to at least mention as many new and interesting puzzle designs as possible.

I never use shop drawings in my work, and don't really see what purpose they would serve to anyone. I don't even know what most of the dimensions are. It's all done with a few basic jigs described in the woodworking section, plus experience and intuition. If you start with the simple ones like the STAR, you should be able to work up to the more complicated. If you get stuck, there are plenty of places where we start out again with simple things.

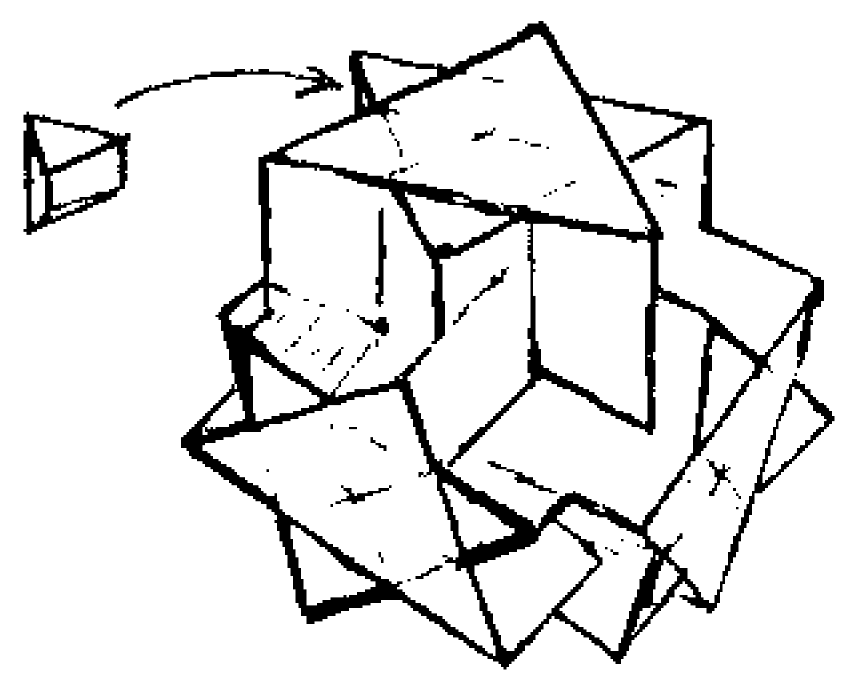
The Triangular Prism shown on the cover is made of Honduras mahogany.

The General (Four Star)

This puzzle is made by taking the Triangular Prism and adding yet twelve more triangular sticks, as indicated in the drawing, making each face into a Star of David prism. I made a few of these for fun, but I much prefer the simpler versions with cleaner lines.



Triangular Prism

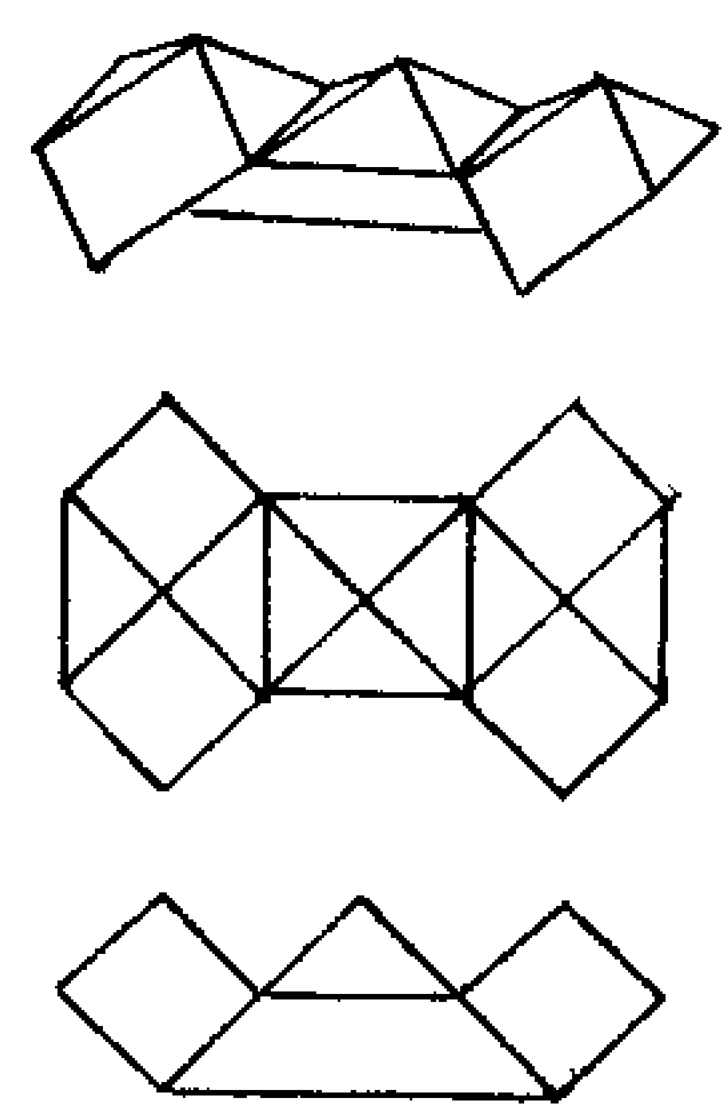


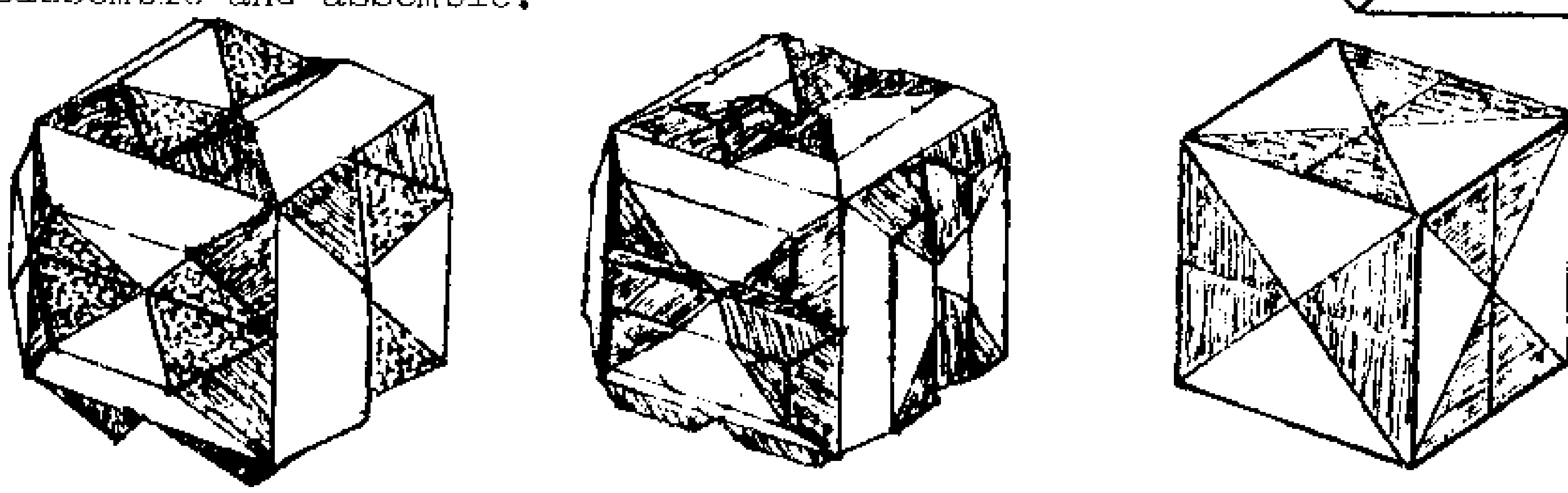
The General (Four Star)

Diagonal Cube

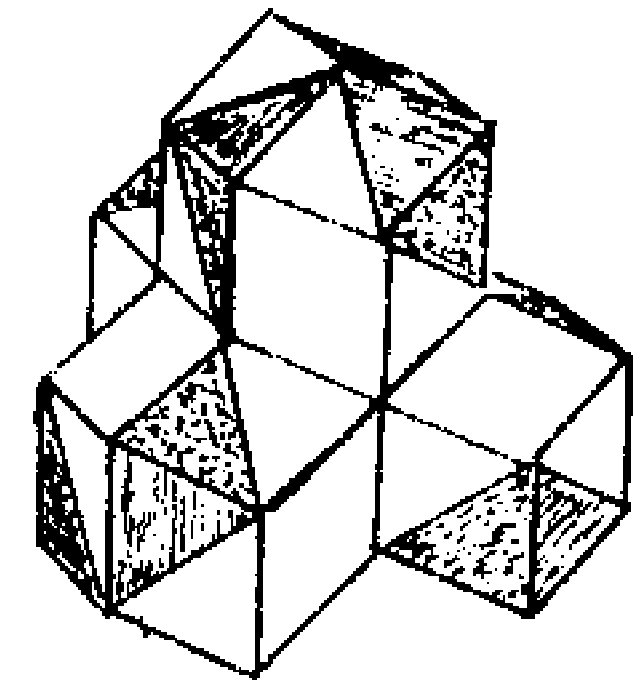
The first step in making the Diagonal Cube is to make six identical pieces, each one made up of three six-sided center blocks, just like the Seven Woods puzzle except that the end blocks are turned upside down. When these six pieces are assembled together, there will be 24 empty spaces. Rhombic pyramidal blocks are glued in these spaces in such a way that all puzzle pieces are dissimilar and non-symmetrical. The six faces may then be cut down until the puzzle is cubic or nearly so. The puzzle has only one solution and one axis along which it can be assembled. It is quite hard to disassemble unless you know exactly where to press with six fingers.

The one shown on the cover is made of zebrawood and breadnut. It makes a very handsome puzzle with contrasting fancy woods, as well as being interesting to disassemble and assemble.





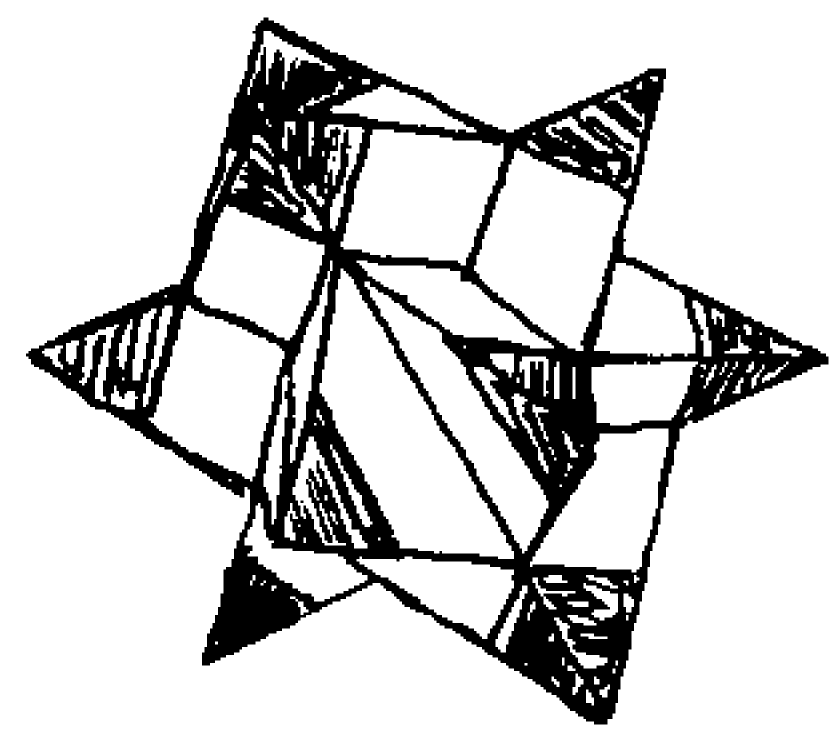
Augmented Four Corners



Although this puzzle might appear to have little physical resemblance to the Diagonal Cube, it is made in almost exactly the same way. Each of the six puzzle pieces is made up of a six-sided center blocks to which are glued a pair of Four Corners end blocks. When assembled, there are twelve empty spaces to be filled by the rhombic pyramidal blocks. It has one solution and one sliding axis.

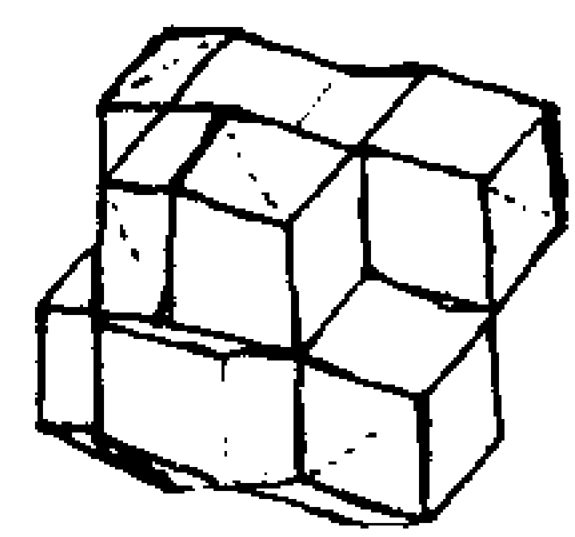
The one shown on the cover is made of cherry and Brazilian rosewood.

Vega



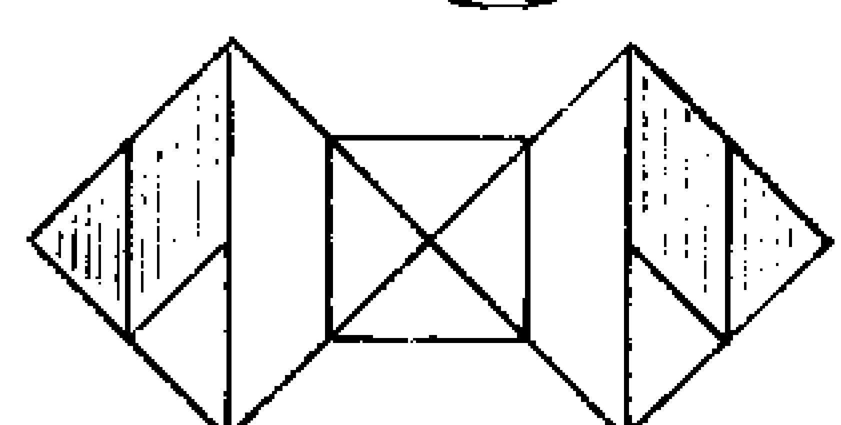
Returning to simple puzzles with identical pieces, the Vega is an easy one to make. Make six puzzle pieces, each with three six-sided center blocks, exactly as for the Seven Woods puzzle (page 42). Then add tetrahedral blocks at both ends of each piece to form an attractive stellated polyhedron.

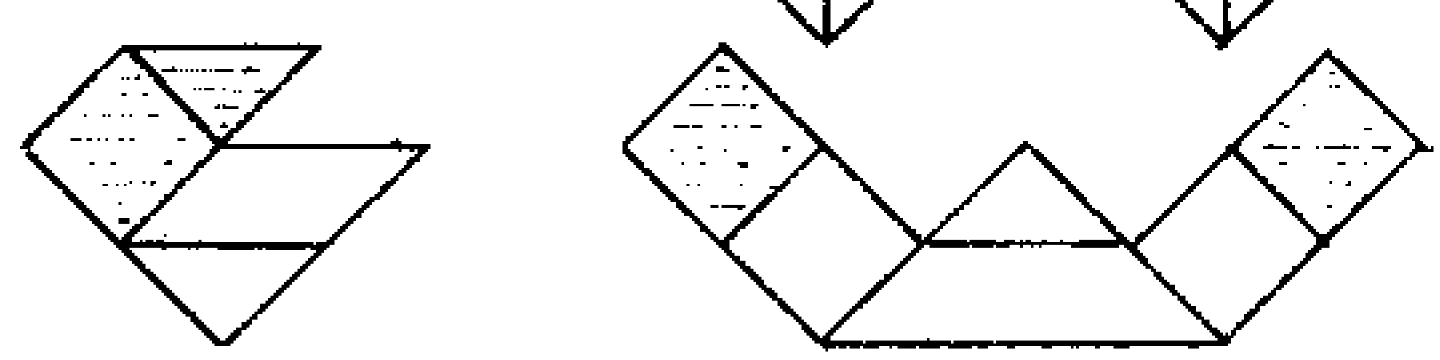
Cluster-Buster



Start with six puzzle pieces, each made of three six-sided center blocks, as for the Vega puzzle above. With the puzzle assembled, attach a mirror-image pair of Four Corners end blocks to the ends of each piece, thus making six identical puzzle pieces.

This puzzle is very difficult to disassemble, as it has only one sliding axis, and six fingers must be awkwardly placed in just the right spots, which however can be located by careful inspection. Reassembly is easier.

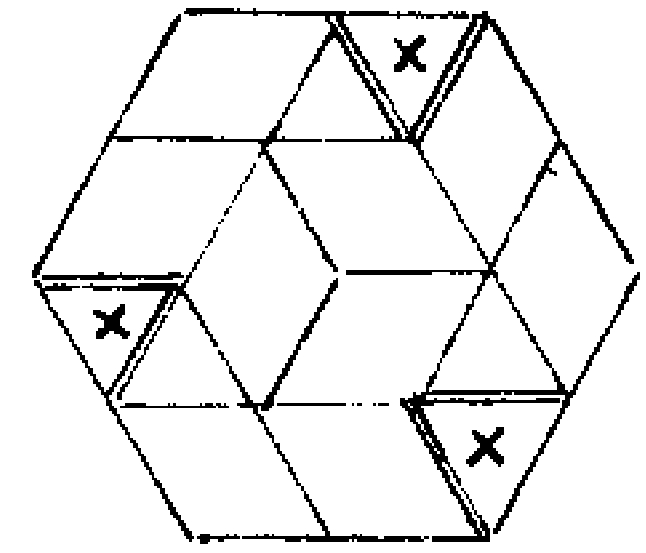




Improved Cluster-Buster

This is similar to the above, except that it uses four right handed and two left-handed pairs of Four Corners end blocks, attached in such a way that there are three dissimilar pairs of puzzle pieces, again with only one sliding axis. There is essentially only one solution with one minor variation. It is even more confusing than the above to disassemble and reassemble.

The one shown on the cover is in zebrawood with matched grain. Close inspection of the photo will reveal that the matching grain patterns in the end blocks suggest solid blocks of wood, even though they are all dissected. This will occur automatically with either solution.

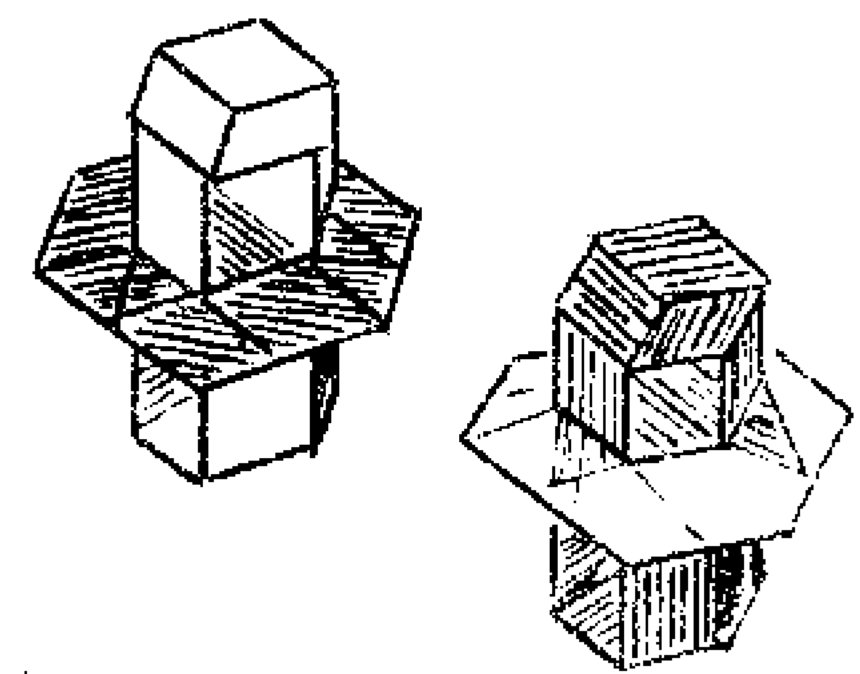


x - push here to disassemble

Solid Dissections

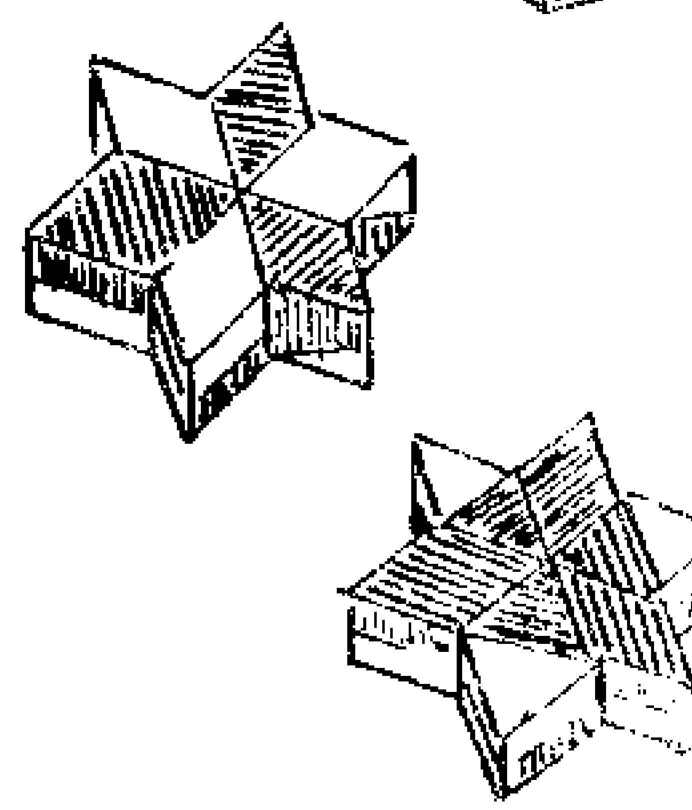
On page 20, we discussed plane geometric dissections. Wouldn't it be fun if someone would invent some clever three-dimensional dissections, such as a set of blocks that would form some Platonic solids, prisms, pyramids, etc.? But how would we hold them from slipping and sliding apart - a separate box for each solid? That is one problem we can forget about, because practically all such dissections are known to be impossible.

Triumph Puzzle



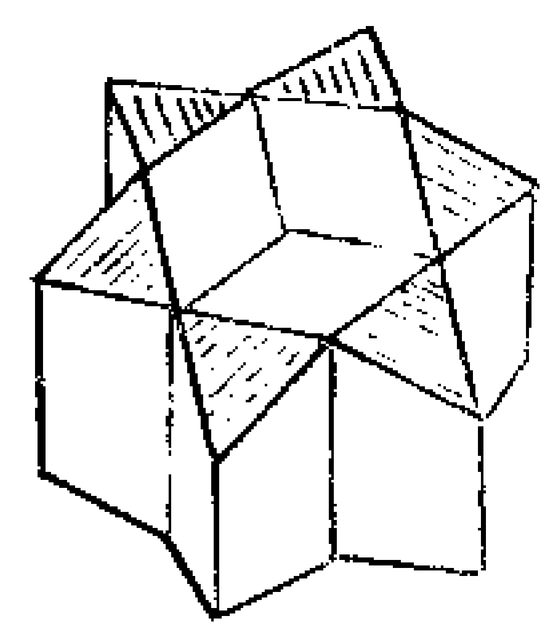
This simple but unusual puzzle could be regarded as a geometric dissection of sorts, since it forms three different symmetrical geometrical solids. One is a hexagonal column surrounded by a hexagonal ring. The second shape is a six-pointed Star of David column. The third shape is not easily described. The puzzle is interlocking, which takes care of the sliding problem mentioned above.

When made as it normally is of a light and dark wood, each shape can be assembled in two different color patterns: A dark hexagonal column surrounded by a light ring, or a light hexagonal column surrounded by a dark ring. A Star of David column with a light and dark diamond pattern, or with a dark triangle and three light points.

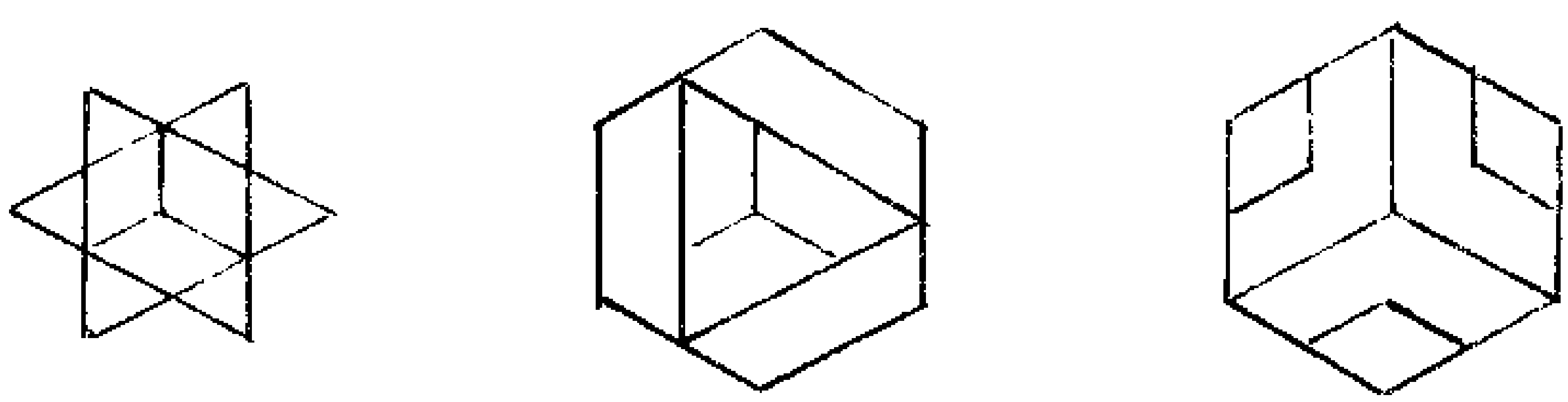


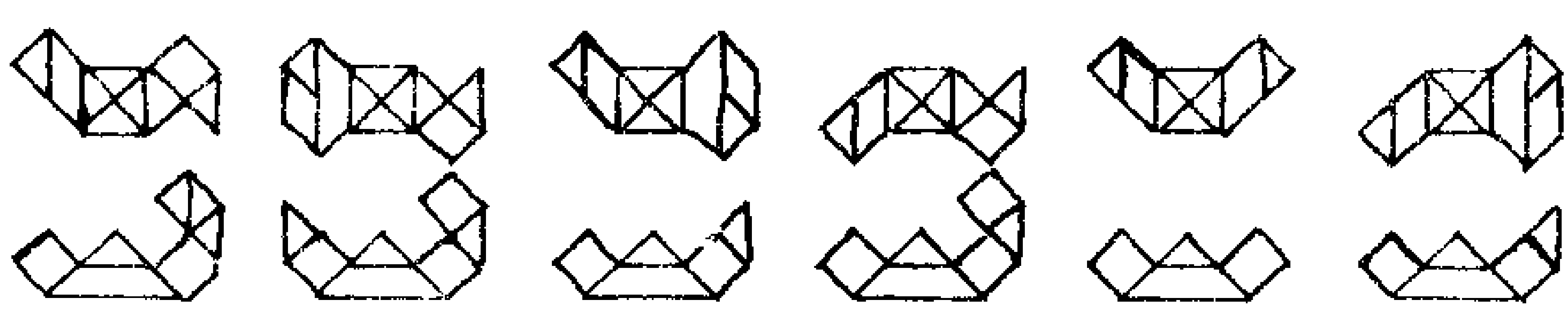
Only about 50 of these were made and sold, 1974-1976, but I have mailed out hundreds of the instruction sheets, which contain essentially the same information given here. Many persons have tried to work backwards and figure out from the instruction sheet how to make the puzzle. So far as I know, no one has done so yet. I will even give some additional hints here: All six puzzle pieces are identical in shape. Each puzzle piece is made up of three simple blocks, all of which have already been described in this section, with directions for making them in the section on woodworking. Good luck!

Star-of-David Puzzle

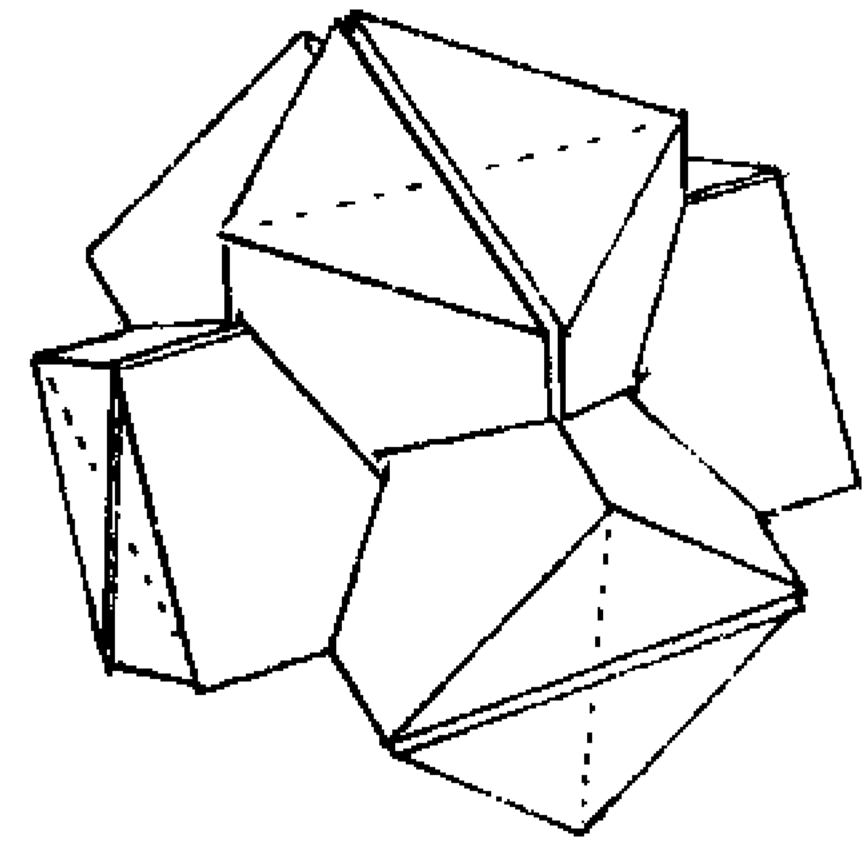


The Star-of-David puzzle is just a more complicated version of the Triumph puzzle. It too makes three symmetrical shapes, but its six pieces are all dissimilar. For posterity, plan drawings of the pieces are shown below, but it is not an easy puzzle to make. I usually made them in Honduras mahogany.



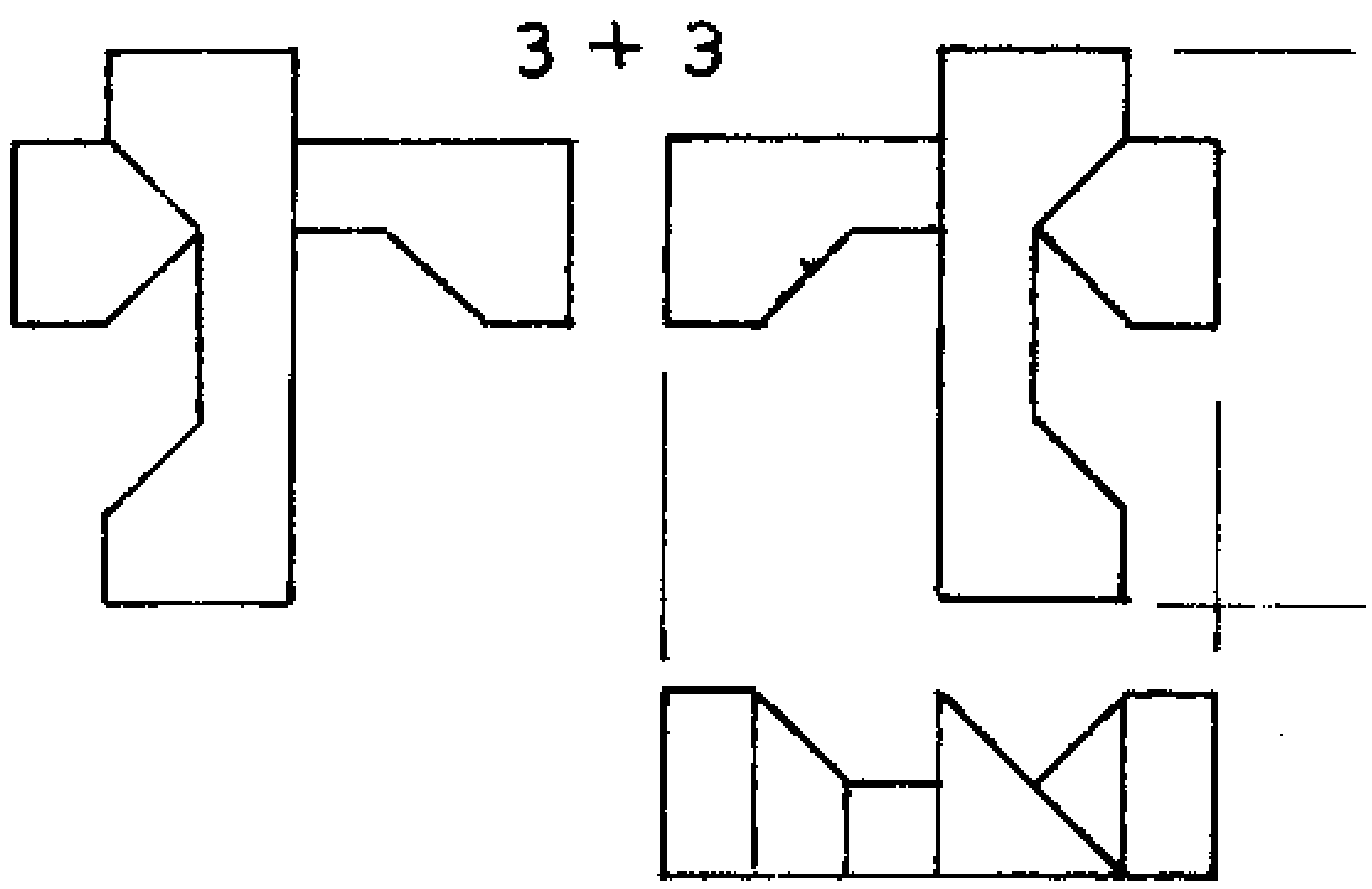


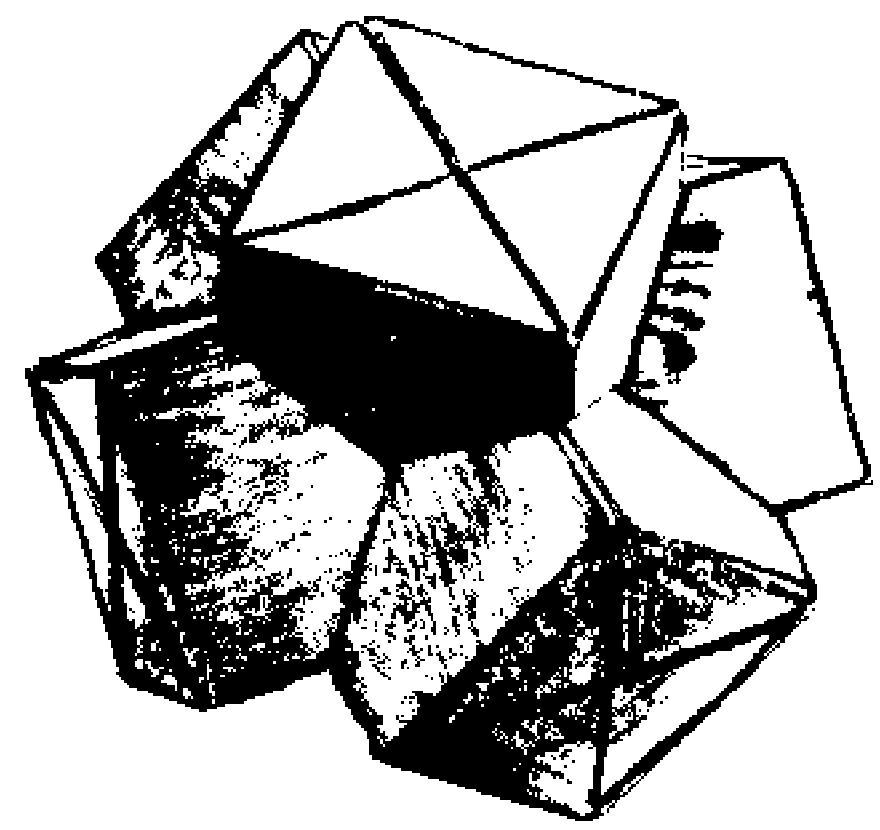
The Three Pairs Puzzle



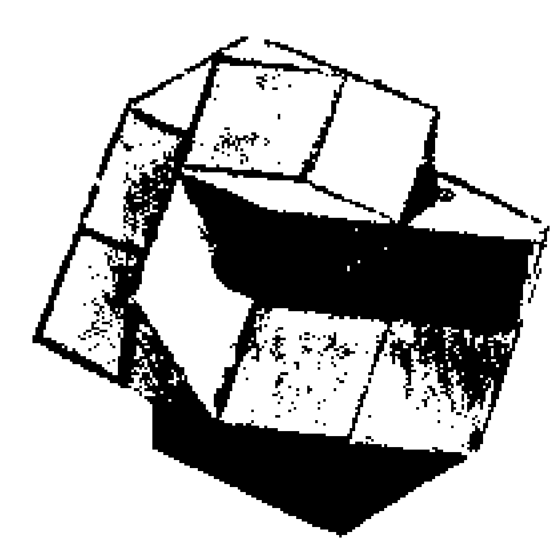
A fine puzzle - simple yet baffling. Shown at right is a simple interlocking assembly of six identical pieces, which is very similar to the Seven Woods puzzle, (page 42). Imagine each of these six pieces split down the center into two identical halves, as shown by the broken line. Then glue these twelve half-pieces together in pairs at right angles, three right-handed pairs and three left-handed. Now reassemble. It __is__ possible, and very tricky. After you have seen the trick, it is easy.

It would be a fairly simple puzzle to make except that it requires close tolerances to be entirely satisfactory. The one shown on the cover is cherry.



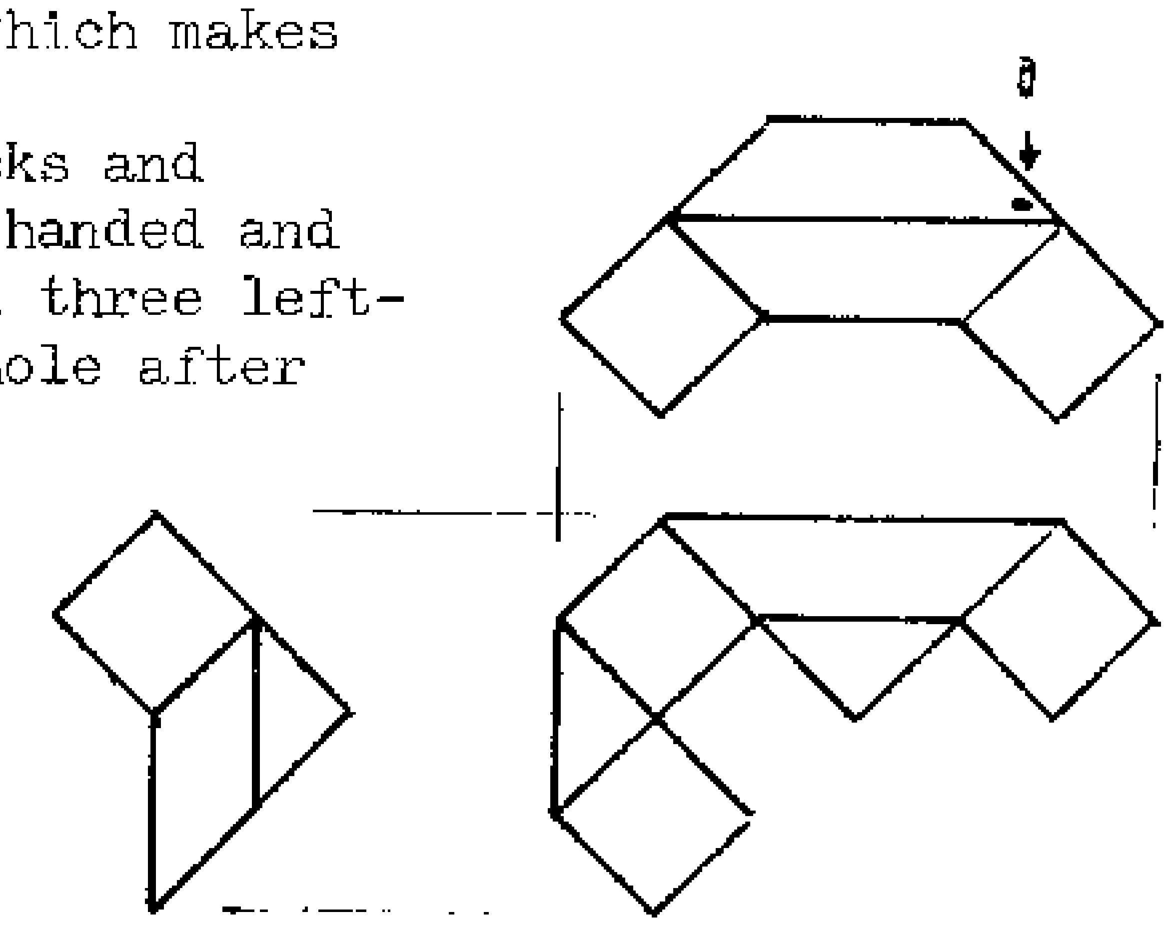


Rosebud Puzzle



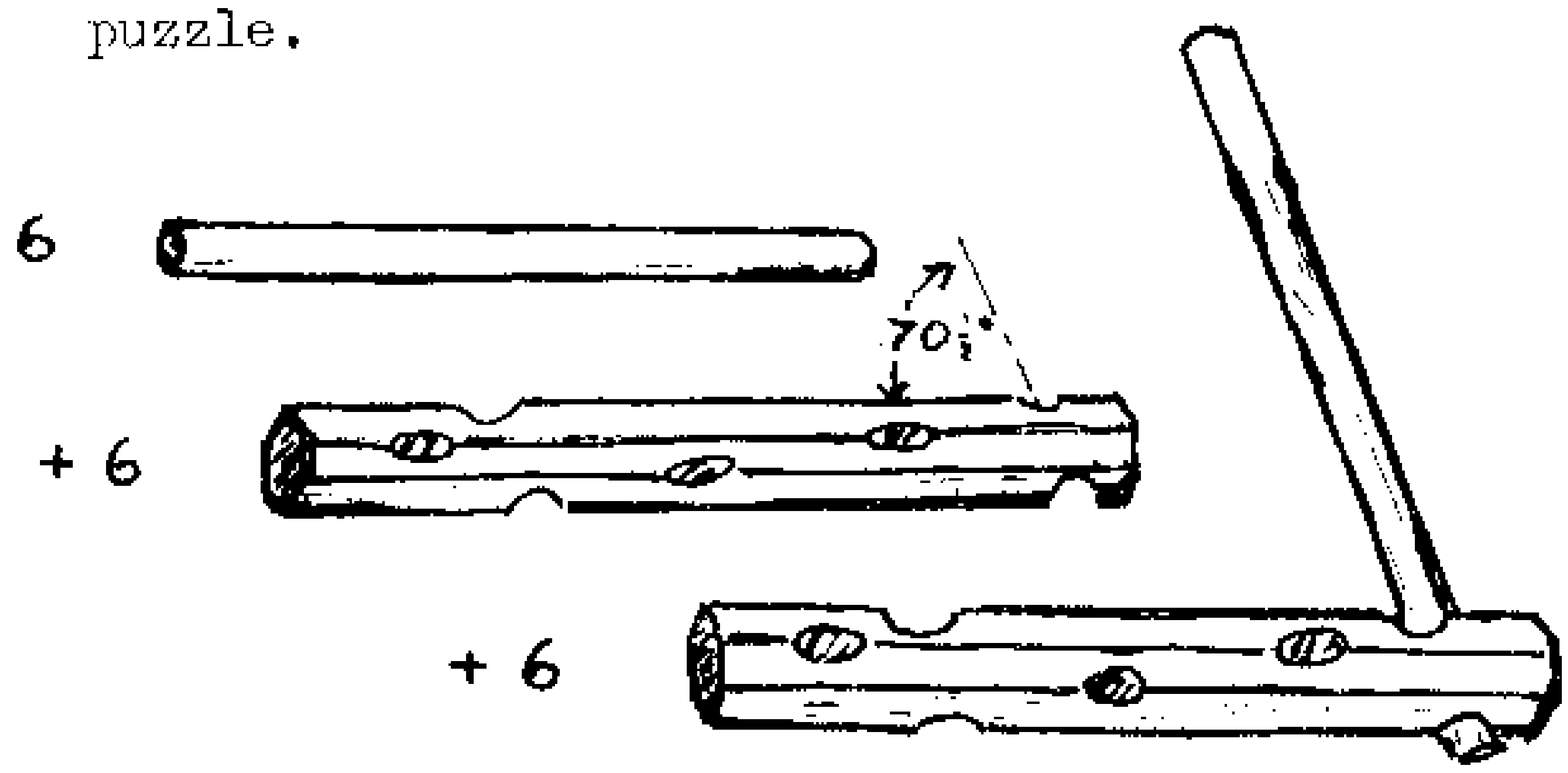
The puzzle above requires the sumultaneous manipulation of three pieces to assemble. It does not require much dexterity, but is not obvious and never occurs to most persons. Usually I do not much care for dexterity puzzles. The Rosebud puzzle requires the simultaneous manipulation of all six pieces to assemble correctly, which borders on the impossible unless you use masking tape or an assembly jig to position the pieces. I include it here because it is so unusual and has such an intriguing mechanical action when assembled. Of the fifty or so sold disassembled, I think fewer than a dozen have ever been assembled. As a consolation, there is a second easy solution which makes a different shape.

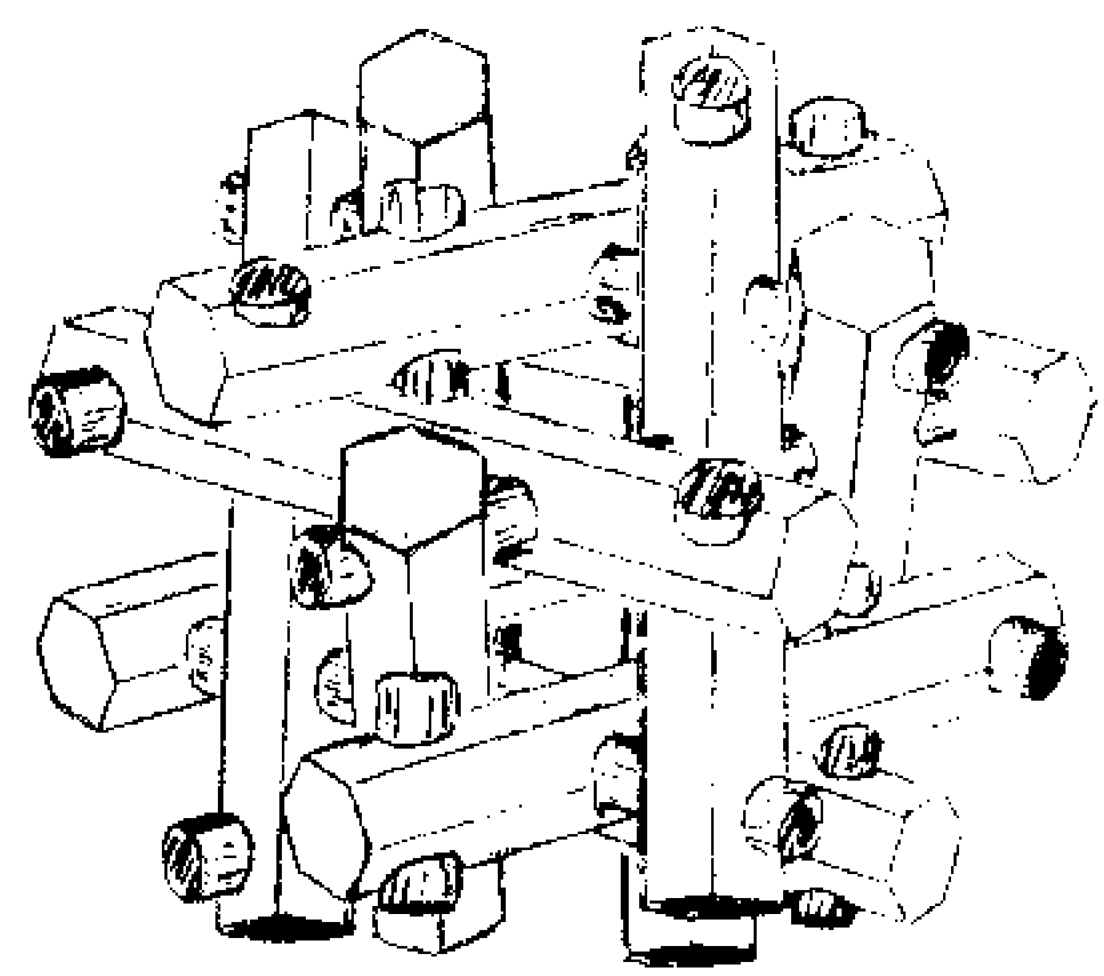
Parts required: six six-sided center blocks and eighteen Four Corners end blocks - nine right-handed and nine left-handed. Make three right-handed and three left-handed pieces. A small peg is inserted in a hole after assembly to prevent disaster.



Locked Nest Puzzle

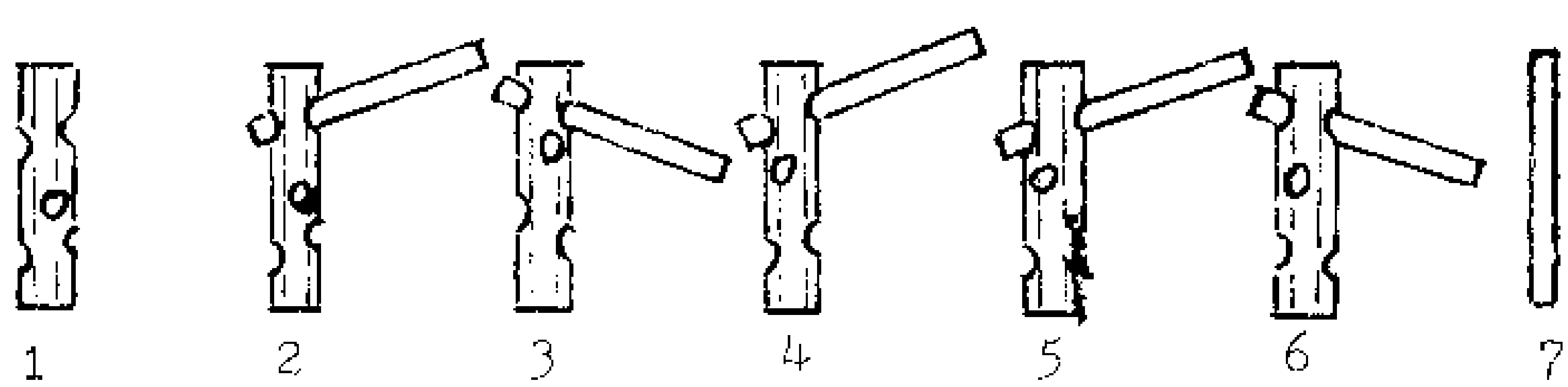
The Broken Sticks puzzle (page 44) gives the illusion of twelve triangular sticks in a symmetrical array, even though if they were actually just that, the structure would collapse. For an idea on how to hold them together, refer back to the PIN-HOLE puzzle (page 38). We reduce the sticks to hexagonal cross-section (not necessary), and drill five holes in each one. Once you have the hexagonal stock, the holes are easy, as they are all at an angle of 70½ degrees to the sticks and all equally spaced. The spacing can be determined by trial & error so that the sticks just rest against each other. The one shown on the cover is made of 3/4-inch hexagonal birch sticks, 7/16-inch dowels, and 15/32-inch holes. Six of the dowels may be attached to the sticks with brads to make ELBOW pieces, leaving six plain sticks and six dowels. It is a fairly hard puzzle.

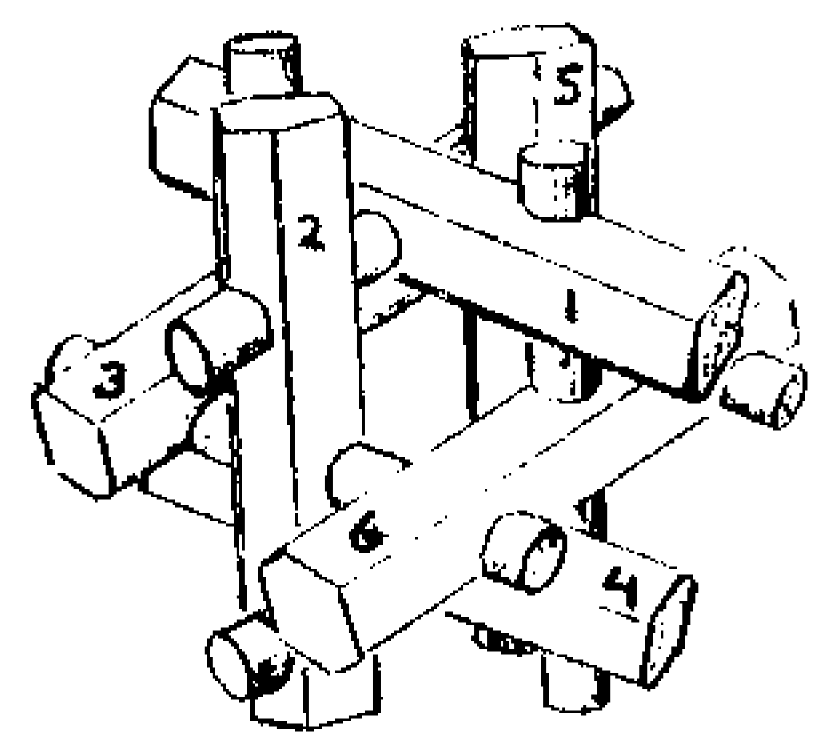




Cuckoo Nest Puzzle

There is an interesting variation of the Locked Nest which I made for a while and called the Cuckoo Nest. It uses only six sticks and six dowels, but most persons will find it more confusing than the Locked Nest.





Assemble in the order numbered. 4 and 5 are alike. There is a second solution.

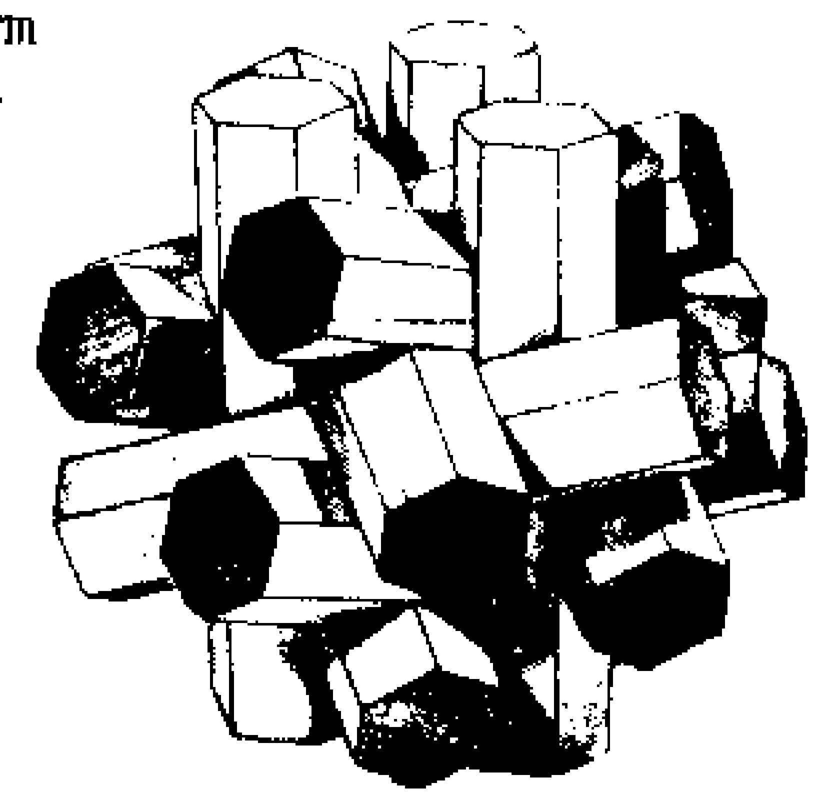
Nine Bars Puzzle

There is a variation of the Cuckoo Nest which I call the Nine Bars puzzle. Six of the bars are the same size as those in the Cuckoo Nest, and the remaining three are longer and have four holes. It is harder than the Cuckoo Nest. I don't want to clutter up Puzzle Craft with too many variations of variations, so I leave this one for others to rediscover.

(There is a variation of the Locked Nest which would use thirty pentagonal sticks and thirty dowels. Each stick would have five or seven holes, depending on how long you wanted to make them. I think it would be far too complicated to make a satisfactory puzzle, and would be a piece of sculpture more than anything else. I have never made one, and I shall certainly not attempt to draw one!

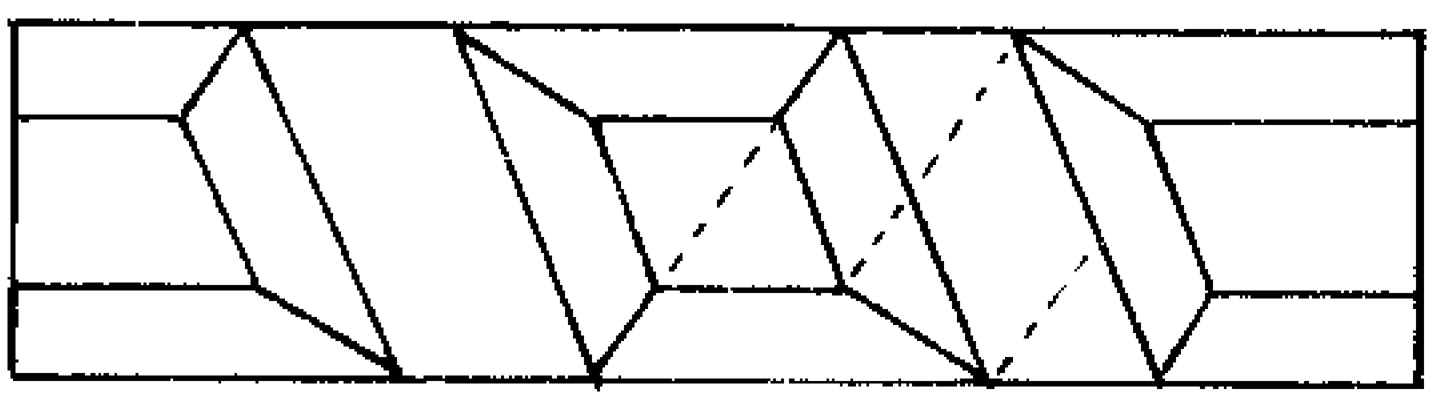
Hexsticks

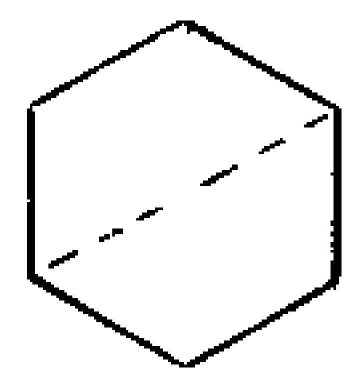
Instead of holding the twelve hexagonal sticks together with pins, as in the Locked Nest, we can notch them to form a very neat puzzle. This puzzle idea was discovered first by Bill Cutler around 1965 and independently by myself in 1968. In the original version, which was once made in plastic, there are nine sticks with two notches and three with three notches. In the wooden version, two of the notches are omitted, making two sticks with one notch. Both versions have three solutions. All of the notches are trapezoidal, same dimensions as the sticks and exactly to the center. They are cut at an angle of $70\frac{1}{2}$ degrees to the axis of the stick.

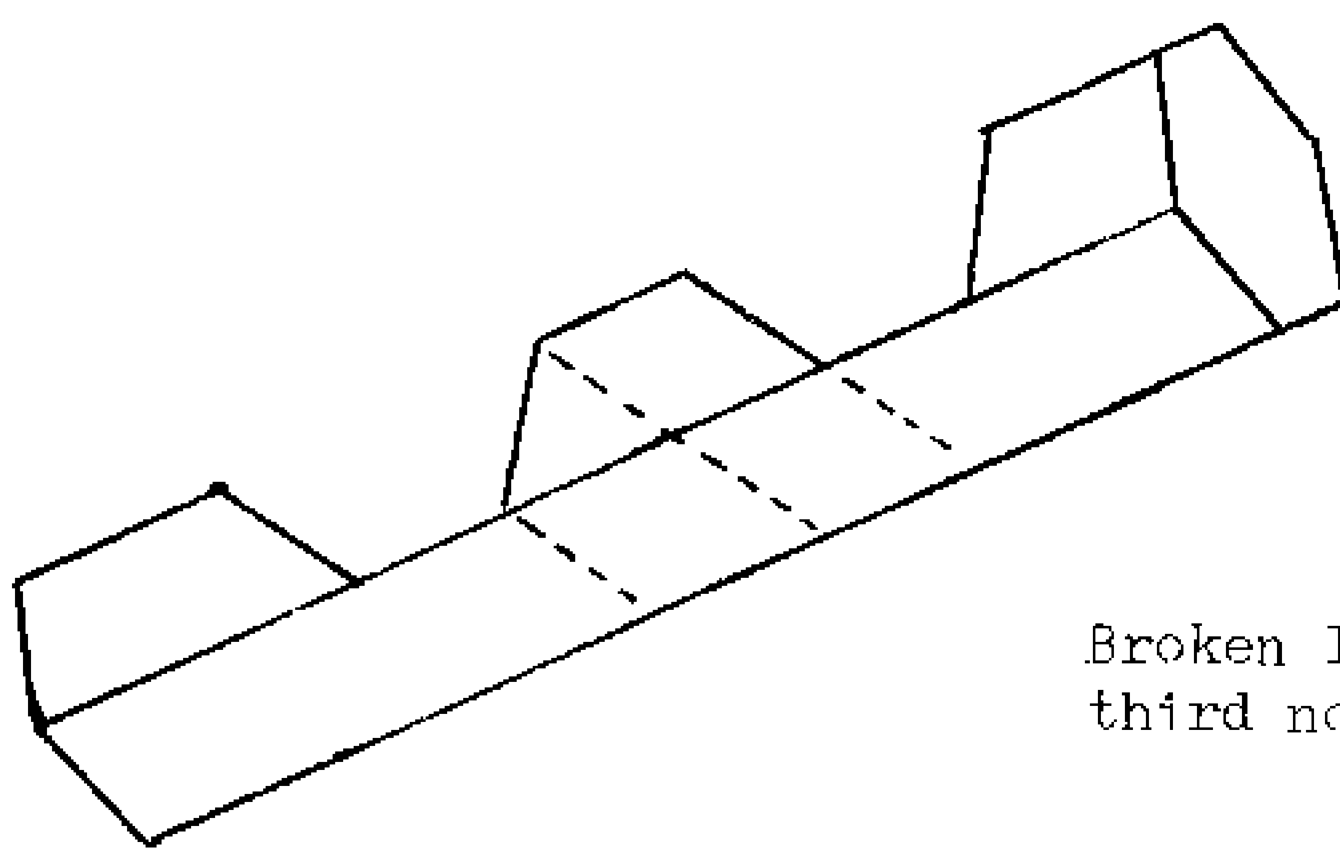


The puzzle is difficult to make in the home shop, requiring both accurate hexagonal stock and accurate notches. On the other hand, with the proper machinery it could be manufactured very easily.

The one shown on the cover is in 3/4-inch birch.





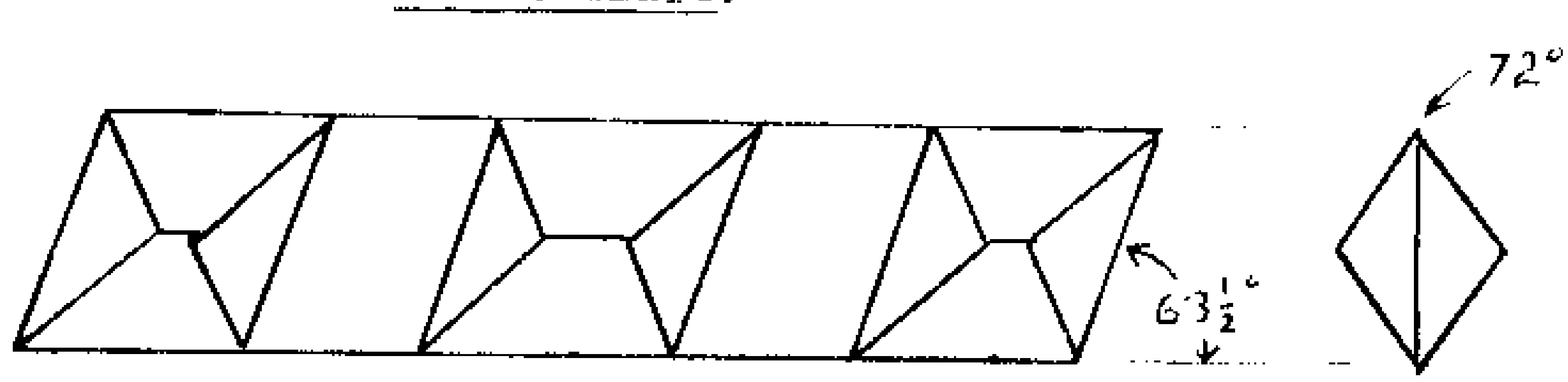


Full scale drawing of standard piece

Broken lines show location of third notch

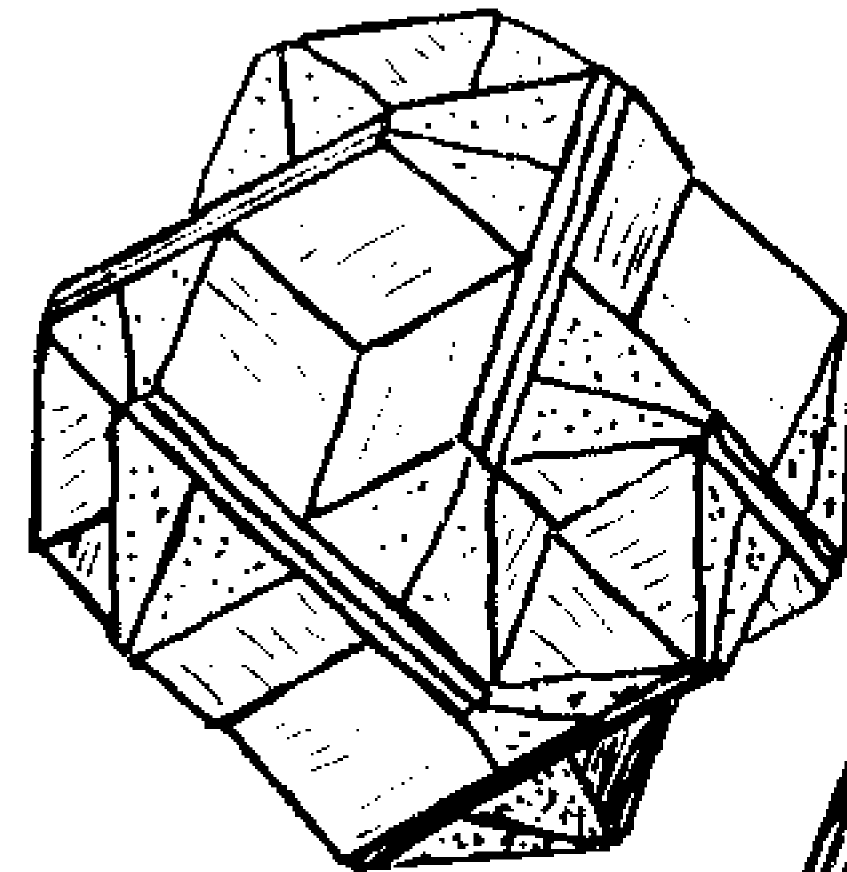
Notched Pentagonal Sticks

Based on the same idea as Hexsticks, there is an analogous arrangement of thirty notched pentagonal sticks, and several variations such as the one shown (or suggested?) by the illustration at right, which uses thirty notched sticks of rhombic cross-section. I have tinkered with these ideas, but find them much too complicated to make satisfactory puzzles. If any reader is thinking of doing honors work in school in both math and mechanical drawing, they can draw one of these to be included in the next edition of Puzzle Craft.



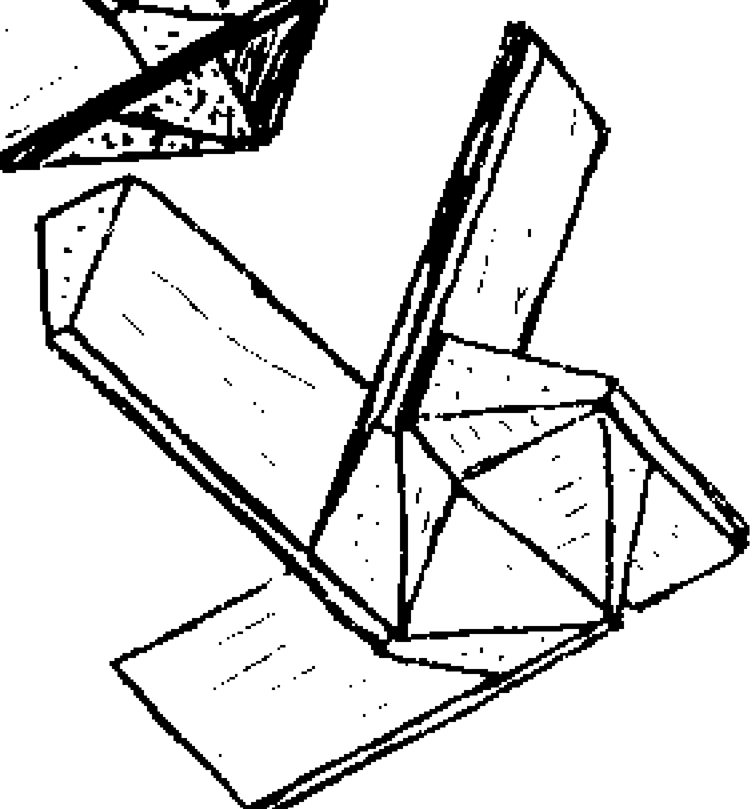
Scorpius (The Spider-Slider)

Refer once again to the cluster of twelve triangular sticks shown on page 44. Now imagine each stick divided longitudinally into two identical halves of 30-60-90 degree cross-section. Joining these half-sticks in fours to make six identical symmetrical pieces, we have a simple but intriguing puzzle. The ends may be cut off at any desired angle for the sake of appearance. The sharp 30 degree edges may also be beveled.



If made accurately, this puzzle feels solid when you pick it up, and it may take a while to discover that it can be slid apart into two halves along any one of four axes. Yet if you toss it in the air, it flies apart.

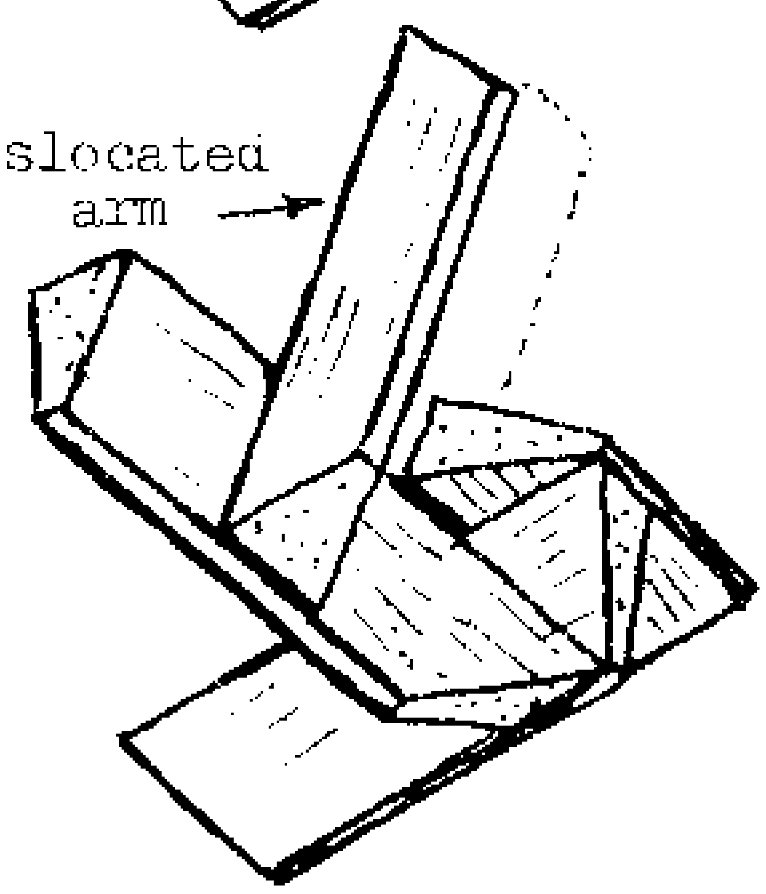
I made these in four contrasting woods, such that when assembled correctly all like colored arms are mutually parallel. Other color symmetry arrangements are also possible.



Dislocated Scorpius

If one arm in each of the Scorpius pieces is exchanged with one of its neighbors, we have six identical but non-symmetrical puzzle pieces. They assemble two different ways. This puzzle was known as the Dislocated Scorpius. There were never any color symmetry problems worked out for it, so it was made in all one kind of wood. Very few were made because a much improved version was soon discovered (below):

dislocated arm

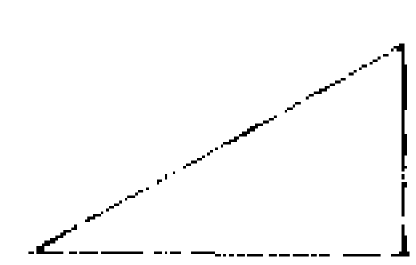


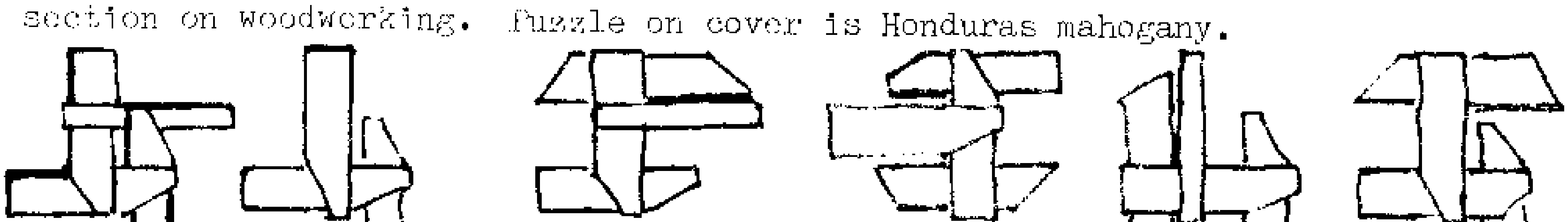
Scrambled Scorpius

An investigation of all possible ways of joining different arms of the Scorpius puzzle in fours shows that there are seven usable pieces. If we throw out the one symmetrical piece (Spider-Slider), we are left with a set of six pieces. By an extraordinary stroke of luck, they just happen to assemble one way only to form a very satisfactory and challenging puzzle. The six pieces are represented schematically below.

As a crude estimate of the difficulty index of this puzzle, we arbitrarily select one piece for the bottom, and note that any of the five remaining pieces may go in any position oriented four different ways. 20x16x12x8x4 gives a difficulty index of 122,880. And then you have the problem of getting them together in the right order, which is a little trick in itself.

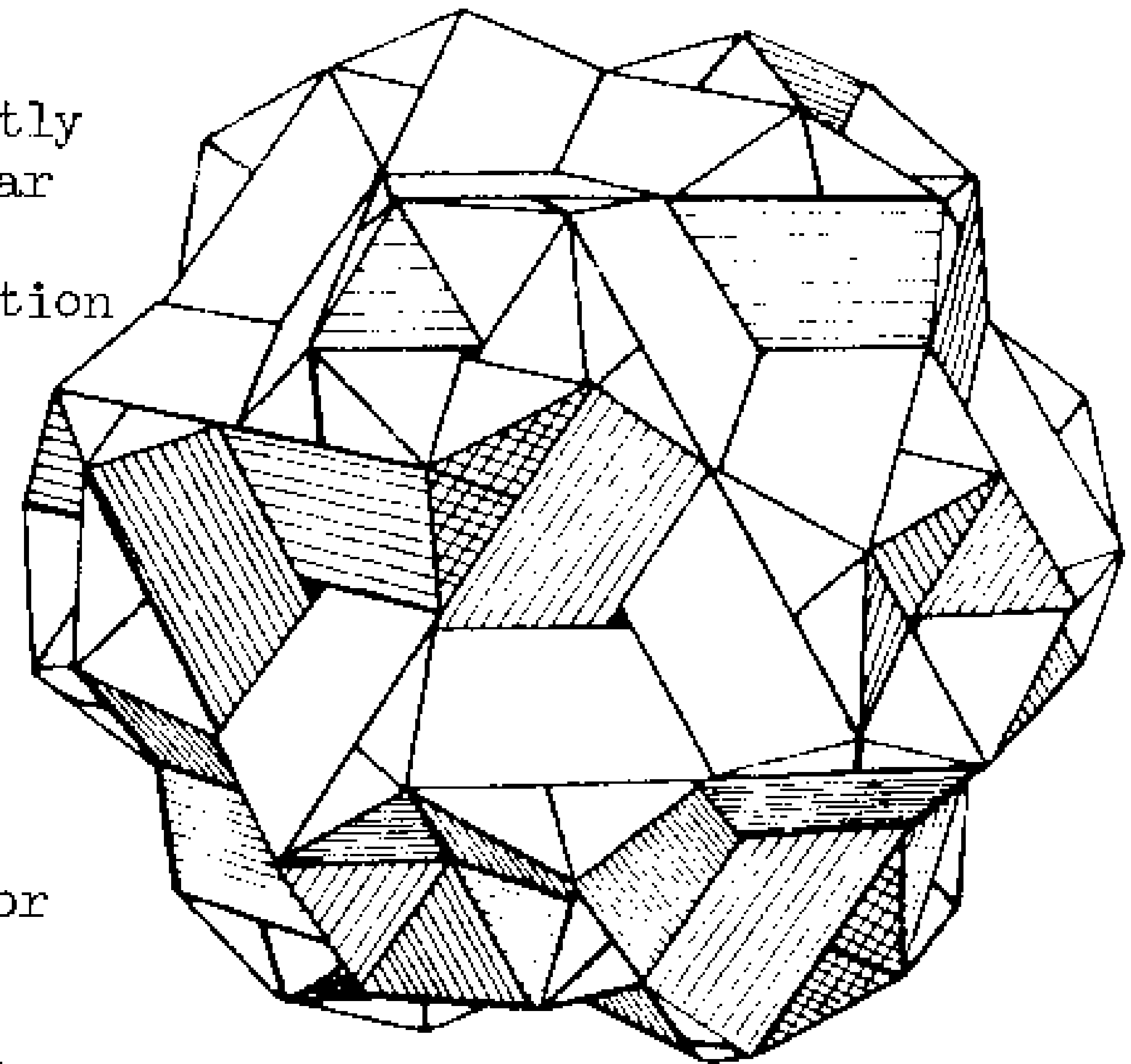
Since the puzzle is made simply out of a bunch of uniform triangular sticks glued together and trimmed, it is not too difficult to make. However, to be entirely satisfactory the gluing must be done very accurately, and for that you need accurate jigs. If making only one, the easiest way might be to find one of mine and use it as a jig. The steel gauge I use for checking each stick for accuracy before gluing was used to make the full scale cross-section shown at right - dimensions unknown. More information will be found in the section on woodworking. Puzzle on cover is Honduras mahogany.





Jupiter

The Scorpius family of puzzles leads directly by analogy to an arrangement of sixty triangular half-sticks surrounding a hollow center having the shape of a triacontahedron. The cross-section of the sticks is a 36-54-90 degree triangle. These sticks may be joined in fives to make twelve identical symmetrical pieces which when assembled and trimmed make quite an attractive puzzle-sculpture. It has six sliding axes, and it flies apart when tossed just like the Scorpius.



Jupiter is made in six contrasting woods, such that when assembled correctly all like colored arms are mutually parallel. Other color symmetry arrangements are also possible.

An article in the Nov. 1984 issue of Fine Woodworking shows a Jupiter in color right next to the subtitle of the article "Easy to make, but tough to solve." As a result, I have received numerous inquiries from readers asking for directions on how to make one. Please note that the choice of photo and subtitle were those of the editors, not mine! Nevertheless, you may find some helpful hints in the section on woodworking.

The Jupiter shown on the cover is in sumac, satinwood, pernambuco, breadnut, Honduras rosewood, and tulipwood.

Dislocated Jupiter

There is of course a Dislocated Jupiter puzzle which is exactly analogous to the Dislocated Scorpius and should not need any further explanation. It has several solutions.

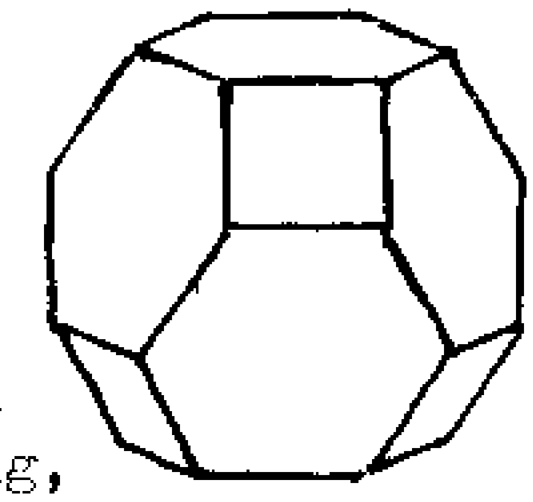
Saturn

You might expect that there would be a design of twelve dissimilar five-arm pieces analogous to the Scrambled Scorpius. If there is such a design possible, I have never been able to discover it. And if there was, it would be so difficult that probably no one could solve it. A compromise was my Saturn puzzle. It used six dissimilar non-symmetrical pairs of pieces which formed two identical subassembly halves. It was supposed to have only one solution, but later we discovered others. I now realize that the simpler Jupiter was the better design, which many customers realized all along.

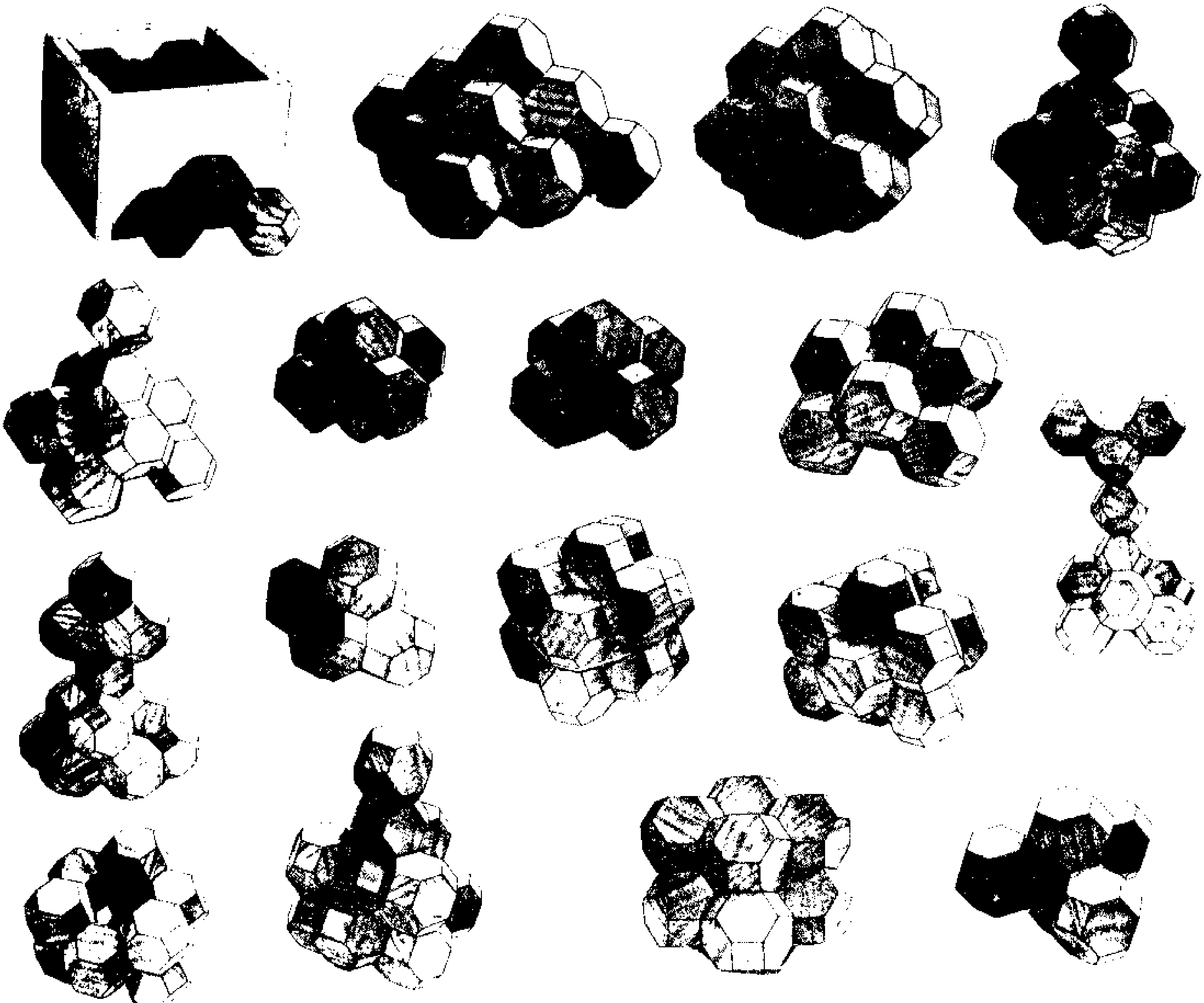
Polyhedral Block Puzzles

There is a large family of puzzles made up of polyhedral blocks joined together different ways. We have already discussed the cube (page 28). Now we will look at other polyhedra.

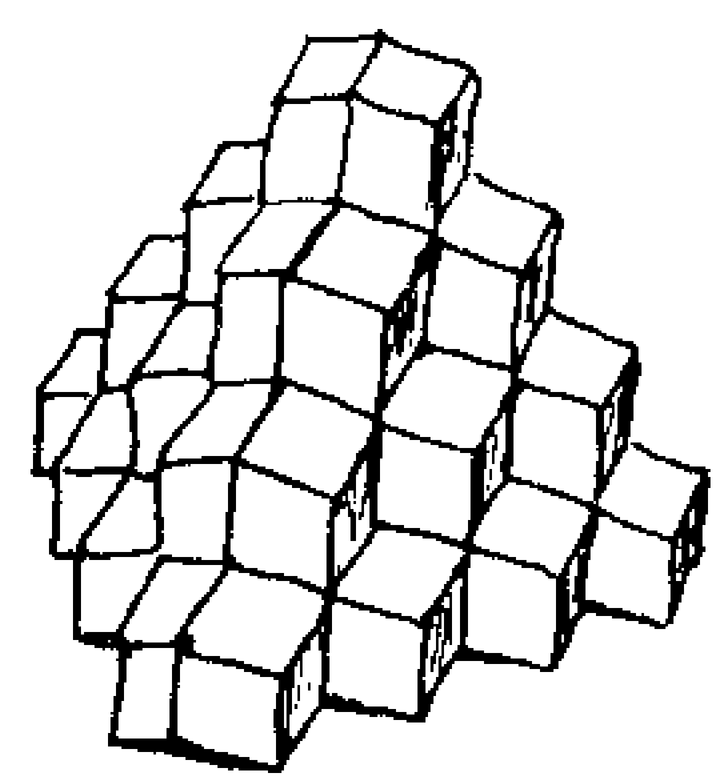
Truncated Octahedra Puzzle



Jay Kirsch designed a puzzle made up of fourteen truncated octahedra joined together different ways into six puzzle pieces. I have attempted to improve on his design with my fourteen-block, five-piece Truncated Octahedra puzzle. It packs into a square box, makes a square pyramid, and fifteen other symmetrical shapes, as shown on the next page. None of these are interlocking, and one or two of them even require a rubber band for support. The puzzle pieces are formed by gluing a pair of blocks together on their square faces, and then four pieces of three blocks each in all possible ways of joining them except in a straight line.



Truncated Octahedra Puzzle Problems

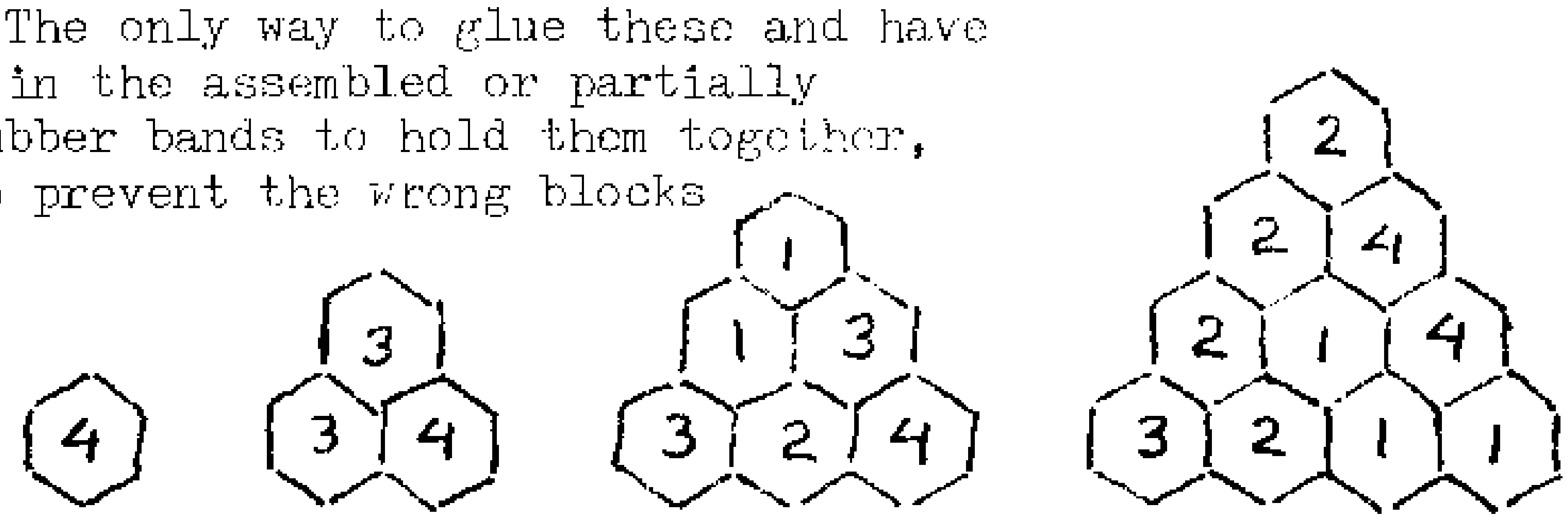


Four Piece Pyramid Puzzle

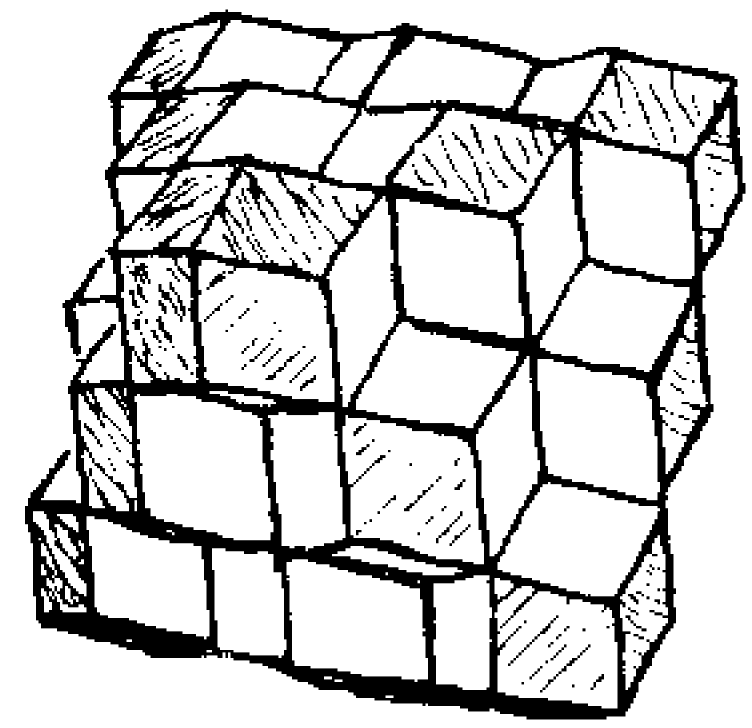
Twenty rhombic dodecahedra can be stacked neatly into a triangular (tetrahedral) pyramid. Problem: Join them in fives to make four dissimilar non-symmetrical interlocking puzzle pieces which assemble one way only and in one order only to reconstruct the pyramid. Surprisingly, this is possible! The one known design is shown here. Are there others? For having only four pieces, this is quite a difficult and confusing puzzle.

The one shown on the cover is a variation made with edge-beveled cubes (i.e. truncated rhombic dodecahedra) in Honduras mahogany. It is even more confusing.

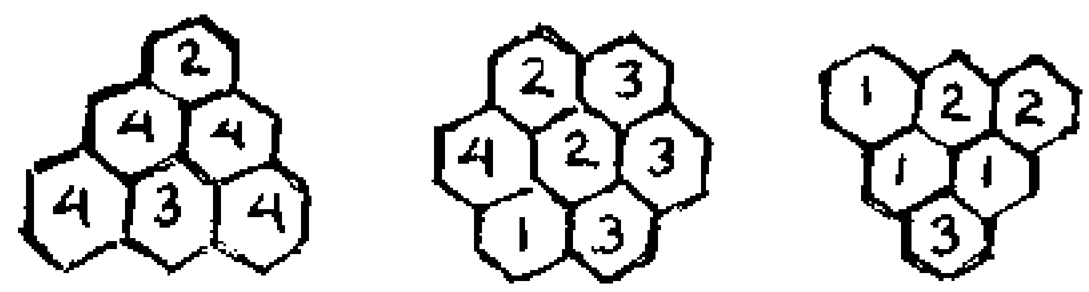
Directions for making the blocks are given in the section on woodworking. The only way to glue these and have them fit is to glue them in the assembled or partially assembled state, using rubber bands to hold them together, and wax or waxed paper to prevent the wrong blocks becoming stuck together.



Octahedral Cluster Puzzle

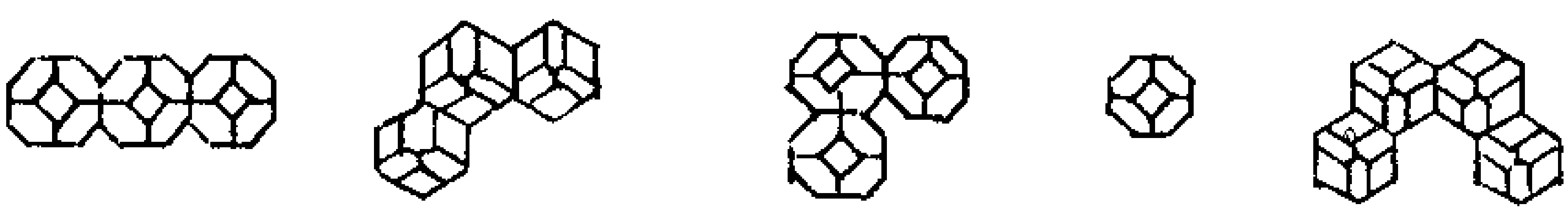


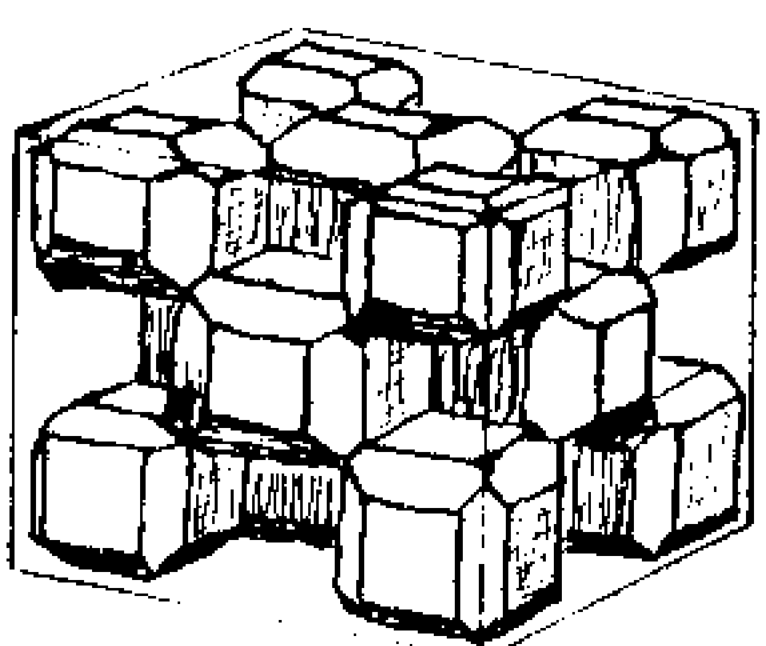
Nineteen rhombic dodecahedra can be packed into an octahedral cluster. The same design criteria are used as for the Four Piece Pyramid, except that obviously one piece will have only four blocks. One and only one design was found which satisfies all the requirements. This puzzle is reported to be even more confusing than the Four Piece Pyramid. Same woodworking directions apply. The one shown on the cover is made of limba, sawn from $1\frac{1}{4}$-inch square stock.



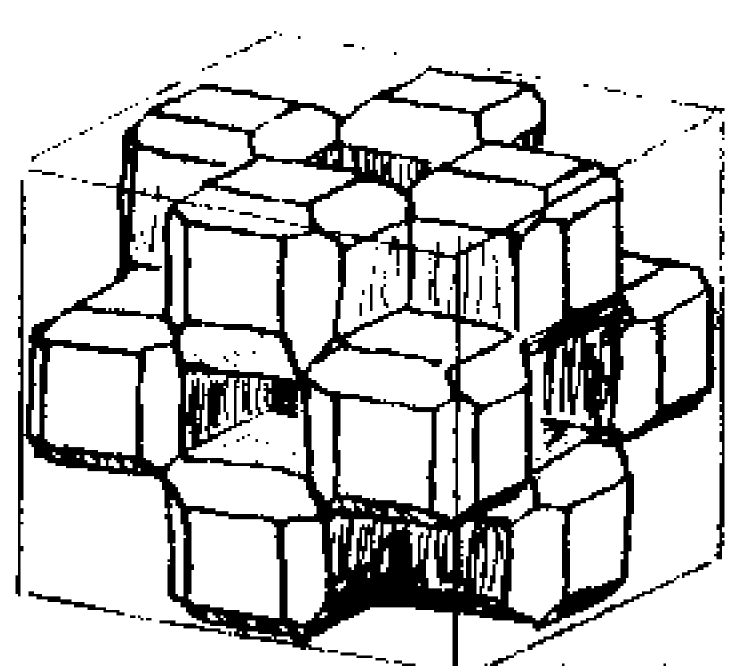
Pyracube

This puzzle consists of fourteen edge-beveled cubes (truncated rhombic dodecahedra) which are joined to make five puzzle pieces. They pack into a cubic box, build a square pyramid, rectangular pyramid, and with one piece omitted a triangular pyramid. Another amusing thing they do is pack neatly into the box with one block left over. A variation of this puzzle made with spheres by Prof. van der Poel is shown in Creative Puzzles of the World, page 85.

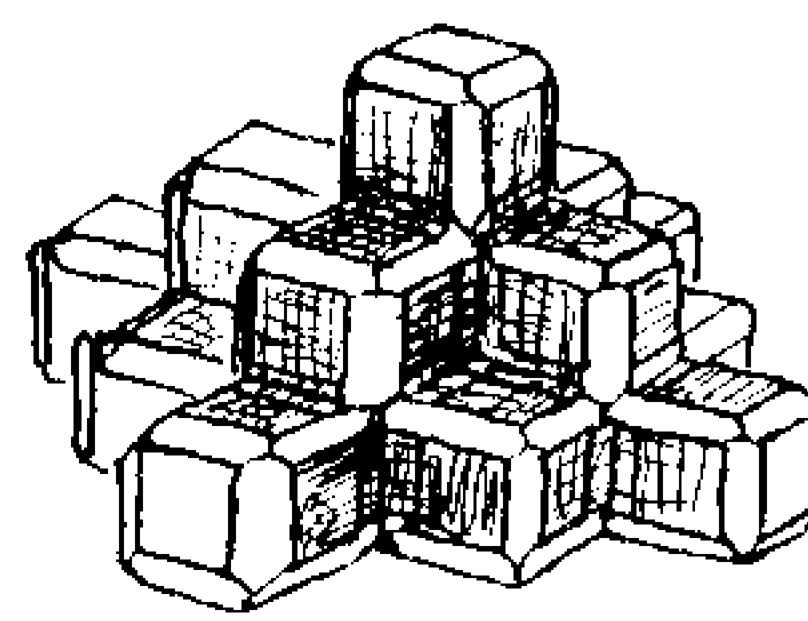




1

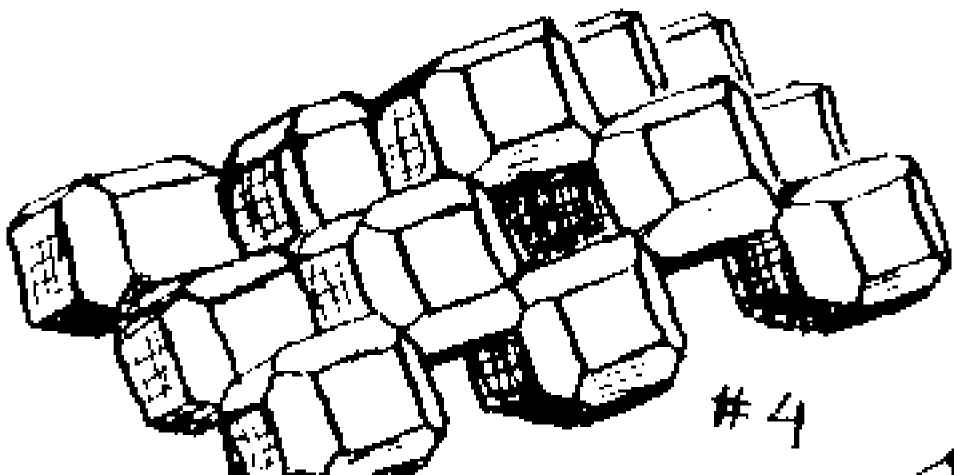


2 (omit one block)

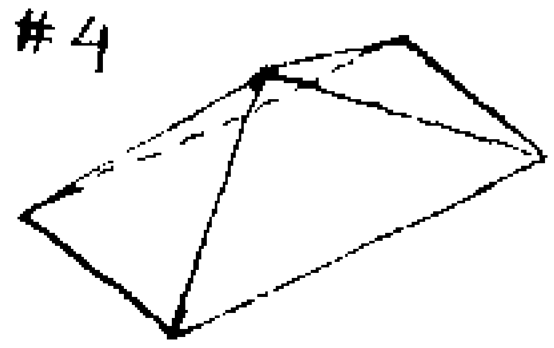


SQUARE PYRAMID

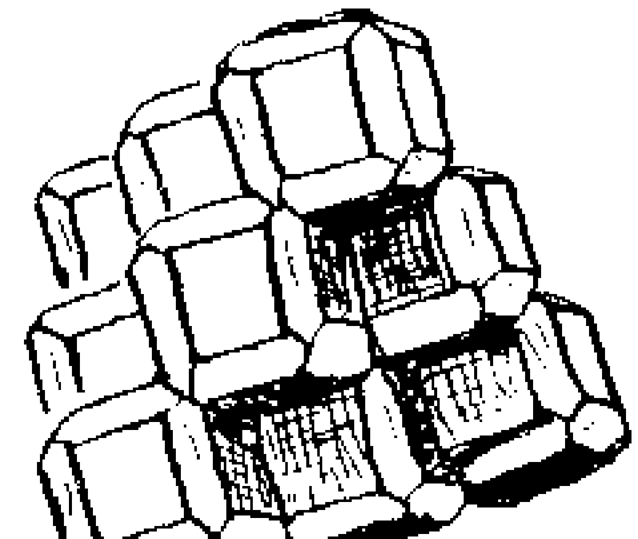
3



4



RECTANGULAR PYRAMID



5 (omit one piece)

TRIANGULAR PYRAMID

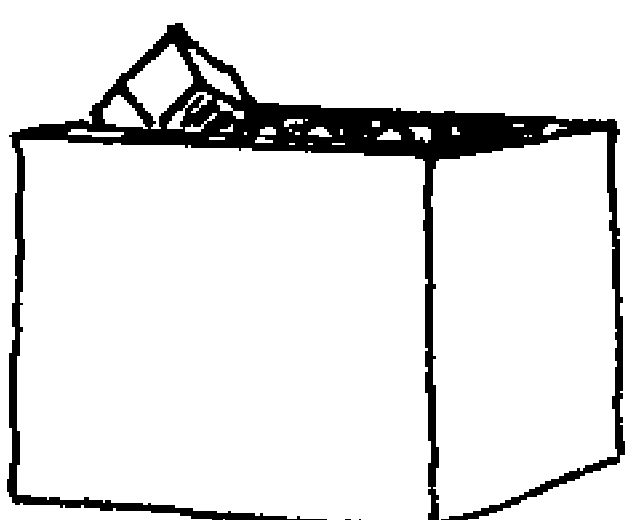
The Setting Hen Puzzle

Same idea as Pyracube. Four puzzle pieces made up of fourteen rhombic dodecahedra fit inside a cubic box. Perhaps best explained (if that is the right word) by quoting the instruction sheet:

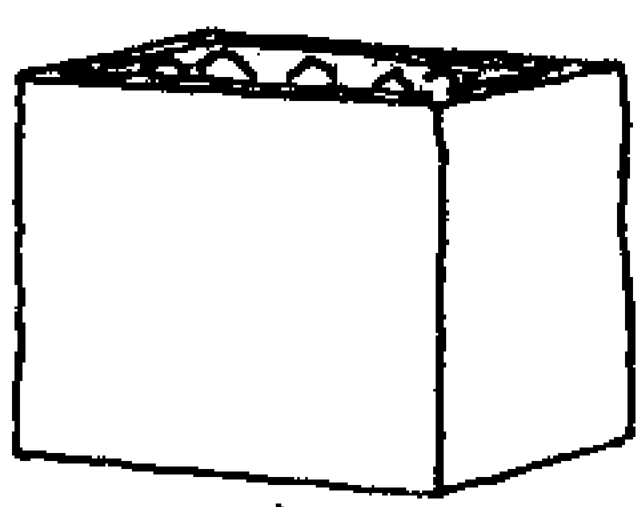
"As you can see, Mrs. Hen is setting on her nest with just her head poking out above one corner, no doubt on the lookout for Mr. Fox. She wants to be able to duck and hide so that no part of her or her chicks shows above the top edge of the nest. It's pretty hard to do with such a big family, but can you show her how? Suggestion: Dump all the pieces out and construct a pyramidal pile with a square base. It is sure to be just the right height. Ooops - doesn't the base quite fit in the box? What a shame! Nice try. Now start all over again. There are at least three ways to fit all the pieces completely inside the nest. After you have solved the square pyramid and the box problem, omit one piece and make a triangular pyramidal pile.

"Additional notes for the precocious, the curious, and the mathematically inclined: The rhombic-dodecahedral blocks are made from one-inch square stock with eight saw cuts - can you see how? The inside dimensions of the cubic box are nominally $2\sqrt{2}$, (the corners of the blocks are sanded down for easy clearance). The pieces will also pack into rectangular boxes having the following dimensions: $2\frac{1}{2} \times 3 \times 2\sqrt{2}$, $2 \times 3 \times 2\frac{1}{2}\sqrt{2}$, and $2 \times 3 \times 2\sqrt{2}$. You might want to make a set of boxes with these inside dimensions."

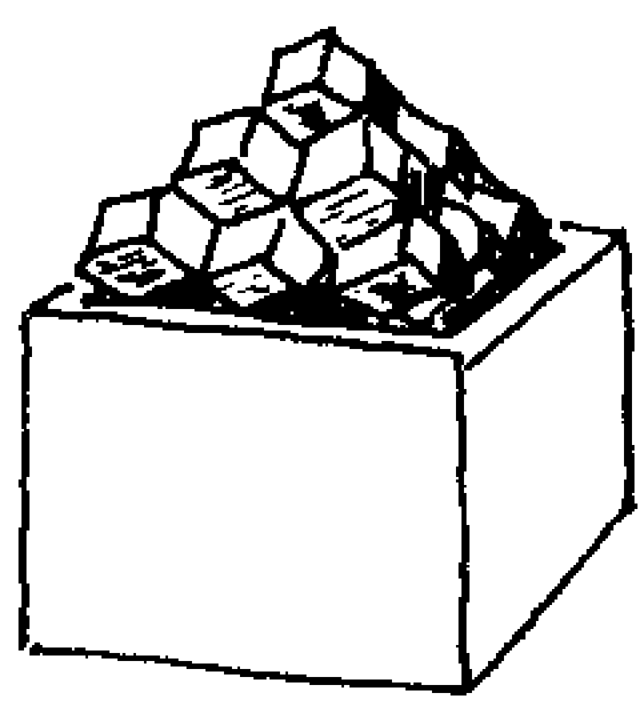
Rather than show the construction of the pieces, I will let the reader try to figure them out - a puzzle within a puzzle. If you can't, you can probably come up with some new and better puzzle idea of your own.

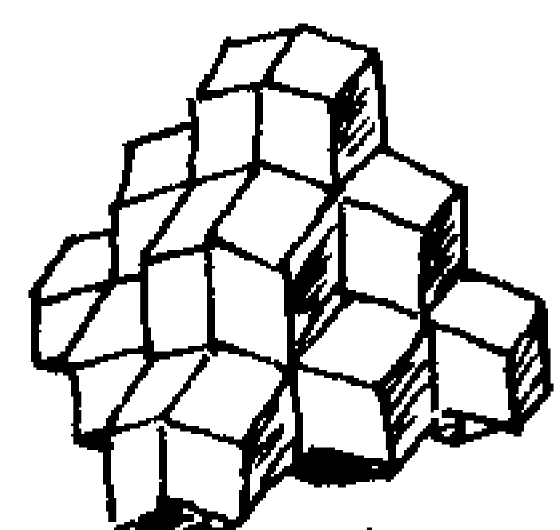


start



hiding

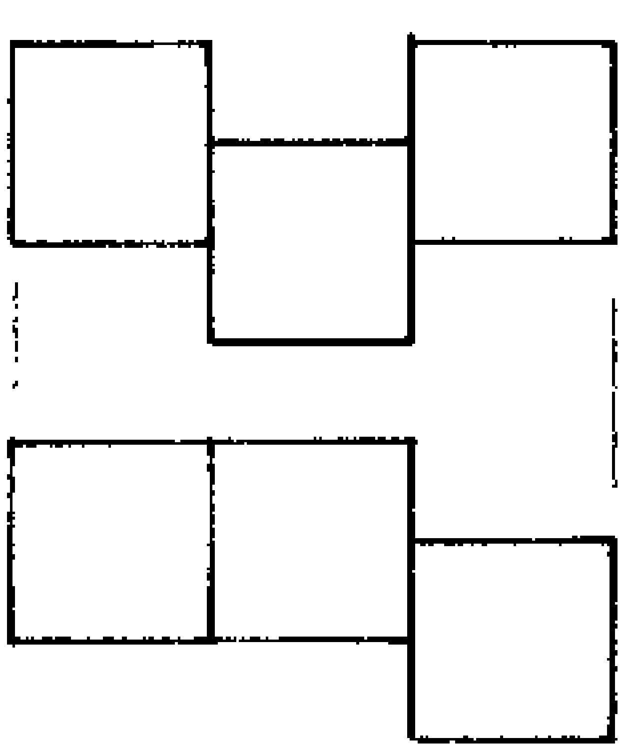


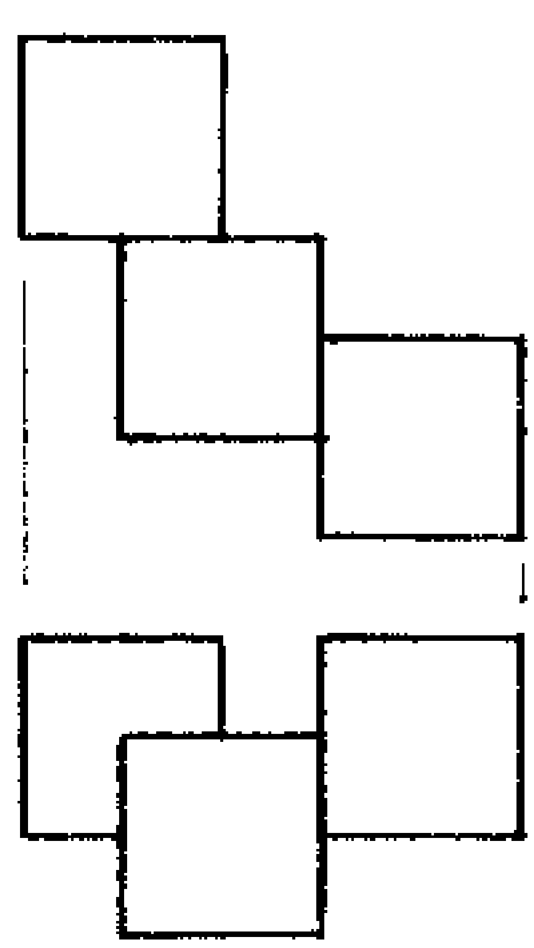


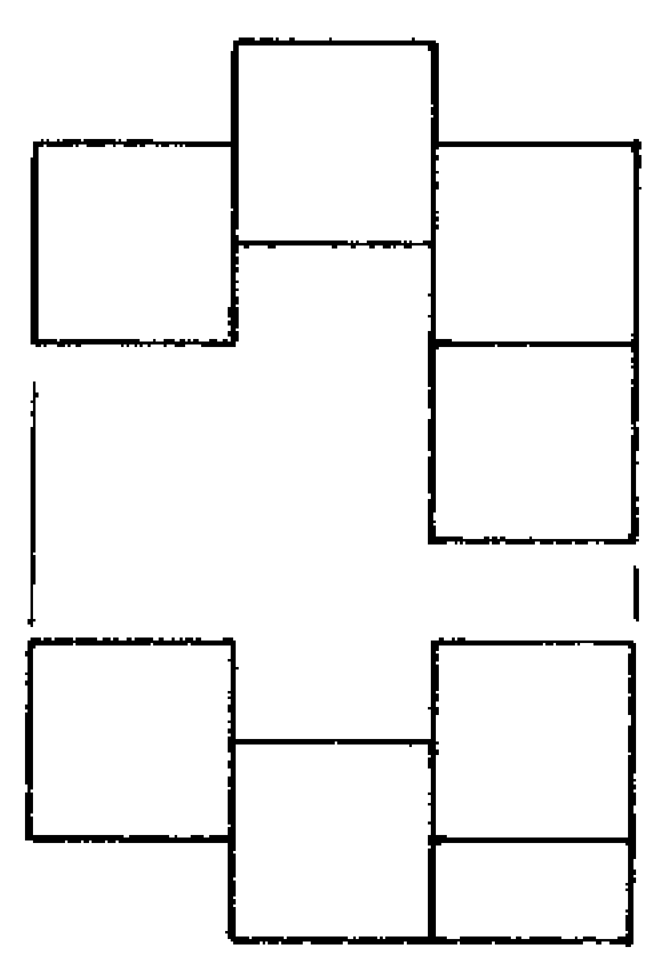
triangular pyramid will fit inside the box

Three-Piece Block Puzzle

Glue ten cubic blocks together into three pieces to make a difficult interlocking triangular pyramid puzzle. Common sense says this is impossible, but common sense is wrong in this case. This amazing little puzzle has baffled experts. The drawings below contain all the information you need to make it. It is drawn on quadrille paper, so half scale if you use one-inch blocks. Remember, it is interlocking, so all measurements must be accurate. Ordinarily a puzzle like this would be glued in assembly , but then you would miss all the fun of solving it.



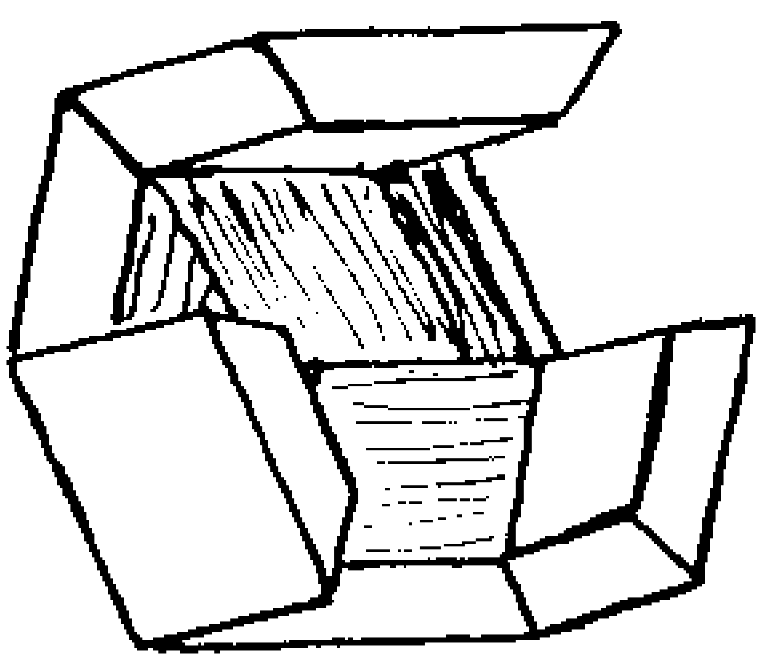


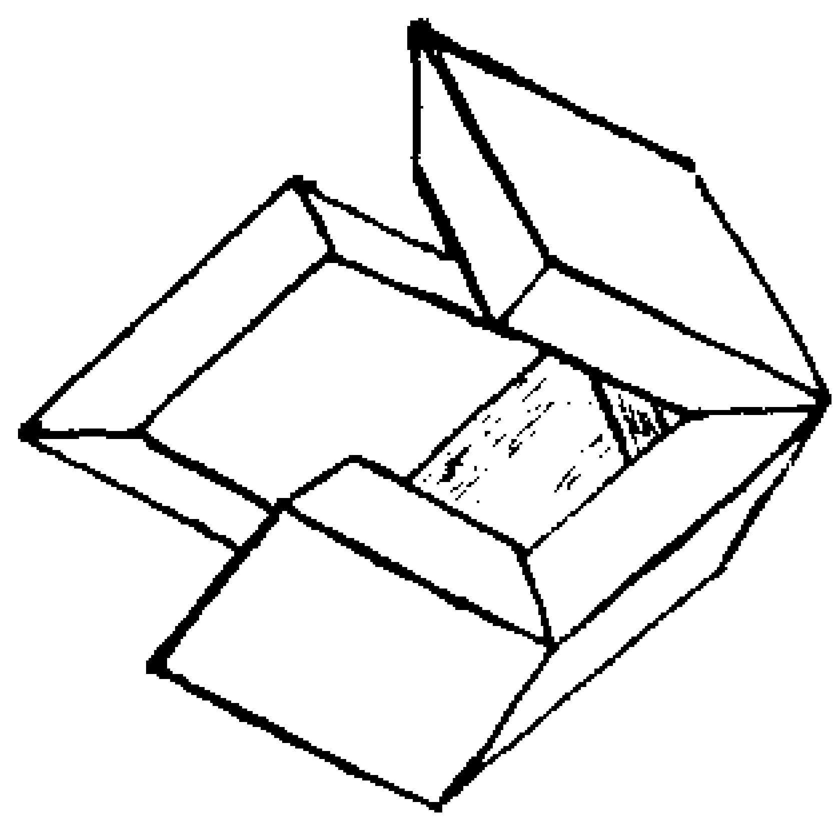


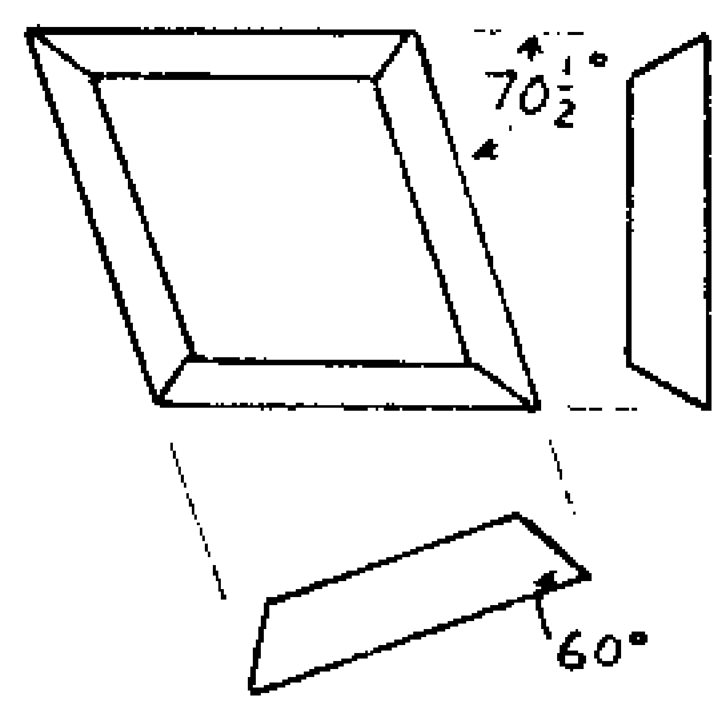
Pennyhedron

A fundamental rule of puzzle design states that the novelty of a puzzle varies inversely with the number of pieces. We have just described an unusual and challenging puzzle of only three pieces. Now, how about two pieces?

When my kids were quite small, they used to spend hours in my shop patiently gluing together little scraps of fancy woods to make "puzzles" for their friends. One time we had a lot of scrap rhombic blocks which they industriously glued together all different ways. Then they got me interested, and together we arrived at a simple little two-piece hollow box. It has two mirror-image halves made of six blocks each which fit together with obviously no difficulty whatsoever to make the hollow block. If made accurately so that there are no cracks to reveal the construction, and with just a little friction, most persons will find it just about impossible to disassemble. The reason is that they will grasp randomly with thumb and forefinger of each hand and pull. It will never come apart that way, because you will always have both pieces in each hand. Only by using an unnatural three finger grip will it come apart. Since there are only four possible axes, this is done easily by random trial and error.

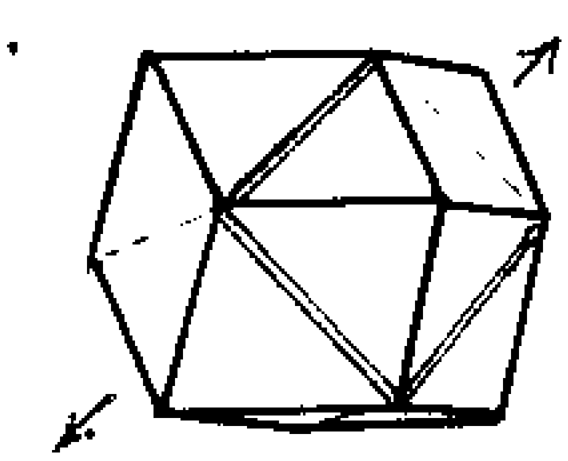






My kids made and sold these for a couple years. They used to put a penny inside, hence the name. I think they used up all the scrap and got interested in other things at about the same time, and production ceased. Years later I became interested again and revived the puzzle for a while with all sorts of variations. The only limit here is your imagination. There are truncated and stellated ersions, rounded, three-piece, nesting sets, different color symmetries, on and on. There was one nesting set of four, the smallest being not much bigger than a pea. The smaller ones we called Minihedrons - a truncated Minihedron in three contrasting woods is shown on the cover, together with an amusing variation of the Pennyhedron. Close inspection of the photo will reveal that it has extra joints. It is made of 24 tetrahedral blocks, two of which make one rhombic pyramidal block. There are two versions. One is the standard version which comes apart with the secret three-finger grasp. The other look-alike comes apart with the common thumb and forefinger pull. Naturally my kids could do the tricky version, but the new easy version had them completely baffled! (Can't tell which one is in the photo.)

To make the Pennyhedron, I suggest using good quality plywood. Saw out long strips with both edges beveled at 60 degrees, taking great care to keep the width uniform. Saw the strips into blocks with the table saw tilted at 60 degrees and the miter gauge set at 70½ degrees. All twelve blocks must be identical and equilateral. Hold together with tape and then glue. Use the first as a gluing jig for the second, trying to make each one more accurate than the one before. If your gluing jig is solid, one jig accommodates all sizes. Additional directions are found in the Nov. 1984 issue of Fine Woodworking.

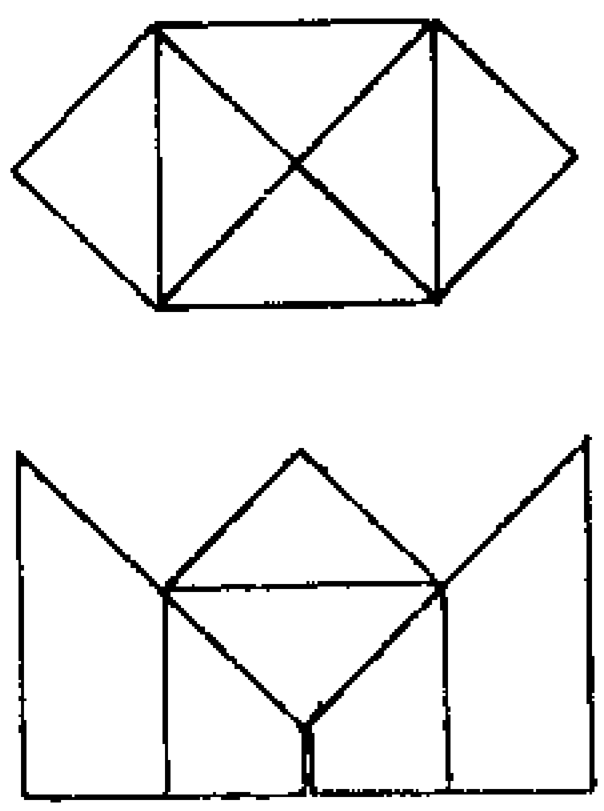


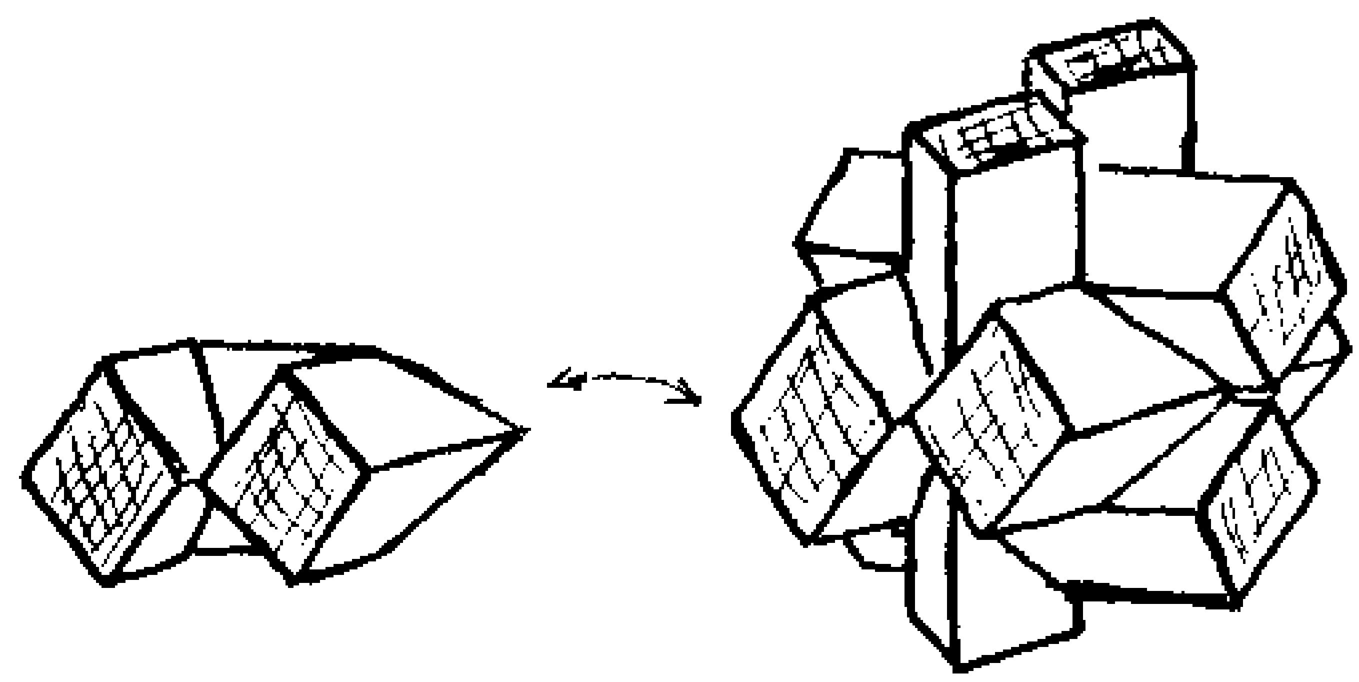
"easy" version
showing cleavage

Pseudo-Notched Sticks Puzzle

In the same vein as the trick version of the Pennyhedron is this absurdity. Anyone familiar with the common diagonally notched square sticks puzzle (page 41) knows that the simplest way to disassemble it, especially if it tends to be tight, is to grasp any opposite pair of sticks by their ends, wiggle them and pull, and the whole thing flies apart. This version also has six identical pieces and looks exactly the same when assembled, but when you grasp what appear to be opposite sticks to disassemble it, all you are doing is pressing it ever more tightly together, and it has the feel of being glued absolutely solid. Only when you grasp in a manner that seems to make no sense at all, it comes apart with ease!

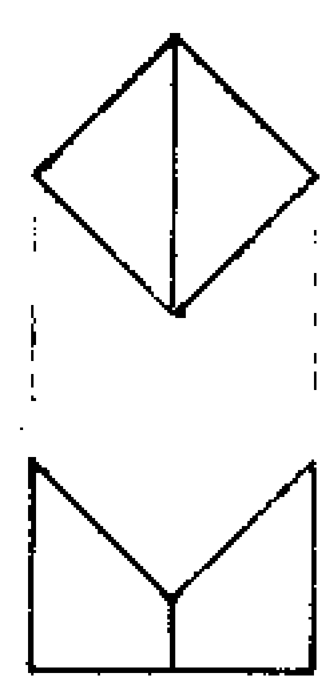
By this stage, the scale drawing of the piece should be sufficient guidance. To be effective, it should be made accurately of stable wood for a smooth snug fit.

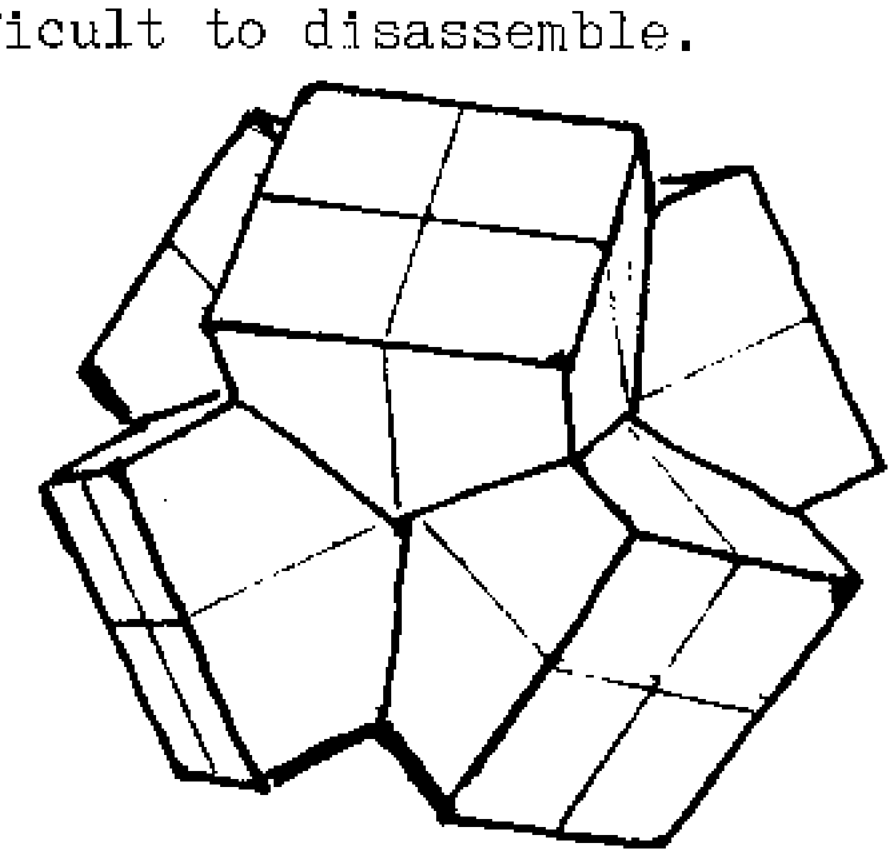




Square Face Puzzle

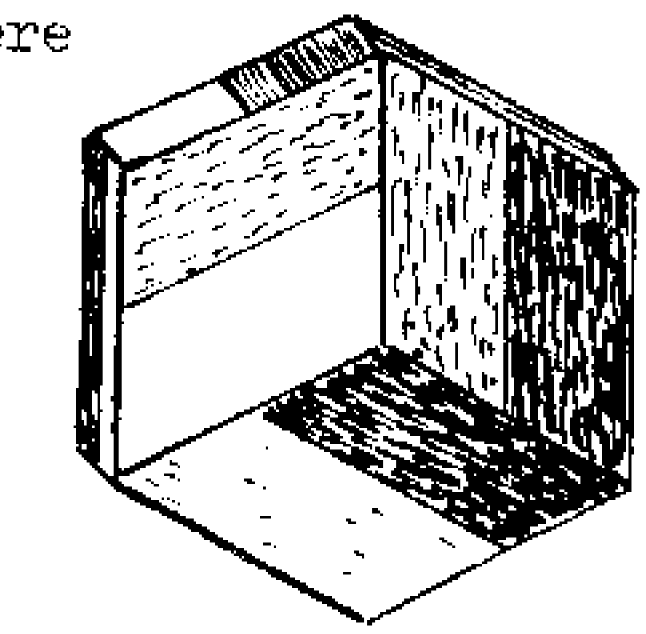
A new inspiration which arrived just in time to be included in this edition of Puzzle Craft. This puzzle is made by first making either the diagonally notched square sticks puzzle (page 41) or the Pseudo-Notched Sticks puzzle (above) and then adding twelve more notched blocks. Six of these are glued on their end and six on a side, such that the six resulting puzzle pieces are all dissimilar and non-symmetrical. There are two solutions. I stumbled upon this because I had a Pseudo-Notched Sticks puzzle that was too loose and I was trying to salvage it. If made with a snug fit, this puzzle is very difficult to disassemble.





The Square Face puzzle is shown on the cover right beside the Three Pairs puzzle, to which it bears a close superficial resemblance. This was done to illustrate a point. The fact that many of these puzzles have intriguing polyhedral shapes (and are made of exotic woods with symmetrical grain patterns) is really supposed to be incidental to their function as puzzles. The shapes always result from the puzzles, not the other way around. When you try to reverse the process, the puzzle design usually becomes contrived and incongruous. The Porter patent (page 8) is a perfect example. So here is an interesting case where two puzzles happen to come out in the same shape, even though internally and functionally they are completely different. By the same token, two puzzles can look completely different (Diagonal Cube and Augmented Four Corners) and yet be essentially the same puzzle.

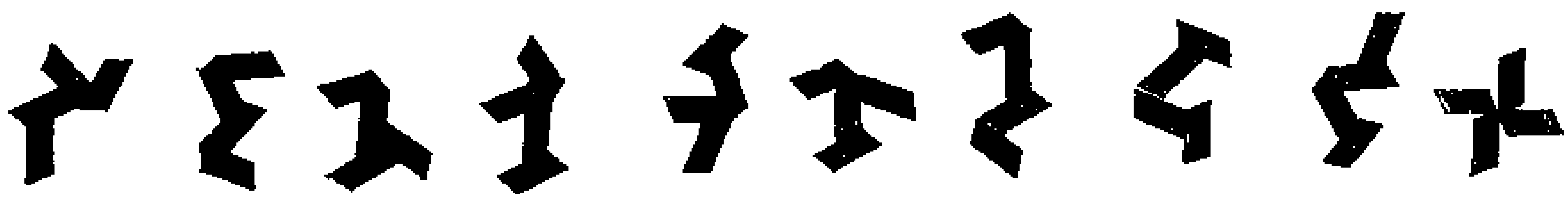
The Garnet Puzzle



The instruction sheet for the Garnet is reproduced here verbatim:

The GARNET Puzzle consists of six puzzle pieces which assemble in an interlocking configuration to form a solid rhombic dodecahedron with bisected faces. Each puzzle piece is made up of four blocks joined together different ways, and each block has the shape of a skewed rhomboid pyramid.

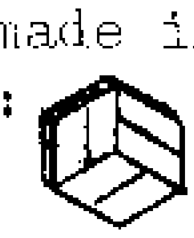
If you consider all practical ways that the four blocks might have been joined, you arrive at a set of ten puzzle pieces. These are shown schematically below as viewed from the inside:



A B C D E F G H I J

One object of the design was to find a set of six dissimilar pieces which assemble one way and essentially one order only. A laborious investigation of the 210 possible combinations has (so far) revealed only two satisfactory combinations - ABCDEF and ACDEFG. Both versions have been or are in production.

Disassembly may be accomplished by randomly pulling in different directions until you discover the one sliding axis which separates the assembly into two halves. Or you may prefer to carefully study the pattern of dissection and see if you can figure it out. This puzzle is normally made in six dissimilar woods - one wood for each piece. This is a departure from all previous designs of mine, and now you see the reason why.

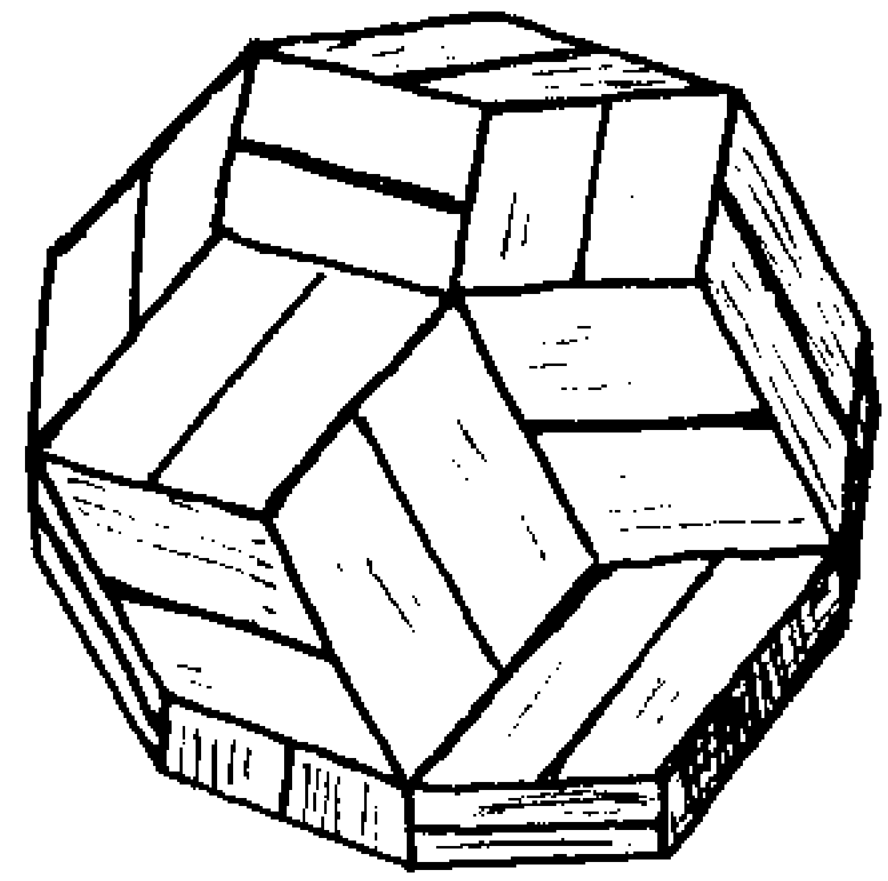
(Note: This puzzle was first produced in Feb. 1984. All those made in 1984 were the mirror image of the version shown here; i.e. like this:  This revised instruction sheet applies to all those made after Jan. 1985.)

This puzzle has many interesting variations, some of which are still being explored at this time. Although the investigation of the 210 possible combinations was believed to be systematic and thorough, it is possible that other interesting designs may have been overlooked, especially if three-block and five-block pieces are also considered. There are truncated versions which together with different color combinations create some surprising and intriguing new geometrical forms. The possibilities of augmented versions are especially interesting. There are stellated versions and puzzles nesting within puzzles in large number and confusing variety. One such version has eight pieces and is very difficult. Even more complex variations are no doubt possible.

This puzzle is especially suitable for those who like to tinker with their own puzzle designs. It is one of the few so-called polyhedral puzzles that does not require accurate gluing jigs. A satisfactory fit may be achieved by first assembling the 24 blocks carefully with tape and rubber bands, and then selectively gluing the blocks one at a time. Sawing the blocks from 30-60-90 degree triangular stock requires a simple but accurate saw jig to saw the ends at a 60 degree angle (page 56) and exactly the right length. An accurately made Garnet may be used as a gluing jig for making another. Smaller or larger ones may be made using the same jig.

The Garnet shown on the cover is made of six contrasting woods: ebony, walnut, breadnut, peroba rosa, sumac, and satinwood, with the light, dark, and reddish woods all being opposite each other.

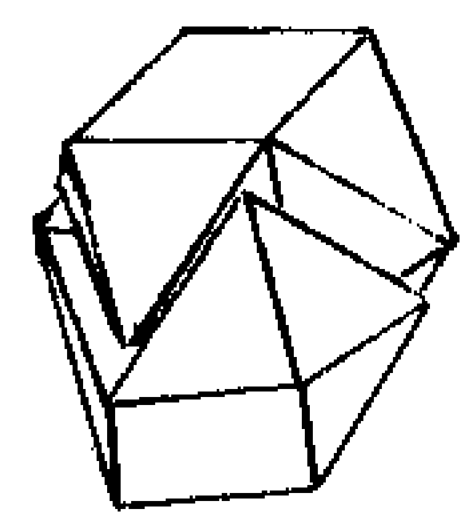
Design No. 72



By analogy, we would expect that a giant version of the Garnet should be possible made up of sixty blocks in the form of a 30-faced triacontahedron. If we consider a puzzle made up of ten pieces of six blocks each, we find there are 45 usable pieces. The number of possible sets of ten is some 20 billion. With this number of possible sets to choose from, how many assemble into interesting puzzles? A laborious search by both John Loeser and myself has failed to discover any so far, and indications are that perhaps none are possible.

One experimental version is shown on the cover. It has five dissimilar non-symmetrical pairs of pieces which assemble in two halves, just like the Saturn puzzle. This particular one is made up of twelve different kinds of wood arranged in color symmetry. Although not very satisfactory as a puzzle, it makes quite an attractive sculpture.

Peanut Puzzle



The idea for the Peanut puzzle comes from the two-piece dissection of the rhombic dodecahedron shown at the bottom of page 56.

We have mentioned puzzles made up of polyhedral blocks which interlock to form some solid, (Four-Piece Pyramid, Octahedral Cluster, Three-Piece Block). These can be quite challenging, but after the one solution is learned, there is nothing more to be done with them. We have also mentioned polyhedral puzzle pieces which make many different shapes limited only by your imagination (Truncated octahedra, Pyracube, Snowflake), but none of them interlocks and many require a box. Is it possible to design a simple interlocking puzzle polyhedral puzzle which makes many different interesting and challenging shapes?

By joining two half-blocks on different faces, dissected as shown, and excluding certain pieces because of symmetry and various other reasons, we arrive at a set of twelve possible puzzle pieces. Aided by a computer, Mike Beeler has found one and only one set of six pieces which will construct all of the following:

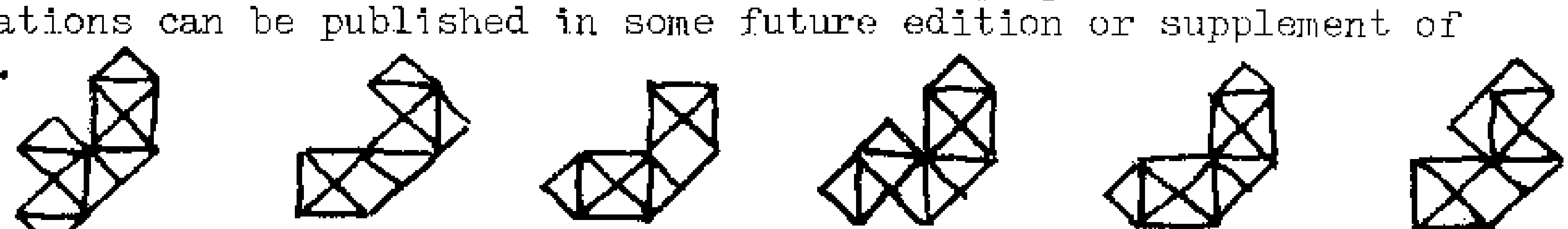
three pieces - Triangle (1 way)
four pieces - Square (2 ways), Tetrahedraon (1 way), Diamond (1 way)
five pieces - Square pyramid (4 ways)
all six pieces - Octahedral cluster (2 ways), Hexagonal ring (2 ways)

as well as numerous other animated shapes.

(In a preliminary version of this puzzle, a two piece construction was possible called the Peanut. That construction is no longer possible with this set, but the name seems to have stuck.)

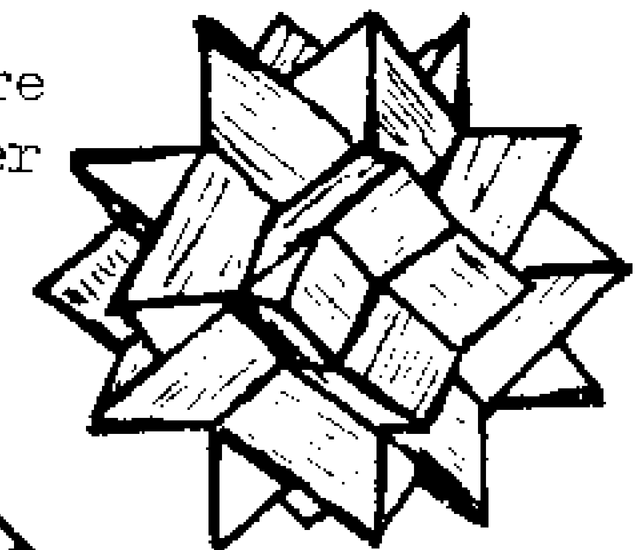
In order to derive the maximum pleasure from this delightful puzzle set, the eight blocks which make up each puzzle piece must be very accurately sawed and glued. This is quite a task, and it is doubtful that this puzzle could ever be manufactured commercially. For the home hobbiest who has made it this far in Puzzle Craft, this is perhaps the best puzzle design I have to offer.

Each half-piece is made up of two tetrahedral blocks and two special blocks made with the Modified Diagonal Jig described in the woodworking section. One half-piece accurately made serves as a gluing jig for others. Joining the half-pieces is what requires the most accuracy. Perhaps a proper instruction sheet with illustrations can be published in some future edition or supplement of Puzzle Craft.

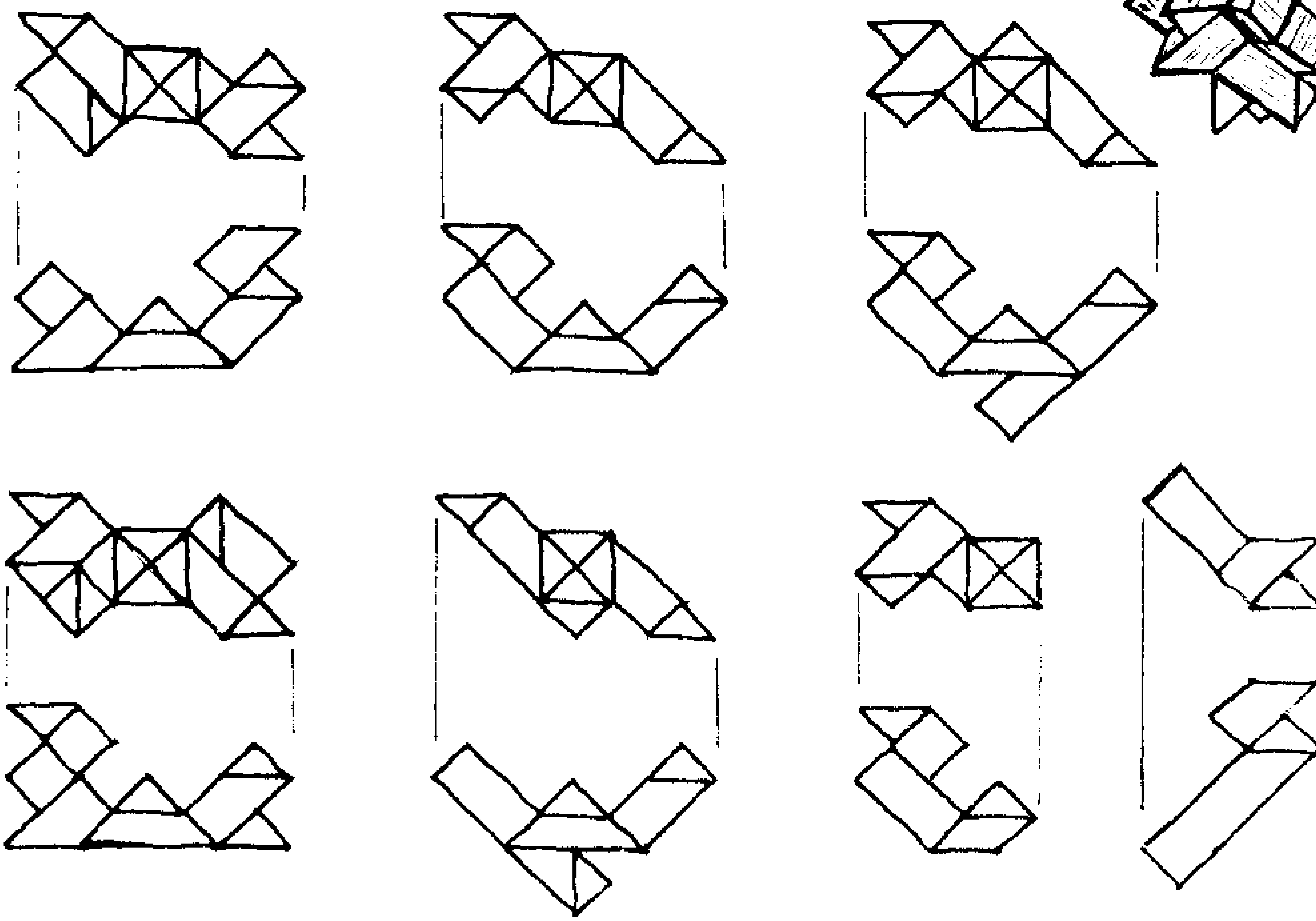


The Third Stellation Puzzle

This unusual seven-piece puzzle combines the combinatorial problems of one like the Twelve Point with the surprise factor of one like Three Pairs. In other words, it is very difficult and confusing. It forms the beautiful third and final stellation of the rhombic dodecahedron, thus closing out that line of development in grand style.



The six-sided center blocks and triangular stick segments are components already described. It is not easy to make. The cover model is in Honduras mahogany.

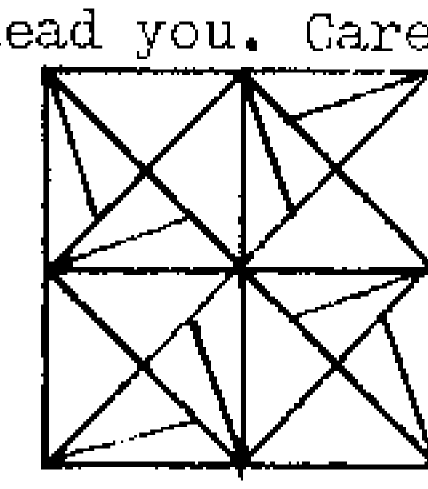


The Queer Gear

If you check this text against the cover photo, you will find that all but two of the puzzles illustrated have been described. The Queer Gear was stuck in there as a joke and to make a point. It is but one among hundreds of experimental models cluttering up my shop. The design was never recorded and is probably not interesting. The puzzle on page 66 of Creative Puzzles of the World is another example. Some passerby picked it up one time and somehow it found its way into the book, to my surprise. The point is, with the tools and skills described in Puzzle Craft, you can make up new designs of your own without limit, and every once in a while some clever new idea may emerge.

The Split Star

This puzzle bears a superficial resemblance to the familiar STAR puzzle, but as we have pointed out this means nothing and can only mislead you. Careful inspection reveals additional lines of dissection in strange places. This last minute addition has six complicated pieces very difficult to describe, to illustrate, to assemble, and even to disassemble. See if you can figure out how it is made, or wait for details in some future edition of Puzzle Craft.



Part 3 - Woodworking Techniques

(First published Jan. 1982, revised Dec. 1984, reprinted Aug. 1985, Oct. 1986.)

In this section, we will look at some of the woodworking techniques used for producing puzzles described in Puzzle Craft.

Lumber

Satisfactory puzzles can be made from a wide variety of woods which are readily available from lumber yards. Clear white pine is very easy to work, but is too soft for hard use, also its pitch tends to rapidly gum up your saw and sander. Yellow pine is harder, and has very attractive grain. Poplar is soft and easy to work, but does not give an attractive finish - I use it often for experimental work. Douglas fir is inexpensive and readily available, but try to find boards with growth rings close together and free of knots if you can. If your local yard sells mahogany, it is probably Philippine, which is the cheapest, softest, and least desirable type. You can usually find a better selection by going to a millwork shop and buying their leftovers.

After you have acquired some proficiency, you may wish to try some harder and more desirable woods such as walnut, cherry, oak, or birch, to name but a few. For puzzles such as the checkerboard type, which require a light and dark wood, birch and walnut is a good combination. Maple is a good light wood, but its hardness makes it more difficult to work than the others.

For really fancy work there are the so-called exotic woods such as ebony, rosewood, bubinga, etc. You will find many suppliers of these woods with ads in woodworking magazines. One of the oldest and best known is Constantine's, 2050 Eastchester Road, Bronx, NY 10461.

The way I got started using the exotic woods was that I needed different colored woods for puzzle designs having multi-color symmetry. For three colors, such as in The Star Puzzle, one can use a light wood (limba, satinwood, primavera), a dark wood (rosewood, ebony, benge), and a reddish wood (padauk, peroba rosa, bubinga). For a fourth color, such as in the Four Corners Puzzle, one can use a yellow wood (Osage orange, difou), or a striped wood (zebrawood). The Jupiter Puzzle requires six different colors, and woods with distinctive colors such as purpleheart, sumac, or the bright green variation of poplar may be used to advantage. An entire book could be written, and probably has been, on just the various properties of woods - a fascinating subject, but we must move on.

The problem with listing the properties of various species of woods is that there is often as much variation within a species as between different species. Anyone who works with wood soon learns to keep an eye out for choice pieces of wood for certain projects, and they can be almost any species. By the same token, individual boards of the so-called exotics may have chronic defects which make them useless for puzzle making or anything else, so you have to keep an eye out for them too. Don't waste your time with them - throw them in the firewood pile.

Seasoning the Lumber

Whatever lumber you use, you will want to make sure it is well seasoned, which usually means kiln dried, although several years of air drying may produce perfectly acceptable wood also. Every now and then, someone comes up with the idea of sawing down an old tree in their backyard and turning it into puzzles; but this is rather impractical because of the trouble and expense of getting it to the mill to be sawn and then dried.

Planing the Lumber

Unless you have access to a good thickness planer, you will certainly wish to buy your lumber already planed to some specified thickness, which is the usual way it is sold anyway. By far the most common is "one-inch" lumber, which is roughly 3/4-inch thick. Puzzle making is ever so much easier if you can start with boards planed to some exact thickness. To begin with, you will need some instrument for measuring thickness. Vernier calipers will do, dial calipers are better, and a micrometer is better still if you are really serious about this work. Unless you are very lucky, the lumber you buy will not be anywhere near the exact thickness you would like it to be. However, perhaps it is all of a reasonably uniform thickness, having all been planed at the same time. If so, and if you expect to make only a few puzzles, perhaps you can adapt your other dimensions to it. Otherwise, the alternative is to plane it a second time down to some exact thickness. An ordinary thickness planer can be set to plane with a consistent accuracy of .001 inch if the lumber is not warped too badly, but don't try to tell that to your local millwork shop - they won't even know what you're talking about. To begin with, they probably do not even have a set of calipers in the shop. Often the knives are not at the same height at both ends of the cutter, so the lumber comes out thicker on one edge than the other.

I used to go around to various shops, trying to find one that was sympathetic to my special requirements. I was very lucky to find one in which they allowed me to actually adjust the planer myself. The trouble with these places is that they do not always have the same man the next time. When I made the mistake of letting the new man see me using a micrometer on the work, he exclaimed: "Look, buddy, this ain't no machine shop!"

Here is how I finally overcame this problem. To begin with, wnen I first started making puzzles, I decided to standardize on a board thickness of 1.000 inches for most of my designs. I buy rough "five quarters" ($1\frac{1}{4}$-inch) lumber, and have it planed to 1-1/16 inch thickness before being delivered. To make one-inch square sticks, for example, I rip them out on the saw slightly oversized and then plane them down to exact size using my own special small thickness planer which will be described a couple pages farther on.

When planing lumber to close tolerances, you have to keep in mind the fact that you are measuring it at a certain moisture content, probably on the high side if it came from the lumber mill recently, and it will be a few thousandths less when fully dried.

Dealing with Warp

This is a major problem. Practically every piece of lumber is noticably warped in at least one of three ways - crosswise, lengthwise, and twist (see Fig. 1).

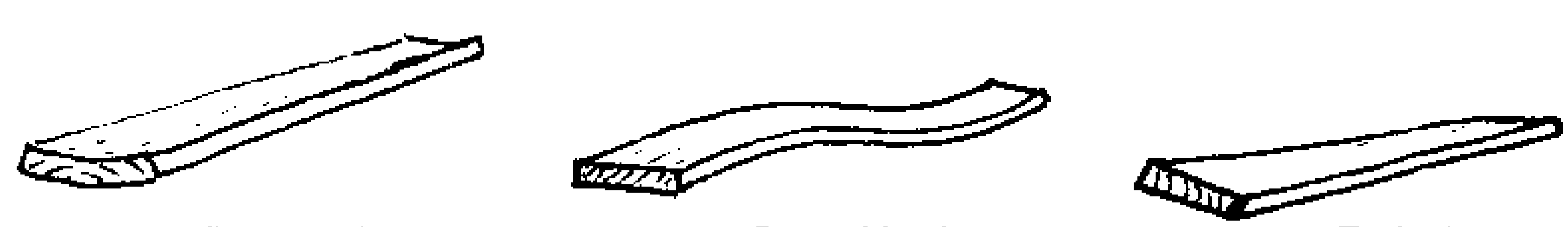


Fig. 1 Crosswise Lengthwise Twist

Of these, twist is the worst, and if it is very bad, you may as well discard it. Lengthwise warp can be tolerated if not too severe, but it can cause inaccuracies in thickness when planing. Reverse curves are the most troublesome, but usually they can be minimized by judiciously cutting the board into shorter lengths. When warped crosswise, which practically every board is unless quartersawn, usually the thickness planer presses it flat while planing, so it emerges from the planer just as warped as when it went in. This can be corrected by first running one side of the board over a jointer to make it flat, and then planing the other side in the thickness planer. This is possible only if the lumber is sufficiently thick to begin with, and even then it may not be worth the bother, as the board will probably warp again later. When ripping any board into square sticks, you should keep in mind the fact that it probably has some crosswise warp which needs to be taken into account.

Storing the Wood

After the lumber is planed, the boards may be sawn into convenient short lengths - say three feet - and stacked in a pile with alternate sides facing up, with heavy weight on top to reduce the warp, or at least prevent it from increasing.

Some thought should be given to the moisture content of the wood in storage. As received, it is probably more moist than you would like it, and you will want to bring it down as close as possible to normal indoor moisture level, whatever that is.

Choice of Wood to Minimize Warp

With all these precautions, warp can still be a problem. Some types of wood are much more prone to warp than others. Most of the domestic hardwoods are bad. On the other hand, the dense oily tropical woods like rosewood, teak, ebony, and padauk tend to be very stable. One of the most all-around satisfactory woods is select straight-grain Honduras mahogany. But even with it, you will have to watch out for the occasional board which for no apparent reason is hopelessly warped and impossible to work with.

Ripping

Now having uniform flat boards of some specified thickness, preferrably slightly oversized, the next step is to rip them into usable sticks. About half of all the puzzles described in this book were made by starting with one-inch square sticks, even those like the Four Corners and Star-of-David, which appear to be anything but orthogonal when finished. Producing accurate square sticks is by no means an easy task, but it is absolutely essential for everything that follows.

If the lumber is quite free of warp, and if you have a good tablesaw with sharp blade and long straight rip fence, with everything set up just right, then you may be able to rip out accurate square sticks directly in one operation. Usually not all of these conditions are met, so you must first saw them slightly oversized and then plane them down to exact size.

For ripping, I have a tablesaw set up to do only that, with table and rip fence firmly and permanently locked in position at exactly 90 degrees, and with a couple of innovations added. One of these is a vertical steel plate mounted just behind the blade and aligned exactly with it, the same width as the kerf of the saw, to guide the stock straight and prevent it from pinching in on the trailing side of the blade. This is unnecessary with some woods, but it is very useful for woods like zebrawood which have internal strains and tend to warp badly every which way when ripped into sticks. The other innovation is a shoe of lignum vitae wood, mounted just beneath the saw table, which rubs lightly against the blade to damp out vibrations. It is adjustable for wear. My blade is carbide, narrow kerf, made especially for ripping.

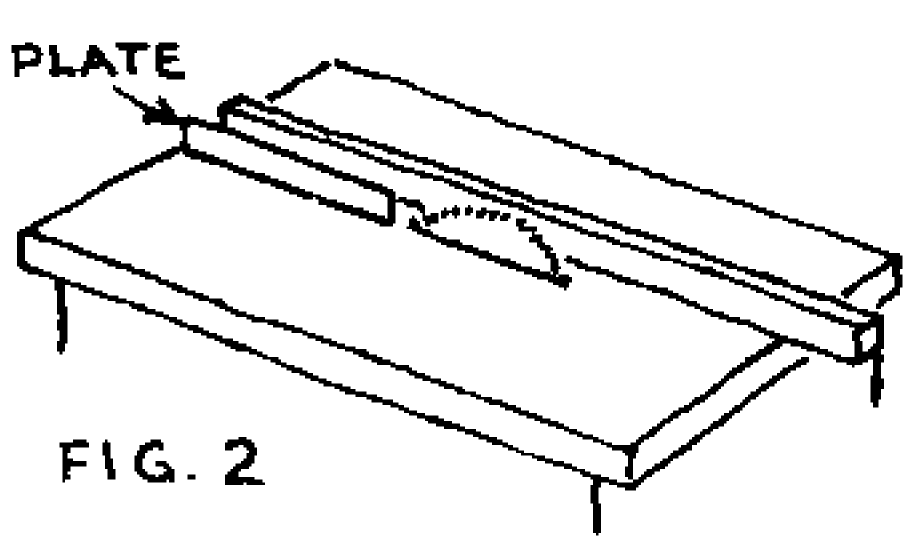


FIG. 2

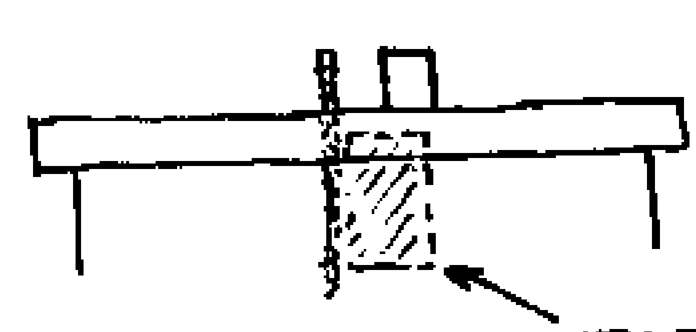


FIG. 3

For ripping thick planks of very hard woods, I will often use my trusty old 20-inch Crescent bandsaw. Bandsaws are not usually noted for accuracy of cut. However, if you have an adequate sized saw with good sharp blade, set at maximum rated tension, with tight guides, you can get very good results. I use only Olympia brand blades, 3/4-inch skip-tooth, with a very accurate factory weld.

The Planer

For planing the sticks down to exact final size, I use an ingenious device which consists of a portable power plane with front shoe removed, mounted securely over an adjustable flat bed, thus becoming a small and very accurate thickness planer.

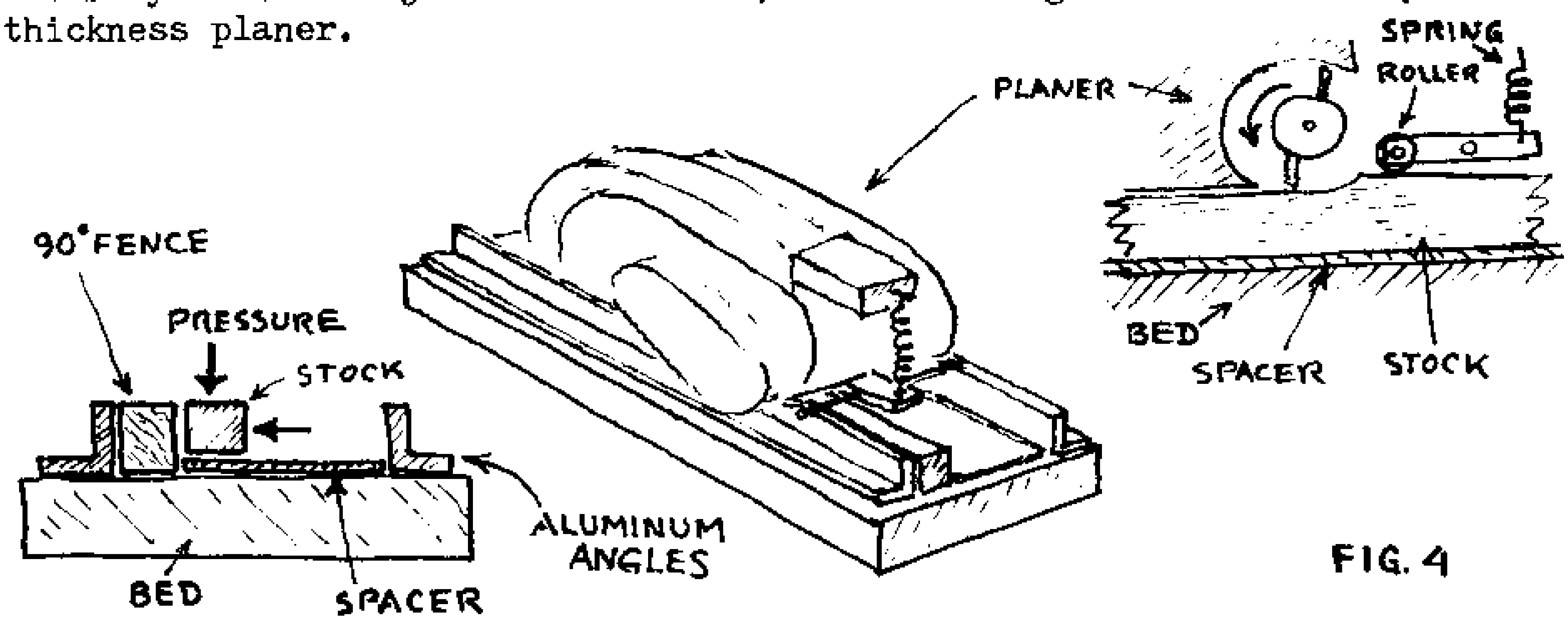
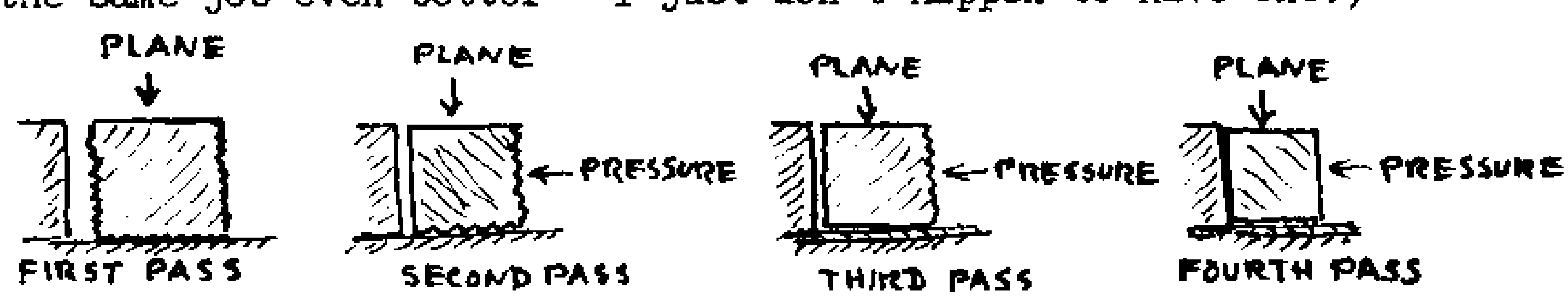


FIG. 4

Here is how it works. Let us suppose you wish to make one-inch square sticks. Start with sticks about 1/32-inch oversized. On the first pass through the planer, you shave the top surface. A small roller with spring tension just ahead of the cutter presses the stick down against the bed. The thickness adjustment (admittedly crude) is made with various plates and shims placed between the bed and the work. Now you rotate the stick 90 degrees counterclockwise and run it through a second time. On this pass, another spring device pushes the surface that was just planed against an accurate 90 degree fence on the left, thus assuring that the first two surfaces are at a right angle. The bed is then adjusted with shims to the final 1.000 thickness, and the stick is run through two more times to finish the job. Many sticks are done in a batch, so it is a fairly fast and efficient operation. (If you have a regular thickness planer, it can probably be set up to do the same job even better - I just don't happen to have one.)

FIG. 5



One of the common complaints when planing hardwoods is gouging and splintering of the surface, especially with really difficult woods like bubinga. This has to do with the type of wood, direction of grain, feed speed, speed and sharpness of the cutter, among other factors which you don't have much control over. One thing you can control is the angle at which the knives are ground. The planer blades in most cabinet shops are ground at a so-called "softwood" angle. To correct this, sharpen the knives by grinding on the front surface, as shown in the drawing at right.

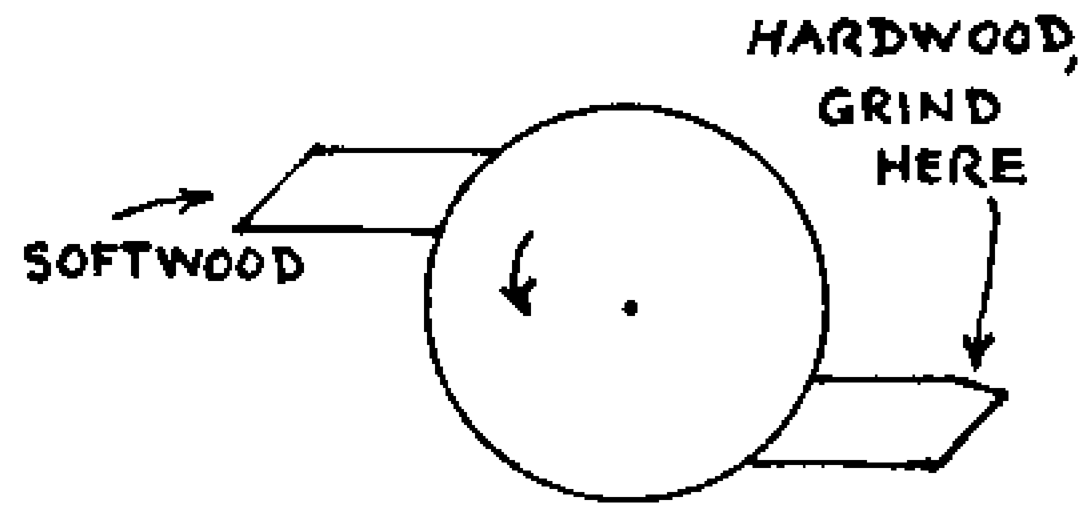


FIG. 6

Drum Sanders

Before I made the planer described above, I used a small drum sander for this operation. It was not very satisfactory, being slow, inaccurate, and unable to handle oily woods without gumming up. Probably the fault was not in the method, but rather in my particular tool. I am told by other woodworkers that a good drum sander is as good as a planer, if not better. Probably the drum should be metal or some other hard material, rather than expanding rubber as was mine, and the whole machine needs to be big and sturdy. Bear in mind that a sanded surface will have a dulling effect on cutting tools in subsequent operations.

Cross-cutting

The final sawing operation is usually to saw the long sticks into various shaped blocks. For this operation, I use an eight-inch table saw which is equipped with a large assortment of special jigs, most of which are placed on the saw table and slide back and forth in the miter grooves. The blade I use is a hollow ground, thin rim (.0625-inch), 150-tooth alternate bevel, hard rim Simonds "plastic cutting" blade (about $60). These have to be sharpened frequently - as often as once a day when sawing tough woods. This is a job for a professional, as a file will not touch them, and is quite a nuisance. Much better would be a carbide blade, if one could be found which produces a smooth cut with narrow kerf. I am told that such saws do exist, but I have never found one in the eight-inch size. You are probably much better off with a ten-inch saw because of the wider choice of blades.

For the casual woodworker, there are "hollow ground" (no set) fine-tooth blades readily available in hardware stores which will do a satisfactory job, and may be discarded when dull.

A circular saw blade is quite flexible, and the only way it can possibly make accurate cuts is to be extremely sharp. The first sign of dullness may be slight errors in the saw cuts. You can also sometimes tell by the sound, resistance to feed, and appearance of the cut. By the time burn marks start to show, it is hopelessly dull.

Radial Arm Saws

If you have a radial arm saw, but no table saw, you may wonder if it can be adapted to perform these operations. I have known of those who have attempted to do this, but I don't believe it was ever entirely satisfactory in terms of accuracy or convenience, so I can't recommend it.

Saw Jigs

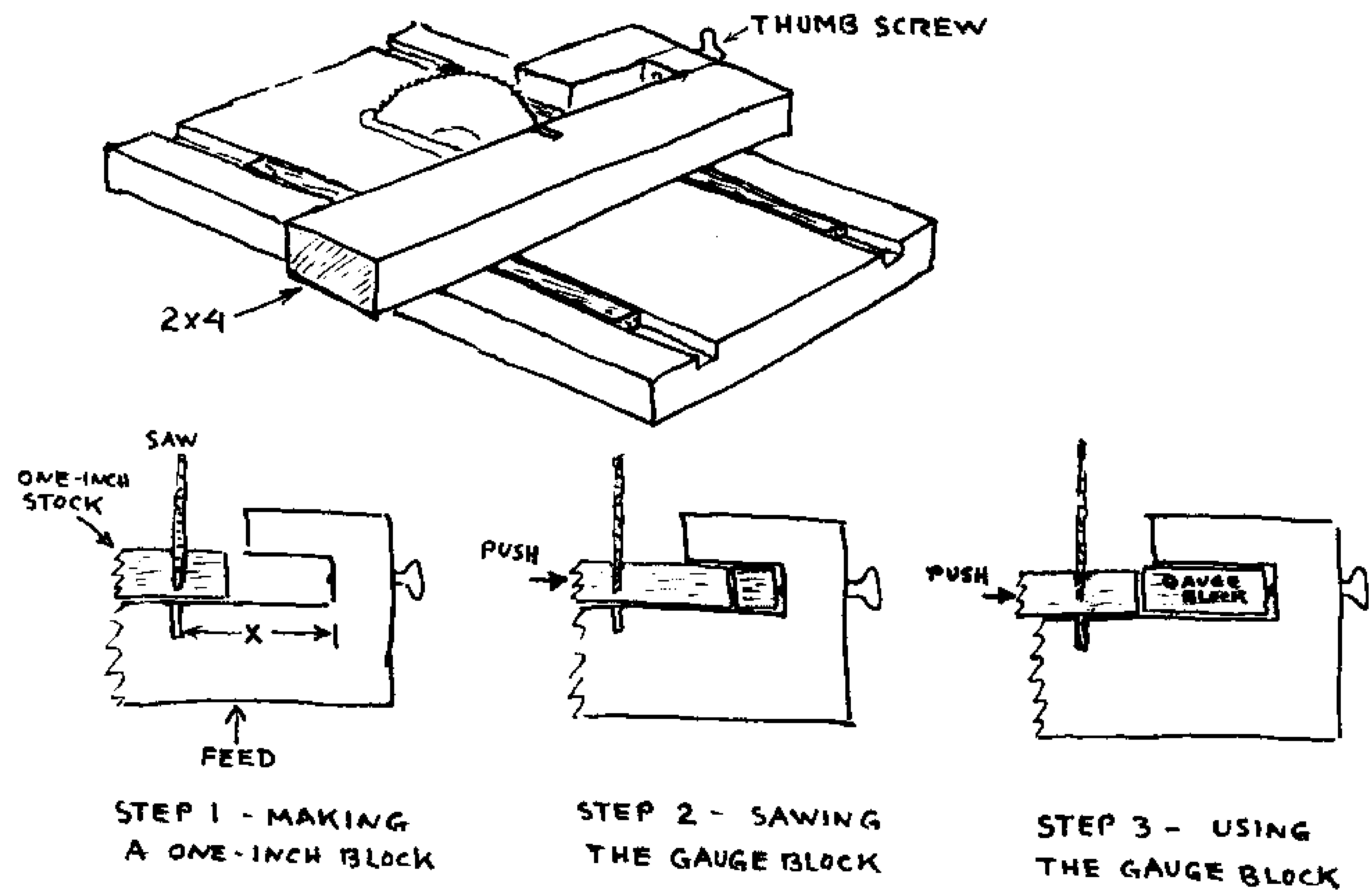
Most puzzles of the type under consideration here are made up of large numbers of identical blocks, produced from long sticks by repetitive crosscuts. For this, specialized jigs are essential. They are truly the key to this whole process.

The Square Block Jig

This is one of the simplest and most useful jigs. It is used for making cubes and rectangular blocks from square stock. A sturdy 2 x 4 block of hardwood about 16 inches long serves as the body of this jig. It slides back and forth in the miter grooves on a pair of runners to which it is firmly attached at exactly right angles. By the way, before you do anything else, you should make sure that the plane of your saw blade is exactly parallel to the miter grooves and perpendicular to the table. Once you determine that is so, lock it firmly in that condition. This saw jig has a couple of smaller blocks of wood attached to its righthand end to form a sort of pocket.

Now let us suppose you wish to use this jig to make one-inch cubes from one-inch square stock. First, you carefully make a block exactly one inch long. Place this block in the pocket against the stop on the right. Now using this block as a spacer gauge, you saw a second block in the jig. If the distance from the saw to the righthand stop is some arbitrary length X, then the second block is X - 1.000. Remove the first block and insert the second block in the pocket. You are now all set up to saw as many 1.000 cubic blocks as you wish. When you have finished, save the gauge block and label it for future use. Other gauge blocks will be accumulated for making every possible length of block you require. A thumb screw provides for fine adjustment, which may be necessary when changing saw blades, as they do not always track exactly alike.

FIG. 7



Obviously, the distance X must be somewhat greater than the longest block you wish to make. Five inches is sufficient for most puzzles described in this book.

A good illustration of this jig, far better than I can draw, may be found in the November 1984 issue of Fine Woodworking magazine.

The Diagonal Jig

This is another very useful saw jig. The variety of intriguing puzzle designs which can be created using it is practically unlimited. Its use was implied at several points in Part 2, starting with The STAR Puzzle on page 41 plus at least a dozen others.

The base for this jig may be a piece of good stable plywood, such as Baltic birch, about a foot square. It slides in the miter grooves on a pair of rails just like the jig on the previous page. Attached onto this base is a V shaped cradle which holds the one-inch square stock at a 45 degree angle of rotation, and feeds it into the saw at a 45 degree angle as viewed from above.

You will probably want to make some provision for slight adjustments to get the angles exactly right. You do not need any expensive machinists' instruments to check any of these angles. Ordinary draftsman's triangles and a little common sense will do the job as well or better. Saw a few test blocks and fit them together. If you do this right, the angular errors accumulate and are much easier to detect.

One of the test pieces you have just sawed out is now installed in the cradle and becomes a stop block. You will want to make this adjustable, at least until you get it exactly right. You are now ready to saw out the six-sided center blocks used in the Sirius, Four Corners, Nova, Prism family, and numerous other related designs. Careful inspection of the pyramidal point where the two diagonal saw cuts meet in the center will show when the stop block is adjusted just right. The square stock is rotated 180 degrees after each cut, and produces these blocks without waste.

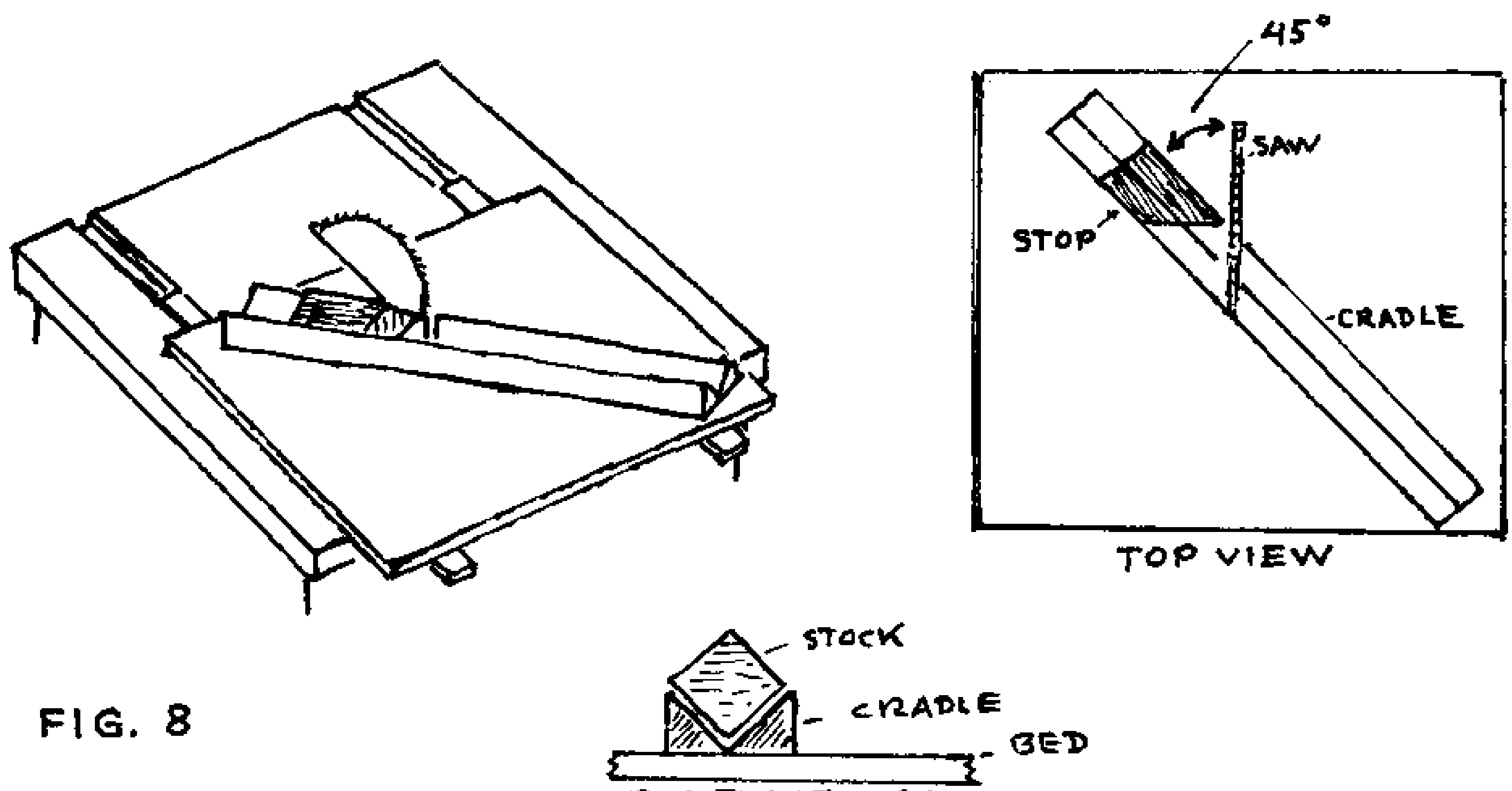
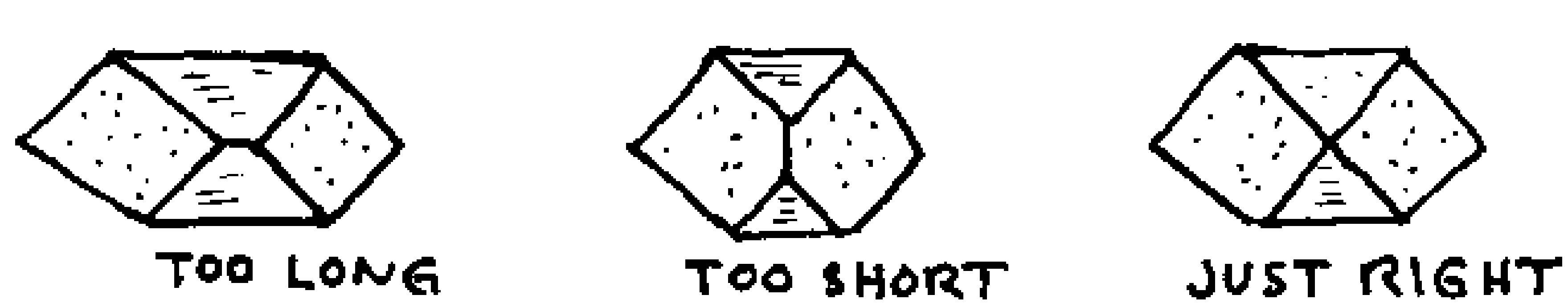


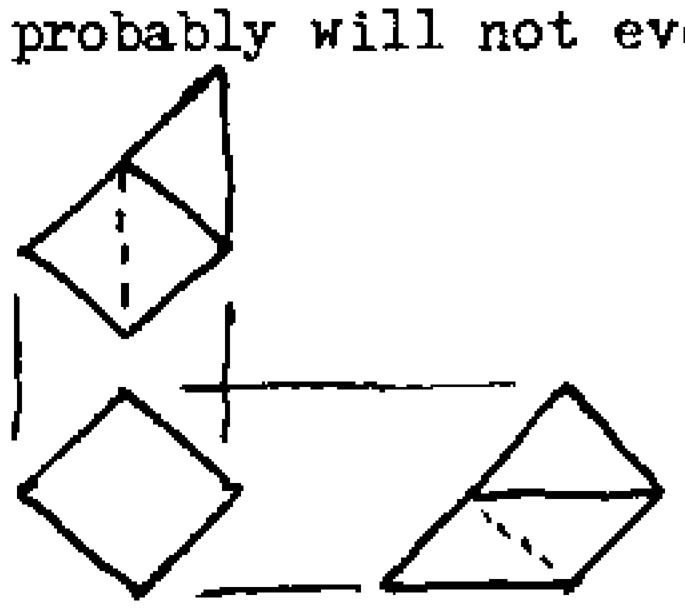
FIG. 8



SIX - SIDED CENTER BLOCK TEST

The diagonal jig described on the previous page produces six-sided center blocks by rotating the stock 180 degrees between saw cuts. The exact same set-up is used to produce the five-sided block referred to as the Four Corners end block simply by rotating the stock only 90 degrees clockwise between cuts. If you have the jig, it is a lot easier to do than to describe. These blocks are used in the Four Corners and Augmented Four Corners puzzles. If the stock is rotated in the opposite direction instead, the mirror image of these blocks is created. The Star-of-David, Rosebud, and Triumph puzzles use both types of blocks. All of these are made without waste.

The tetrahedral blocks used in the Sirius and Star-of-David puzzles are made with this same set-up. First a diagonal cut is made on the end of the stock. Then it is rotated 180 degrees and advanced a short distance until it is stopped by an auxiliary spacer made for that purpose, and the second cut is made. (Don't read this and expect to understand it until you have actually made the diagonal jig and used it. Then it will all be perfectly obvious and you probably will not even need to read it.)



THE FOUR CORNERS END BLOCK
FIG. 9

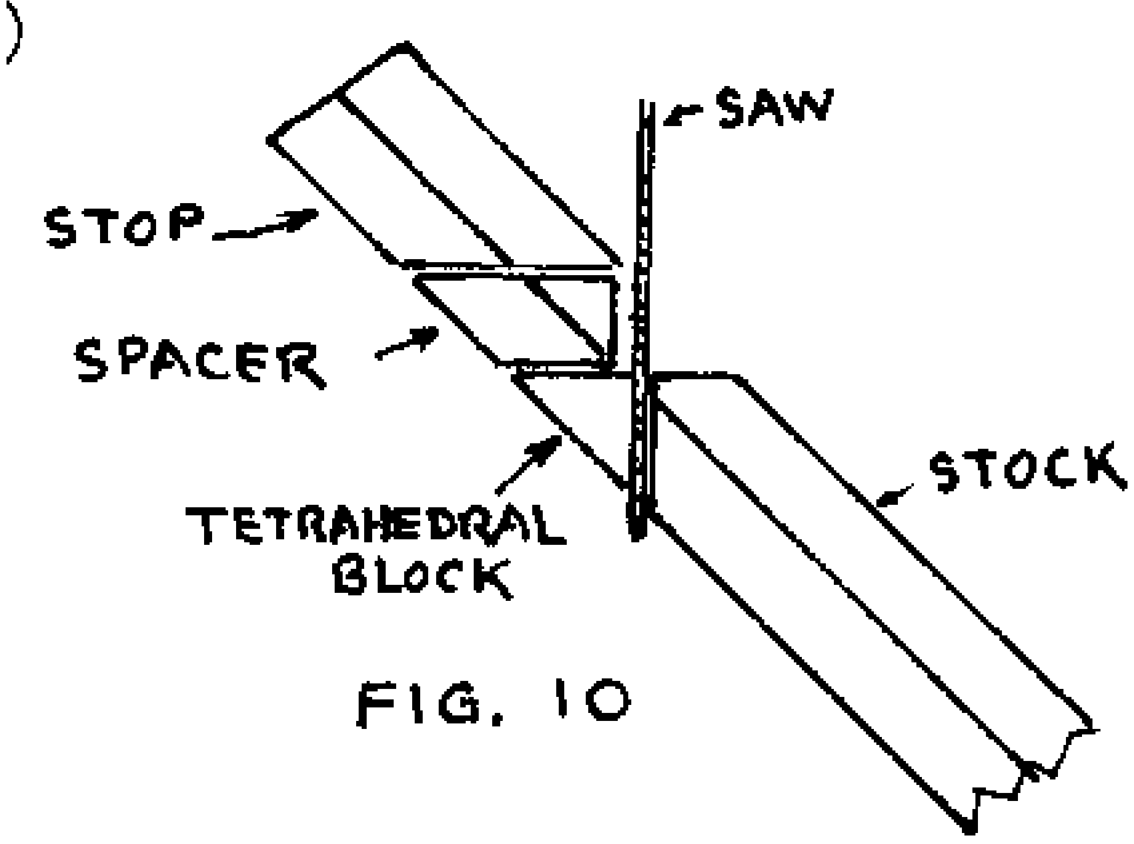


FIG. 10

The Modified Diagonal Jig

This jig is also very useful. Its primary use is for making rhombic-dodecahedral blocks, but it has other uses too. It is essentially identical to the diagonal jig described on the previous page, except that the stop block on the left is removed and a square-ended stop block is fastened far to the right. It works as follows. Place your one-inch square stock in the cradle and against the stop. Make four saw cuts, rotating the stock 90 degrees between each cut. This will bring the end of the stock to a pyramidal point. Now advance the stock a certain distance by means of a spacer block and repeat the process. The first three cuts are only halfway through, and the fourth and final cut severs the block from the stock, making a very neat rhombic dodecahedron. Repeat again and again with more spacer blocks until you have used up the stock.

The length of the spacers is the stock size plus the saw kerf times the square root of 2. For one-inch stock and my Simonds saw, that is 1.502 inches. These blocks were used in my Setting Hen puzzle and one version of the Four-Piece Pyramid. One of the nice things about this jig is that you can use any size stock you wish, with correspondingly longer spacer blocks. The Octahedral Cluster puzzle was made with $1\frac{1}{4}$-inch stock and 1.856-inch spacers.

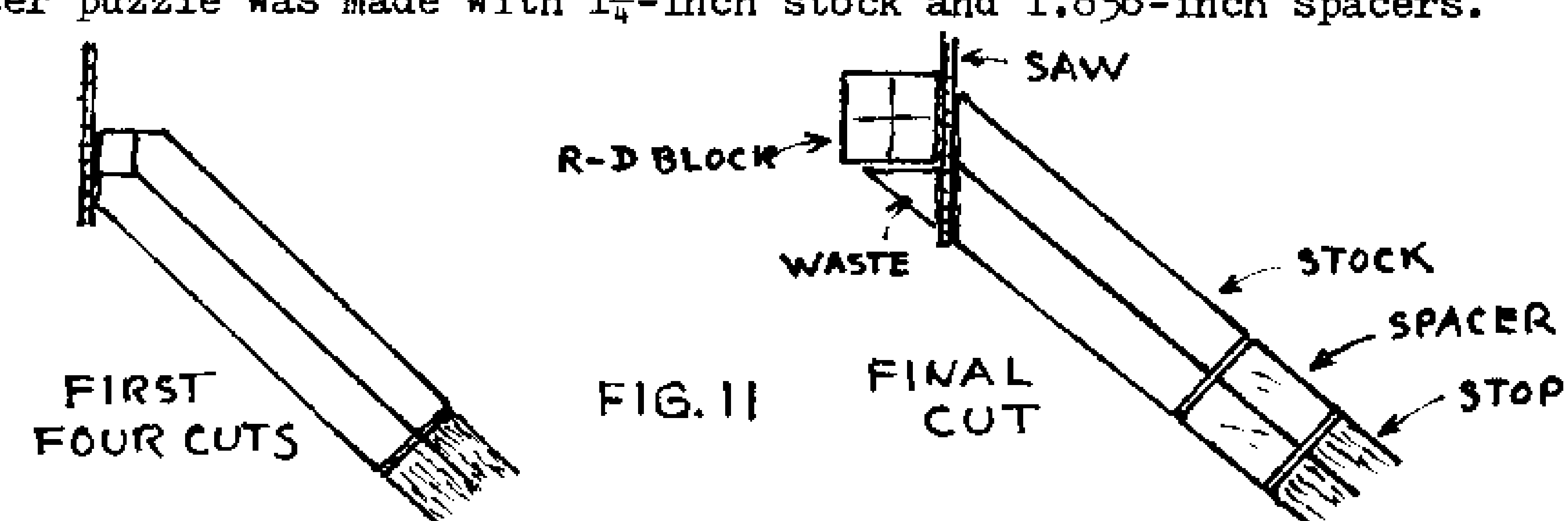


FIG. 11

Truncated Octahedra Jig

A saw jig somewhat similar to the diagonal jig just described is used to make truncated octahedra blocks. It also has a bed which slides on runners in the miter grooves, and a cradle which holds the square stock at a 45 degree angle of rotation. The difference is that the stock makes an angle of 35 degrees, 16 minutes with the saw in the view from above. Also it is a bit more complicated because of the two extra faces.

To make the Truncated Octahedra puzzle, I used 1.500-inch square stock. First, one end of the stock is cut off square before being placed in the cradle. The squared end is then brought up against a stop block just ahead of the saw, and the four corners are sawn off by rotating the stock between cuts. The end of the stock is then cut off at a distance of 1.500 inches from the end using the square block jig of Fig. 7. Finally the severed block is placed back in the truncated octahedra jig the other end to, and the remaining four corners are removed the same way as the first four. This switching back and forth between jigs is tedious, and it is more efficient to have several sticks to work at the same time. The stop block is adjusted such that the eight hexagonal faces are exactly regular hexagons.

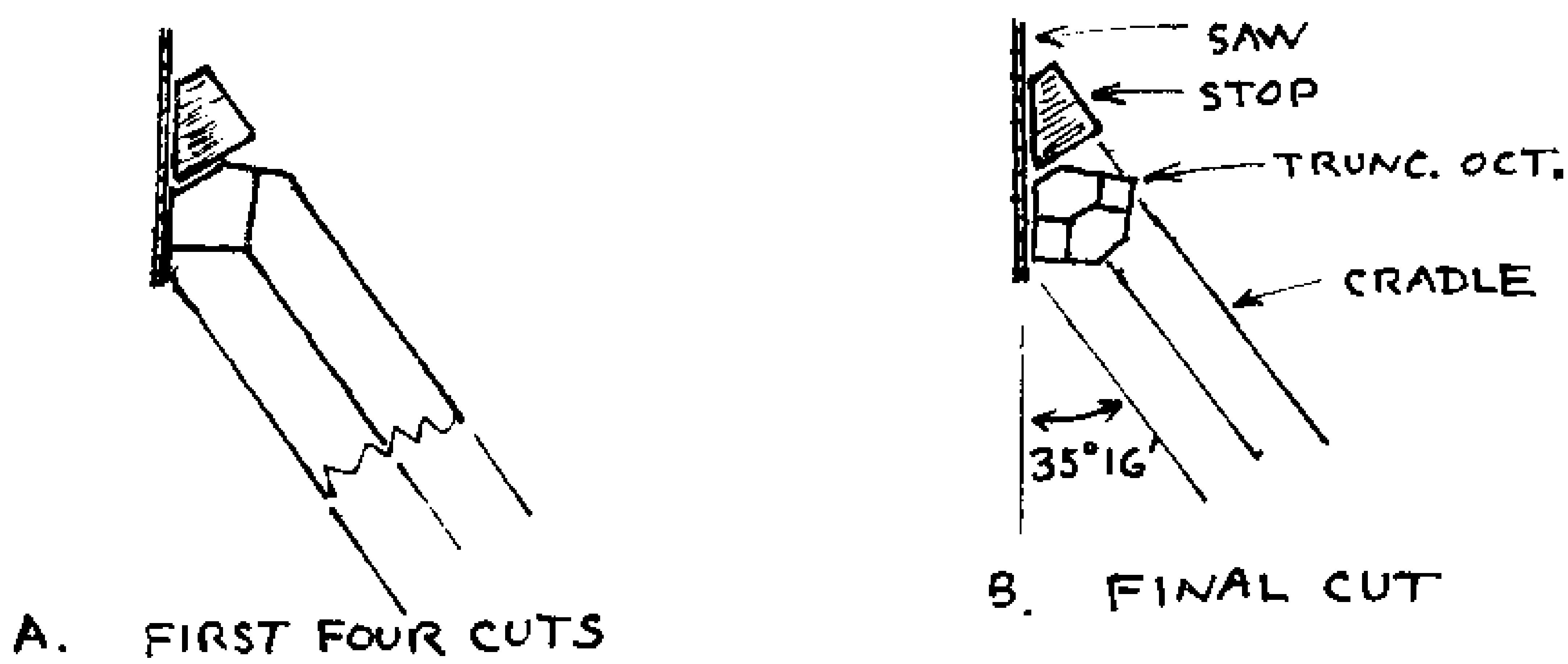


FIG. 12

When making the final four cuts, a specially shaped pusher stick holds the truncated octahedra block in the cradle, rather than fingers.

Making Triangular Sticks

The Hexagonal Prism, Triangular Prism, The General, improved Second Stellation, and a few others are made from equilateral triangular stock. After you have acquired the technique for making good square stock, the triangular is no more difficult. This is the way I do it. First, the 1-1/16 inch boards are ripped on the bandsaw using a special fence, with the table tilted 30 degrees. The boards are reversed end-for-end after each cut. This makes rough oversized triangular sticks. The three sides are then planed in the planer shown in Fig. 4, using special jig inserts of course, so that the third and final pass makes a stick of equilateral triangular cross section and proper size. For all the puzzles mentioned, the correct size is 1.000 inches altitude.

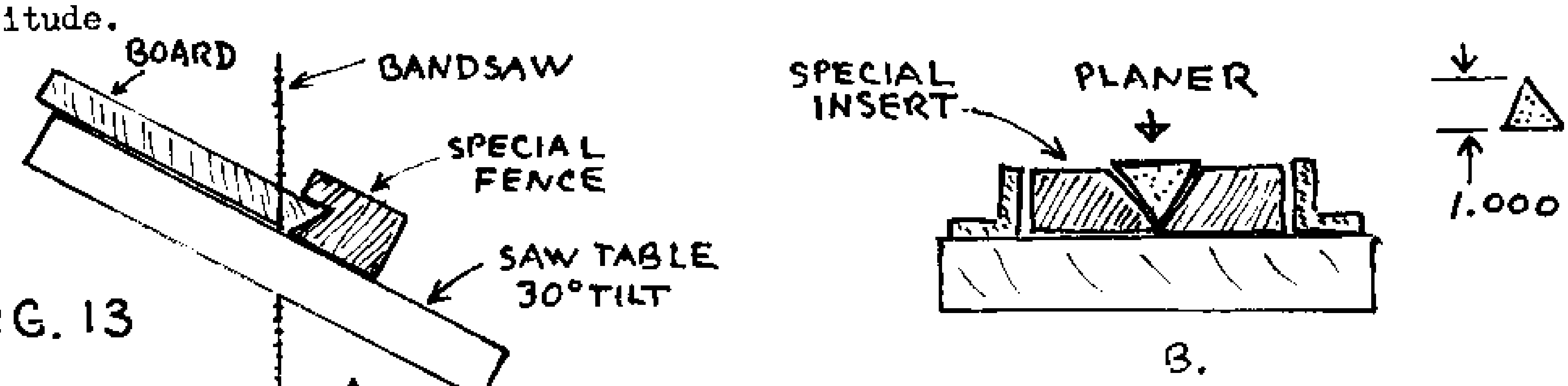


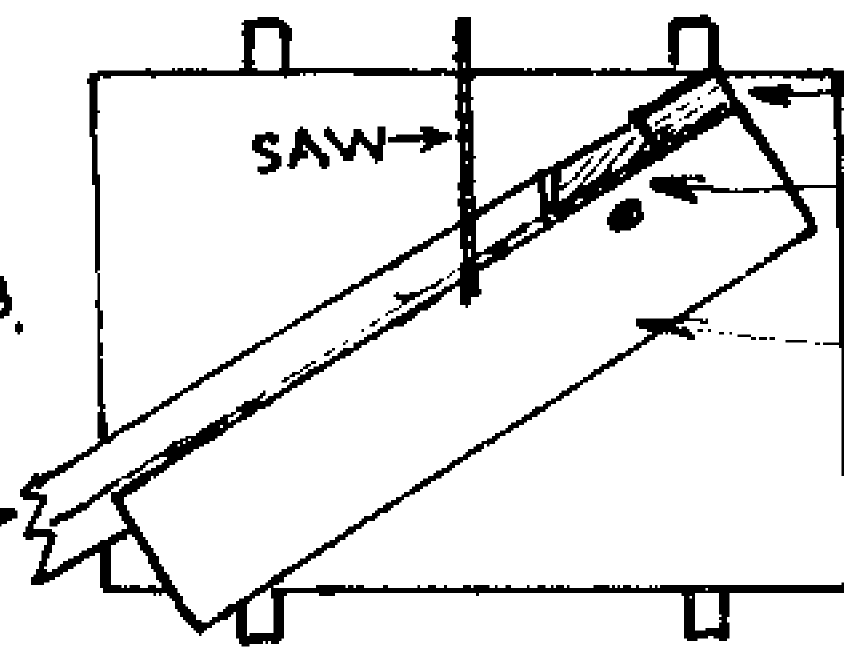
FIG. 13

The Triangular Block Jig

The triangular stock is sawn into the various lengths required using a special jig which is very similar to the square block jig of Fig. 7 except for the different angles. The feed angle viewed from above is 54 degrees, 44 minutes, thus making a diagonal cut. Several puzzles use blocks which are sawn diagonally on one end and square on the other. This is done by first sawing the pieces diagonally at twice the required length, and then bisecting them on the square block jig, with no waste. The Four Corners end blocks and tetrahedral blocks, which are shown on page 8 being made with square stock, can also be made on this jig with triangular stock, as well as the rhombic pyramidal blocks used in the improved versions of the Second Stellation and Twelve Point puzzles and in the Augmented Four Corners puzzle.

FIG. 14

A. END VIEW OF STOCK AND GUIDE

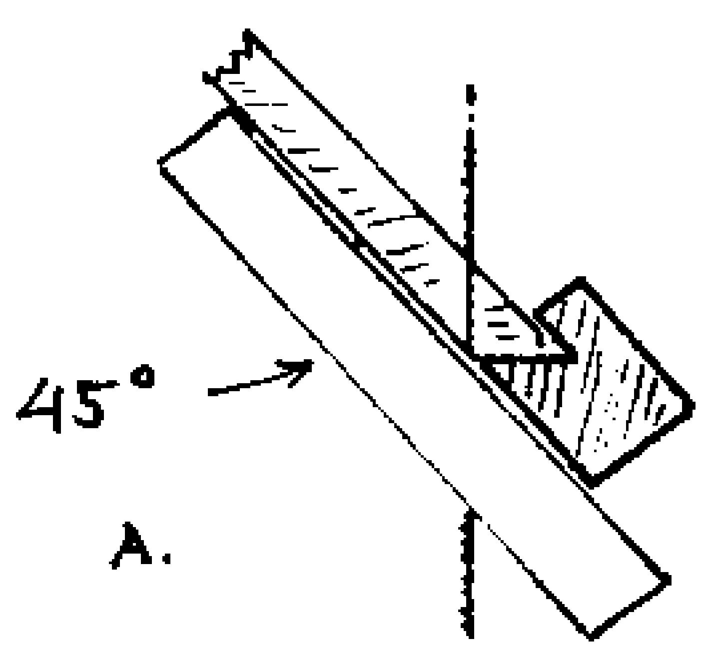


B.

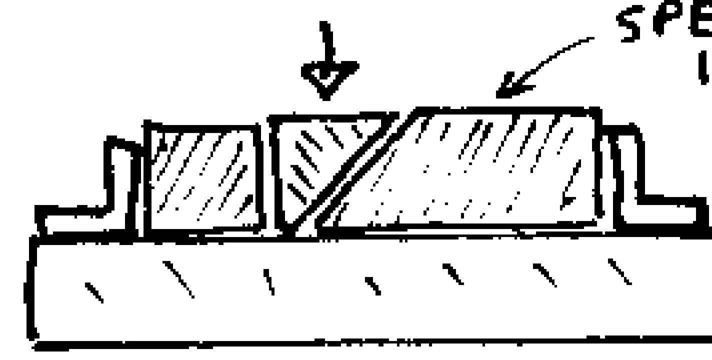
Making the Three Pairs Puzzle

The stock for the Three Pairs puzzle is of isosceles right triangular cross-section. The procedure for making these is exactly the same as that for making the triangular sticks described on the previous page, except that the angles are all different, so an entirely different set of jigs is used, and the bandsaw table is tilted at 45 degrees. Two passes through the planer using a special insert remove the saw marks and bring the stock down to exact final size. The stock is then sawn into blocks of the proper length with a square cut on the square block jig.

FIG. 15



A.



B.

Triangular Stock for the Scorpius and Jupiter Families of Puzzles

The Scorpius and Jupiter families of puzzles use triangular sticks of 30-60-90 and 36-54-90 degrees cross-section respectively, in large quantity. There are many ways to make these - this is how I do it: The nominal one-inch boards are first ripped into rectangular sticks on the table saw. They are sanded lightly to remove saw marks. Then they are bisected diagonally at the appropriate angle on the bandsaw. Next, the rough diagonal face is planed down to exact size in the planer using special inserts. A final light sanding removes sharp edges and planer marks. The sticks are then sawn into short lengths ready for gluing.

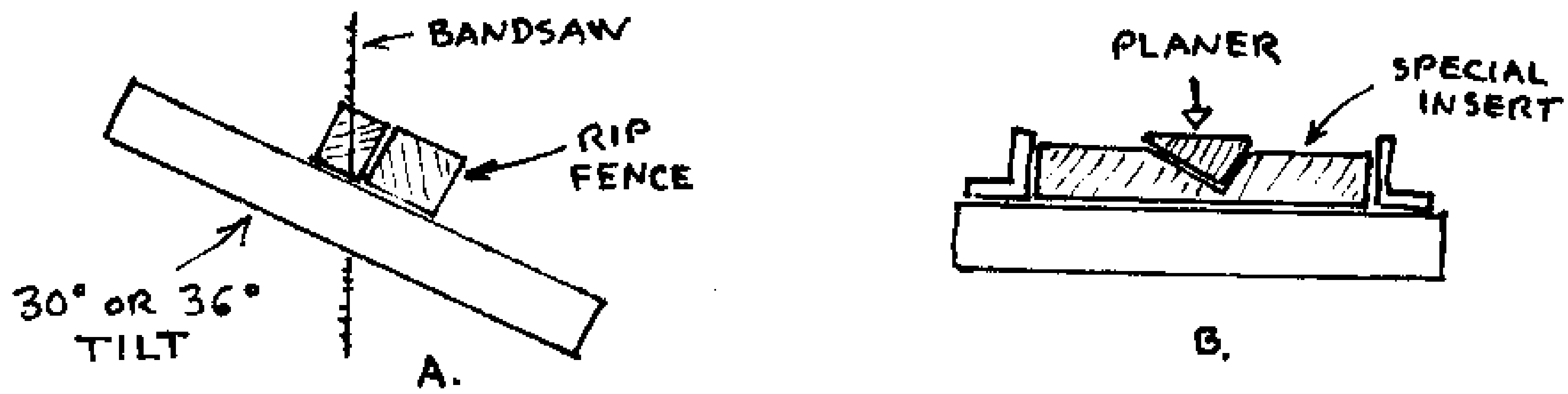


FIG. 16 - RIPPING AND PLANING SCORPIUS AND JUPITER STOCK

Hexagonal Stock

The Locked Nest, Cuckoo Nest, Nine Bars, and Hexsticks puzzles all require hexagonal cross-section stock. This is difficult for the home craftsman to make accurately. Since I did not wish to be bothered with all the special tooling, I had a large quantity of it made for me by a custom millwork shop on an impressive piece of machinery called a four-sided molder. This machine should have turned out very accurate sticks, but for some reason it did not, causing me much difficulty in using them. They would make them only in birch - no reason given. I would have preferred almost any other wood. If I were to do it again, I would try to figure out some way to make them myself, but I'm not sure how. You might be able to start with accurate triangular stock and cut it down to hexagonal.

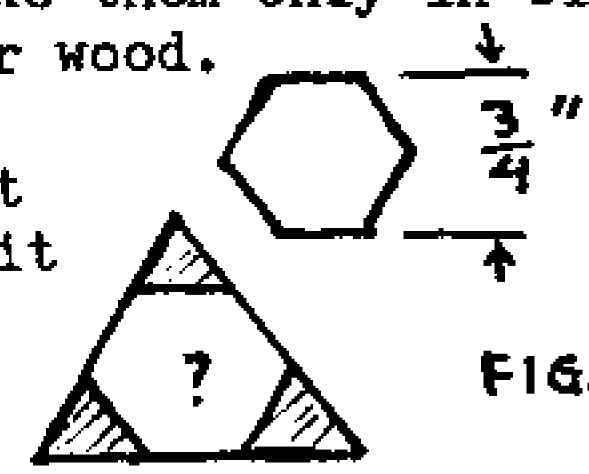


FIG. 17

Drilling Holes

The Locked Nest and Pin-Hole families of puzzles require the drilling of accurate holes for 7/16-inch dowel. The drilling is done in an ordinary drill press, using special jigs which position the pieces accurately. These jigs are so simple and straightforward that there really isn't much point in describing them in detail here.

In order to drill accurate holes, your spindle and chuck should have no significant side play or eccentricity. The most important consideration is how the drill bit is sharpened. It should have a spur point. Ordinary drills are designed for drilling metal. There are special spur bits you can buy for drilling wood, if you can find the right size. For clearance of a 7/16-inch dowel, I use a 15/32-inch drill. Since I have never found a spur bit that size, I make my own from standard drills. The first step (optional) is to cut them down to the minimum usable length for greater rigidity. The second step is to reduce the webb (center thickness) by careful grinding. The final step is to sharpen them with a spur point. It is very difficult to do this by eye accurately, so I made a special set-up for the grinder. The spur must be symmetrical and concentric, as its whole function is to keep the drill centered. (For a couple years, my daughter and I did very little else but make wooden beads and buttons, and we must have drilled nearly a million holes, so I have had a lot of practice at this.)

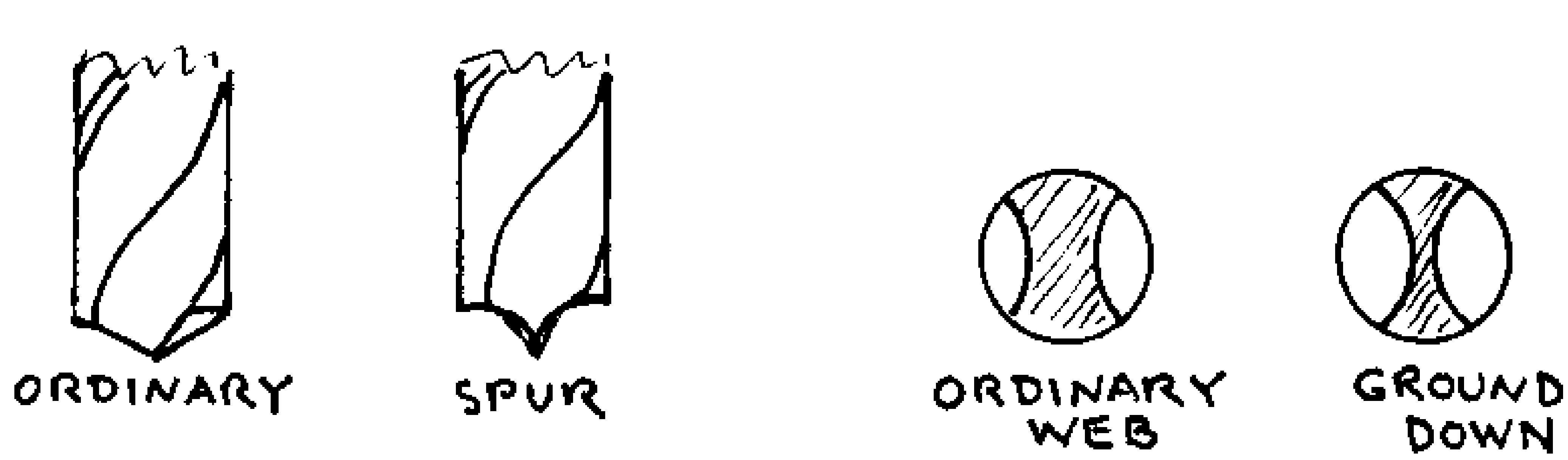


FIG. 18

Notches

Puzzles with square notches in square sticks, such as the six-piece burr and the Altekruse, are among the easiest to make. I use a table saw equipped with a carbide dado. It is the type which is adjusted for width by means of shims, and I have it permanently set for a notch width of .502 inches for making burr pieces from one-inch square stock. A special jig is of course used, similar to the square block jig in Fig. 7. A set of four gauge blocks is used, which move the work in increments of .500 inches. One innovation this jig has is that the piece to be notched must be dropped into a slot which is exactly one inch wide. If the piece is oversize it will not go.

The unnotchable burr pieces are made by first notching them out in the usual way, and then gluing in half-inch cubic blocks, using jigs to position them accurately.

The Altekruse puzzle requires notches which are twice as wide, so you would need another dado, or use this same one with half-inch square stock, to make a pocket sized version.

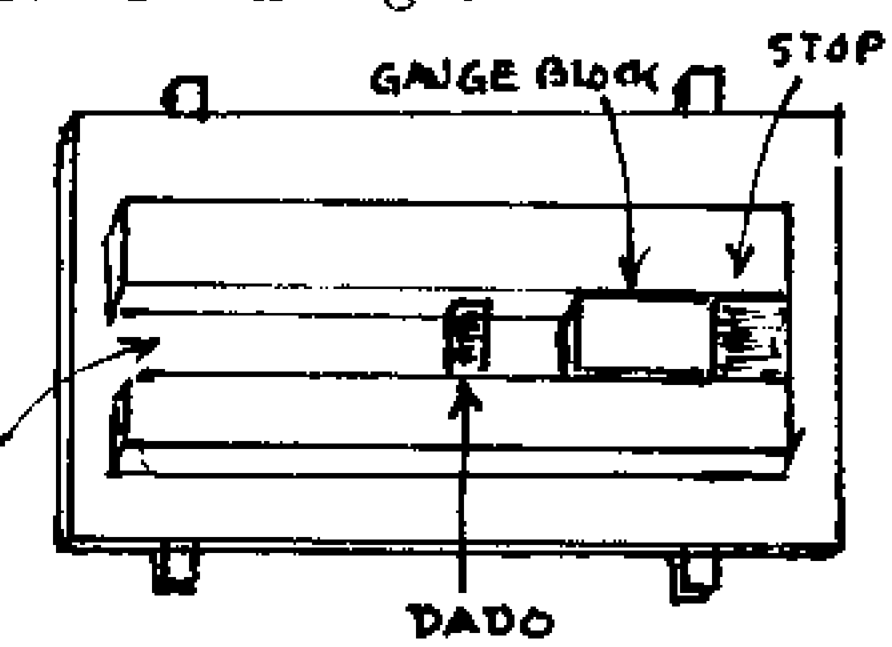


FIG. 19

Hexsticks Notches

The Hexsticks puzzle requires trapezoidal notches, which are much trickier to make well. They can be made with a three-bladed cutter, with the knives ground down to the proper shape. It must be very sharp and accurate in order to make a smooth cut. The problem is tearing and splintering of the end grain. This puzzle lends itself well to mass production, since there are no glue joints. Anyone planning to do this should have a carbide notching tool custom made for the job.

A special jig is used to feed the pieces in at an angle of 70 degrees, 32 minutes to the notcher.

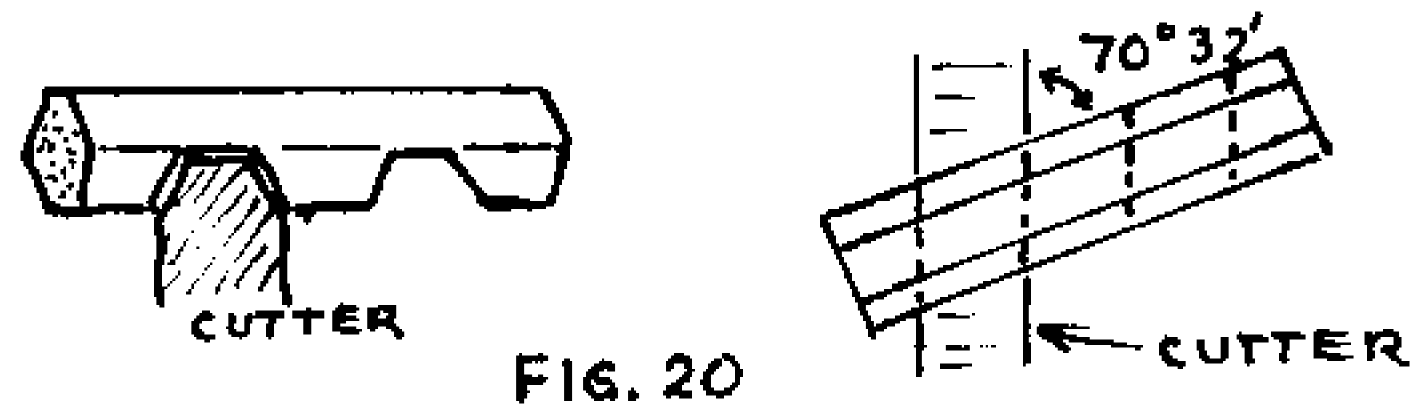


FIG. 20

Three Pairs Notches

The Three Pairs puzzle pieces have a very wide trapezoidal notch. I make them by sawing the two sides of the notch on the table saw, using a special jig which tilts the pieces at 45 degrees. I then chip out the center with a dado. A shift of only a few thousandths of an inch in the saw cuts can make the difference between a puzzle that is too tight or too loose. I test them constantly and make minute adjustments in the jig. Loose and tight pieces can be combined to make a set that is just right.

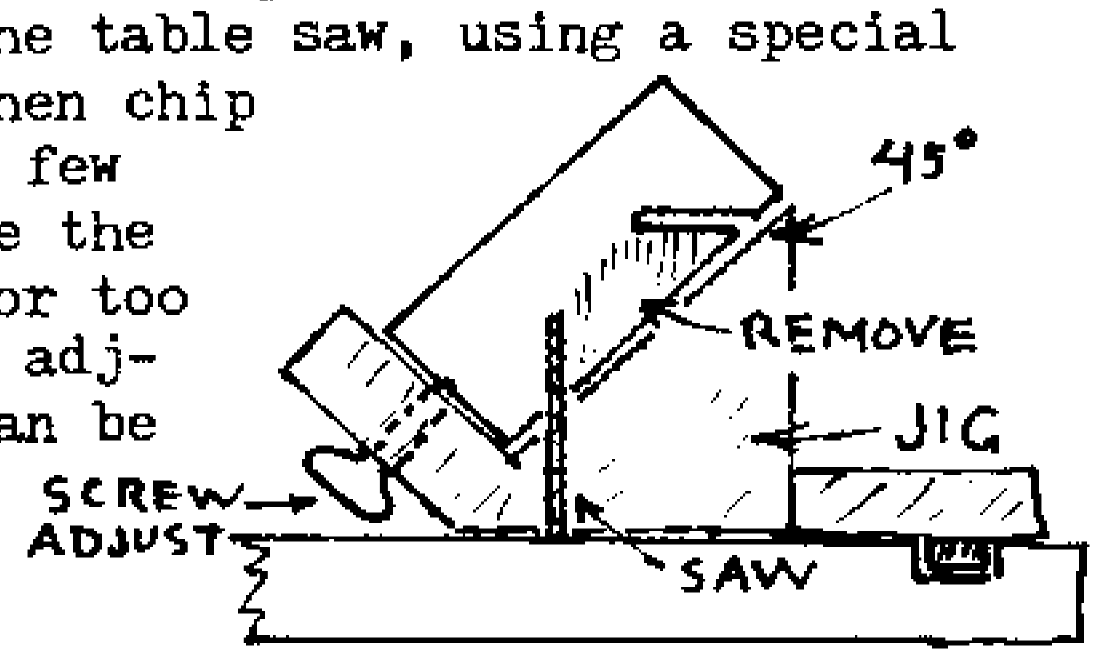


FIG. 21

Gluing Jigs

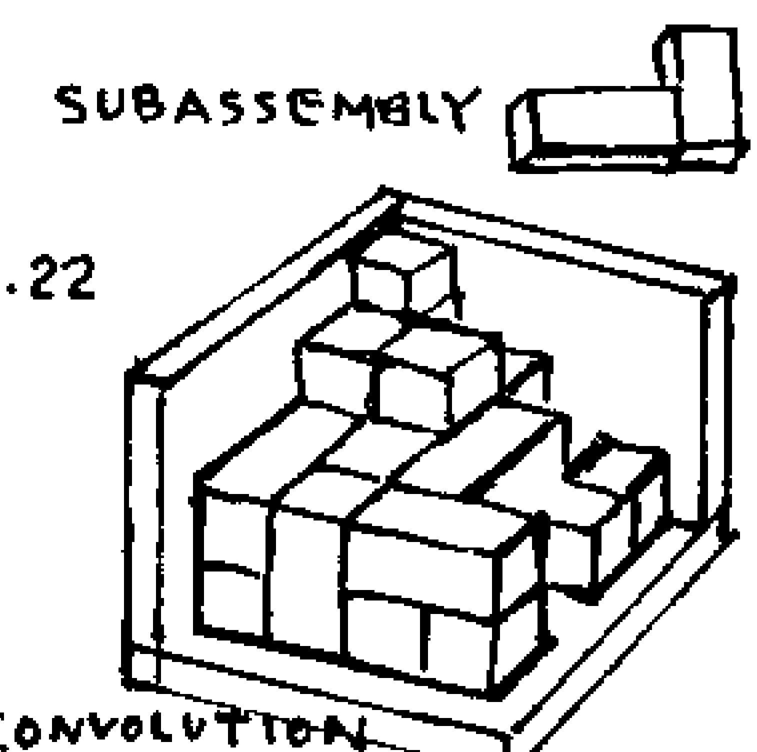
Most of the polyhedral puzzle designs described in Puzzle Craft consist of puzzle pieces which are made up of various blocks glued together. All of these are made using special gluing jigs designed to hold the parts accurately in place while the glue sets.

When gluing together rectangular blocks for puzzles such as the solid pentominoes, Half-Hour, Convolution, etc., the easy way is to just bring the two blocks together face-to-face, using a flat surface to align them. Keep in mind, however, that none of the pieces is perfectly square, and the errors can very rapidly accumulate as you do this. Also, the glue joint itself has a certain thickness which may be non-uniform and not negligible.

The Half-Hour puzzle is a good one to practice on - so simple in fact that detailed gluing directions are unnecessary. You will want a smooth, hard, flat surface to work on - hard so you can clean it repeatedly without destroying it. A small plate of double weight window glass is fine, but make sure it is really flat, as most panes picked at random are not. Wax it so glue will not stick, or cover it with waxed paper. You will need a few really accurate rectangular blocks to use as gluing jigs. You can make these of hardwood for a start, but if you have access to a machine shop, you might want to make some good ones of metal. Glue up the six Half-Hour pieces individually, assemble the puzzle and see how they fit. If there are visible errors, see what went wrong, correct it and try again.

It might be possible to make the Convolution pieces individually and then assemble, but would be extremely difficult because of the totally interlocking nature of the puzzle. Any mistakes and it simply could not be assembled at all. Here is how I do it: The Convolution puzzle is made up of 24 1x1x2 blocks and 8 1x1x1 corner blocks, plus 3 more 1x1x2 blocks and 2 1x1x1 blocks in the center. I first glue up eight subassemblies of pairs of rectangular blocks as shown at right. The puzzle is then built up block by block and glued together in the assembled state, using wax and waxed paper to prevent glue from sticking to the wrong places. The whole operation is done using an accurately made inside corner glue jig to hold the loose pieces squarely aligned. The Unhappy Childhood puzzle is made the same way, except that it uses no subassemblies - the cubic blocks are put in place and glued one by one, starting in the far corner and building outward.

FIG. 22

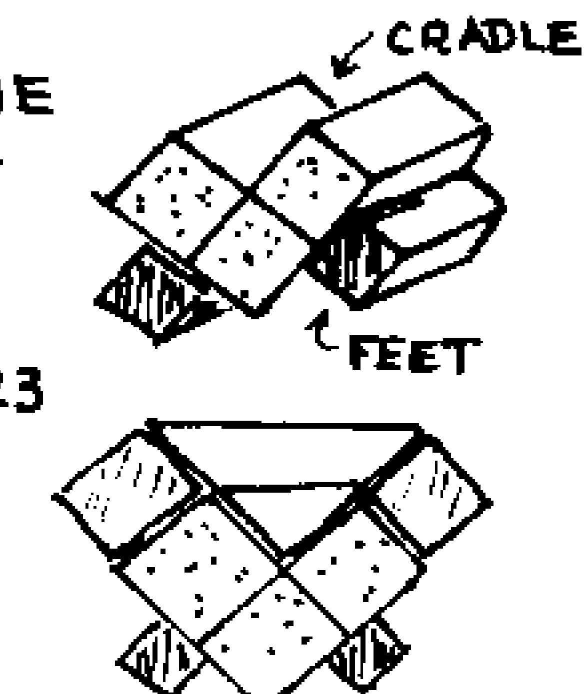


Now you see one of the incidental advantages of making puzzles which have only one solution. When fabricated in this manner, the assembled puzzle fits together with practically no visible cracks anywhere. The Diagonal Cube is another example of this. However, you must not get careless because of this. In order to truly be a combinatorial puzzle, the parts should appear to fit naturally together all sorts of different ways, so there is little room for error even here.

Many of the R-D type puzzles, such as Sirius, Four Corners, Seven Woods, Nova, Triumph, Vega, and others far too numerous to mention, are glued using the very simple jig shown at right. It consists simply of three one-inch square sticks a few inches long glued accurately together, with a pair of feet added.

GLUE JIG

FIG. 23



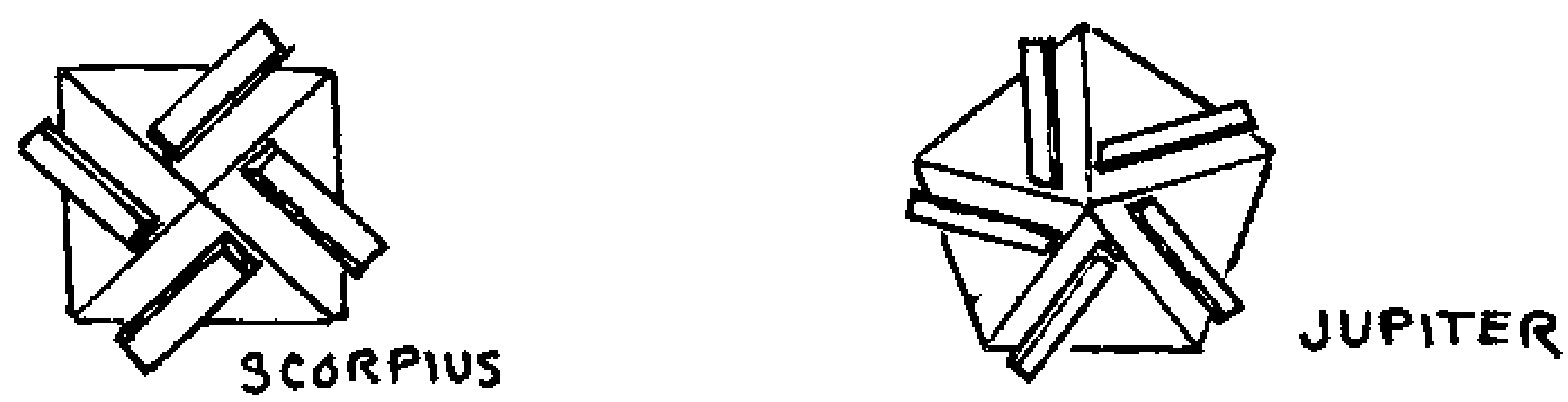
GLUING FOUR CORNERS PUZZLE PIECE

For gluing the Second Stellation, Twelve Point, Broken Sticks, Augmented Four Corners, Hexagonal Prism, Star-of-David, and a few others, the jig just described may be used. For production, however, I find it useful to have customized glue jigs for the various puzzles. These consist of the same basic three-block cradle just described, but with extra blocks judiciously added here and there to hold the particular shaped end blocks accurately in place.

Special Gluing Jigs for Scorpius and Jupiter Families

The Scorpius gluing jig is basically a square pyramid with four rectangular blocks added. The Dislocated Scorpius and Scrambled Scorpius jigs are simply modifications of this basic scheme. I made an accurate mold to start with, and then cast all the pyramidal bases in Hydrastone (a type of gypsum plaster). The Jupiter and Saturn gluing jigs are basically the same idea, and made the same way by casting in Hydrastone and then adding blocks. The difference is that the pattern for the base of the jigs is a pentagonal pyramid which must be very accurately made. I found this task beyond my capabilities, so I had a very capable machinist friend of mine mill one out on a Bridgeport milling machine with rotary base. The shape of the base is the vertex of a triacontahedron, and the angles may be found in any textbook on polyhedra. I assume that few home hobbiests will wish to go to all this trouble. While on the subject, however, I will mention that the Scorpius and Jupiter type puzzles are glued up with sticks which are rough cut slightly too long. After the puzzle is glued and assembled, the ends are trimmed on the table saw. Good photos of the gluing and trimming operations may be found in the January 1979 issue of Fine Woodworking magazine.

FIG. 24



Glue Release

In order to prevent excess glue from sticking to things you don't want it to, sometimes you can insert little bits of waxed paper, or use some sort of release agent. The most effective release I have found is beeswax dissolved in warm turpentine, in a ratio such that when it cools it is the consistency of whipped cream. It can be applied with an artist's brush. Care must be taken not to contaminate surfaces to be glued later.

Glue

I use aliphatic resin glue (Franklin Titebond or Elmer's Professional almost exclusively. Plastic resin glue (Weldwood) may form a stronger bond to certain difficult woods, but it seems to be too brittle, and sometimes joints will pop apart for no apparent reason - possibly because of differential expansion and contraction with humidity changes. Epoxy may be stronger still, but I find it messy to work with, and much too slow for production. The contact cements I have tried did not hold well at all, nor did the hot melt glues.

Gluing

Some woods are ever so much easier than others to glue. The medium-hard domestic hardwoods such as birch and cherry make an almost instant bond when brought together with a dab of Titebond. Walnut, oak, maple, and ash all bond well too. The dense oily woods like rosewood and satinwood may eventually form an adequate bond, but with setting times of hours rather than minutes. A warm environment helps a lot. The very oily woods like cocobolo and teak do not make a strong bond, and it is claimed by some that this can be improved by first cleaning the surfaces with a solvent such as acetone. When certain very hard woods such as Osage orange are sanded with a worn belt, they can acquire a shiny glazed surface almost impossible to bond to, and the remedy for this is to remove the glaze with medium sandpaper.

Very soft porous woods such as poplar and certain mahoganies (especially Philippine) present a contrary problem, especially when gluing on the end grain, as the glue can just soak into the wood and disappear. These require a heavier spread of glue. Leave them open a minute or two, and then bring them together lightly. It helps if the end grain surfaces were sawn with a very sharp saw, or sanded before gluing.

A postmortem of many failed glue joints reveals that in many cases the two surfaces did not mate properly to begin with, so that as the glue dried and shrunk, air pockets formed.

Occasionally it is advisable to take the extra trouble to dowel the joints. The easiest way to do this is to first glue the pieces together in the usual way, then drill in from a side that doesn't show, squirt some glue in the hole and insert a 1/8-inch dowel. After the glue has set, the dowel can be trimmed and sanded flush. I have done this on Three Pairs and Scrambled Scorpius puzzles made of rosewood. On puzzles with no definable hidden side, like the Four-piece Pyramid, the dowels must be set in as the blocks are being glued, and this is a very tedious process.

Sanding

Many of the polyhedral puzzles are characterized by a type of geometry in which each of the six pieces is held in place by the ends of two adjacent pieces, the Sirius puzzle being a good example. Achieving just the right fit is accomplished by making the pieces ever so slightly oversized, and then sanding down the two outside longitudinal faces of each piece on a belt sander until the correct fit is obtained. After much careful adjustment of all sawing and gluing jigs, this should require just a light sanding with #150 or #220 grit, just enough to remove all saw marks and leave an attractive smooth finish. The trouble with having to sand a lot is that it is usually done freehand without jigs, so that the accuracy so painstakingly built into the piece up to that point becomes lost. Only the slightest excess sanding can make the puzzle too loose, and once done is difficult to correct. Sometimes the pieces can be exchanged between a puzzle that is too loose and one that is too tight.

As a final touch, all sharp edges and corners are rounded off with fine sandpaper. On certain puzzles such as the Six-piece Burr, certain edges are beveled with a file.

Dealing with Expansion and Contraction

All woods expand and contract with changes in humidity. If this were uniform in all directions, there would be no problem, but that is far from the case. It is greatest along the growth rings (tangential), less across the growth rings (radial), and much less along the grain. Consequently, nearly all interlocking wooden puzzles of the notched stick or glued up polyhedral type become too tight when humid, and too loose when dry. There are several ways of trying to cope with this very serious problem.

Since some woods are much worse than others in this respect, an obvious idea is to use only the more stable ones. As you might guess, these also tend to be the most expensive and difficult to work.

Worst - cherry, maple, birch, beech, hickory, oak
Slightly better - ash, walnut, satinwood, bubinga, most mahoganies
Good - Honduras mahogany, limba, koa, primavera
Very good - Brazilian rosewood, tulipwood, ebony
Excellent - teak, cocobolo, padauk

In this list, Honduras mahogany stands out as the one good wood which is moderately priced and, for the moment at least, readily available. It was also singled out as being relatively free of warp. It is easy to glue and finish. The only slight objection I can think of is that it does produce a fine dust which can be irritating. I have used more of it than any other wood.

Since some puzzle designs are more susceptible to humidity than others, we might try to avoid the worst and concentrate on the best. The Sirius, Four Corners, Seven Woods, and numerous others of the same basic geometry are particularly susceptible, and that is one reason why most of those were discontinued after only a short run. On the other hand, the Jupiter-Saturn geometry is of a type which has the peculiar ability to expand and contract without becoming too tight or too loose. The Triangular Prism and Convolution puzzles are examples of designs which may become loose when dry, but the effect is not too noticable or objectionable because of their complicated interlocking geometry.

Another scheme is to cleverly arrange the grain of the pieces so that the expansion effects tend to cancel rather than accumulate. This is done in the Four-Piece Pyramid and Octahedral Cluster puzzles simply by having the grain in all the blocks run in the same direction. A person knowing this would find these puzzles much easier to solve, but my assumption is that very few would think of it. The effect is that these puzzles are practically unaffected by humidity.

On some of my earlier puzzles, the expansion problem was taken care of by installing little silicone rubber bumpers on some of the inside mating surfaces. These were made by forcing short lengths of rubber rod into slightly tapered 1/8-inch holes, and protruding about 1/64 of an inch. They worked ok as long as they didn't get sheared off, but they certainly looked out of place.

Finishing

Most of my puzzles are finished by dipping the separate pieces in thinned clear lacquer and then immediately wiping them dry with a cloth. This impregnation seals the surface of the wood slightly, brings out the color and grain, and makes it somewhat less susceptible to soiling and easier to clean. It does not seal out humidity. Lastly, the outside surfaces are usually waxed and polished. If the sliding parts tend to bind, they are waxed too.

Over the years, I have tried every type of wood finish that has come to my attention, but always come back to lacquer. Most varnishes remain tacky for months, and on certain woods like rosewood they never dry. Most oil finishes tend to look dull and get dirty over a period of time with handling. On certain woods like ebony, there is no need for lacquer - just wax and polish with very fine steel wool. I have used an impregnation of very thin epoxy (Arcon Seep-n-seal) on some puzzles like the mahogany version of the Four-Piece Pyramid, on the theory that it helps to strengthen the pieces. It is slow and messy work, and some persons have objected to the smell, although I think it goes away after a while.

Puzzle Care and Repair

The finish on most puzzles may be cleaned and restored simply by rubbing with a small amount of wax on a cloth. I use Butcher's Bowling Alley paste wax, or other similar kinds. If too much wax is allowed to accumulate in the pores and cracks, it may turn an objectionable white when it dries. Bee's wax does not do this, but it is soft and will not stand handling as well. For a more thorough job of refinishing, scrub with very fine steel wool and then wax.

Broken joints are repaired by scraping both surfaces clean, regluing with Titebond (or equivalent), and then using the assembled puzzle as a jig while the glue sets, held tightly together with rubber bands. One must use a sufficient amount of glue to completely saturate the joint. In order to prevent adjacent pieces from sticking, isolate the glued joint with bits of waxed paper or foil, or coat with a release agent as explained on a previous page.

If you have a puzzle that is too loose and you wish to tighten it up, coatings of lacquer, clear fingernail polish, or the like can be applied to the inside working surfaces, but it takes a great many applications to have much effect.

Hazards of Woodworking

The most obvious hazard is cutting one's fingers on a saw or other power tool. We will assume that the reader already has some familiarity with safety in the shop and has read the power tool instructions. Proper design of the sawing jigs will minimize the chances of one's fingers coming close to the saw blade. For example, do not try to hold the truncated octahedral blocks with your fingers when making the final four cuts, but rather clamp them in place. My planer and dado are set up so that the cutters are completely shielded when in use, with no possible chance for accidental contact.

I have never had a saw blade break or throw off a tooth but do consider it a possibility, so most of my sawing jigs have a shield built in to guard against this and also against bits of wood being thrown up. Otherwise I would use a face mask.

Probably any kind of dust in the air in large amounts is not good for you. I use a dust collection system with my sander and most other power tools, and sometimes wear a mask besides. The dust of certain woods is especially objectionable, and it is best to avoid using them. Different persons react to different woods, and you may discover some you must avoid. For a start, I would recommend that you avoid cocobolo, mansonia, and makore altogether. Rosewood, padauk, satinwood, and certain mahoganies produce an irritating dust, and so you will probably want to wear a mask when working with them.

Another good reason for disposing of dust is that it is a fire hazard. I once discovered smoke coming from a pile of sawdust underneath a saw, and only the instant application of a stream of water from my ever-ready fire hose prevented the loss of everything. The saw must have struck a spark. A smoke detector and alarm is a good idea too.

The glue I use and recommend is non-toxic. You can avoid breathing the fumes of lacquer thinner by using a respirator. Mine is made by American Optical with R51A cartridges for organic vapors (good for working with fiberglass resins too).

Puzzle Making as a Home Business

One of the advantages of puzzle making as a home business is that it requires practically no outlay of capital to get started. I know of home hobbyists who have more invested in machinery than I have. Most of the highly specialized tools and jigs require only the investment of much time and painstaking workmanship. If you are the type who likes to tinker with mechanical puzzles, then you will probably enjoy the challenge of devising and accurately making all of the special tools and jigs required.

Another advantage is that it does not require much space. I started with just an eight-inch table saw, sander, and drill press. My shop is 1000 square feet, but a lot of that space is so that I can make a canoe occasionally.

The methods of puzzle making described in this book are more of a craft than a manufacturing operation. If you have notions of a puzzle business that will keep growing with hired help, then you should probably ignore most of what is in Puzzle Craft. I have no inclination or knack for that. I work alone - it is the only way I can get anything done. Setting up a business to mass produce and market high quality wooden puzzles strikes me as a very difficult and risky enterprise. I know some who have tried and failed.

Many aspiring puzzle makers wonder how they would sell their product. Like many other craftsmen, I (or rather we) started out by doing craft fairs. Just one good wholesale show (American Craft Council) was all it took to get a good start. Later, when retail mail order sales gained momentum, mostly as a result of magazine articles, I dropped all wholesale business. I have never run paid advertisements, and doubt if it is worthwhile.

Licensing of Puzzle Inventions

The idea of inventing things, patenting them, and then licensing them for manufacture on a royalty basis seems to have particular appeal for puzzle inventors. Just sit back and enjoy life as the royalty checks come pouring in. About once in every decade there is some success story along these lines to rouse our envy, and we tend to forget the thousands of others with good ideas who never made a penny. I spent one entire year (1969) trying to earn a living this way, and my failure to do so was what prompted me to start crafting puzzles in wood myself rather than depend on others. So, even if you think you have some great ideas, better not quit your regular job quite yet.

Don't get enraptured with your inventions. Try to keep coming up with better ones and improving them. Test all of them on your friends. They are a better judge than you are. If you have to explain what is so clever about your puzzle, it is no good, so back to the drawing board. Don't keep them secret. Nobody will steal them. Read "General Information Concerning Patents" and note that a patent application must be within one year of the time you market or publish your invention. Don't waste money on frivolous patent applications. A patent is not necessary to license a puzzle. If a manufacturer thinks your idea worth patenting, they will usually pay the cost (around $2000). Patents do not prevent others from copying your puzzles. I hold four patents, and three have been copied, but on a scale too small to worry about. Patent searches can be rewarding, especially if you do your own rather than hire someone else.

How do you find a manufacturer for your puzzle? Of those listed in Part 1, few and probably none are interested in your puzzle designs. The current issue of Thomas Register of American Manufacturers has twenty-two entries under "Puzzles," practically all of which are die-cutters of cardboard jigsaw puzzles. Nearly all puzzles manufactured in the U. S. are made by toy or game companies. Many of them prefer to sell copies of successful or traditional puzzles rather than risk new ideas. Others have their own design staff and are not interested in your ideas. Unless you want to spend all your time traveling around looking for the one manufacturer who may be interested, you will need an agent who specializes in puzzles. (My agent quit the business several years ago as being unprofitable, and I cannot recommend or direct you to any others.) Your agent will need several well made models of each of your puzzles which you should consider expendable, together with descriptions and drawings. You should have some knowledge of manufacturing processes and economics. Toy companies are interested only in products that can be mass produced at very low cost, such as injection molding or stamping, with almost no hand labor. In order to retail for $10, their puzzles must have a manufacturing cost of less than $1. (My original Snowflake puzzle had a manufacturing cost of about 30¢ and retailed for $3.50. When the cost of the resin jumped by a few pennies in 1973, it could no longer be made profitably by Span Products and was discontinued.)

The manufacturer or your agent will draw up the contract and all you need do is sign it. The usual royalty is 5% of sales, paid quarterly. If paid through your agent, he will keep up to half of it and send the balance to you. Sometimes an advance payment can be negotiated. In certain cases, royalties may be considered long term capital gains with favorable tax treatment.

The most discouraging aspect of puzzle licensing is that most corporate toy or game companies are not really interested in quality. They know perfectly well that most such items are bought on impulse as gifts, and will soon be broken or discarded and forgotten. Packaging and color seem to be their major concerns, rather than good design and durability.

I think you will find much more satisfaction in hand-crafting your own puzzle designs and selling them direct. You will meet the nicest people that way too.

Corrections and Additions

Page 3, Periodicals

Woodworker's Journal, published bi-monthly, P. O. Box 1629, New Milford, CT 06776. Puzzle articles in March 1985, September 1985, and March 1986. Back issues available.

Cubic Circular was published quarterly by David Singmaster, 87 Rodenhurst Road, London SW4 8AF, England. Mostly about Rubik's Cube. Recently discontinued. Singmaster is also an authority on the origins and history of recreational math problems, puzzles and games, and has compiled a comprehensive bibliography.

In Scientific American, the puzzle article mentioned as being scheduled for the September 1985 issue actually appeared in the October 1985 issue.

Michael Keller, publisher of World Game Review, has moved to: 3367-I North Chatham Road, Ellicott City, MD 21043.

Page 4, Sources of Puzzles

Rhombics has moved to 241 Crescent St., Waltham, MA 02154.

Readers report receiving no response from: Mag-Nif, World Wide Games, Creative Publications. Mail to Skor-Mor at their Boston address is returned undeliverable. New address of Gordon Brothers & Associates is 286 E. Lassen, Apt. 14, Chico, CA 95926, (but I received no response from either address). New address of Tenyo is: 5-13-5, Toyo, Koto-Ku, Tokyo, Japan 135. New address of Lumberjack Toys is: 670-C Garcia, Pittsburg, CA 94565.

For Pentangle catalog sent to the U. S., send $2.00 U. S., no personal checks.

Additional Sources of Puzzles:

Tavern Puzzles, Tucker-Jones House, Inc., 9 Main St., Setauket, NY 11733. Rugged and well made by hand of forged iron.

Bits & Pieces, 125 Walnut St., Watertown, MA 02172. Retail and mail order. Mostly jigsaw but including many unusual high quality items.

The Games People Play, 1105 Massachusetts Ave., Cambridge, MA 02138. Retail and mail order. Puzzle brochure available. Several readers have reported this to be an outstanding puzzle store.

Gantt's Wood Things, 111 S. Glenwood Ave., Orlando, FL 32803. An excellent source of inexpensive handmade wooden puzzles. Write for mail order catalog.

Binary Arts Corporation, 703 Timber Branch Dr., Alexandria, VA 22302. Makes the Hexadecimal Puzzle plus original well made topological puzzles.

General Symmetrics, Inc., 2935 W. Chenango, Englewood, CO 80110, (Douglas A. Engel - see October 1985 Scientific American). Engel's Enigma and other original puzzles. Write for catalog.

Gaby Games, POB 9037, 91090 - Jerusalem, Israel, (Phillipe DuBois). Clever, unusual, original three-dimensional wooden puzzles. Write for mail order catalog. (I got no response).

Rick Irby Puzzles, P. O. BOX 4883, Eureka, CA 95502-4883. Wire puzzles and sculptures, fine jewelry, custom designs. Write for catalog.

(Additional Sources of Puzzles):

Howard R. Swift, 3525 Wesleyan Drive, Toledo, OH 43614. Inexpensive hand crafted puzzles, mostly topological. Write for brochure.

Trench Enterprises, (Kevin Holmes), Three Cow Green, Bacton, Stowmarket 1P14 4HJ, Suffolk, England. Jigsaw, topological, three-dimensional, and other types. Clever original designs. Write for catalog.

Page 5, Puzzle Collections, Displays, and Museums

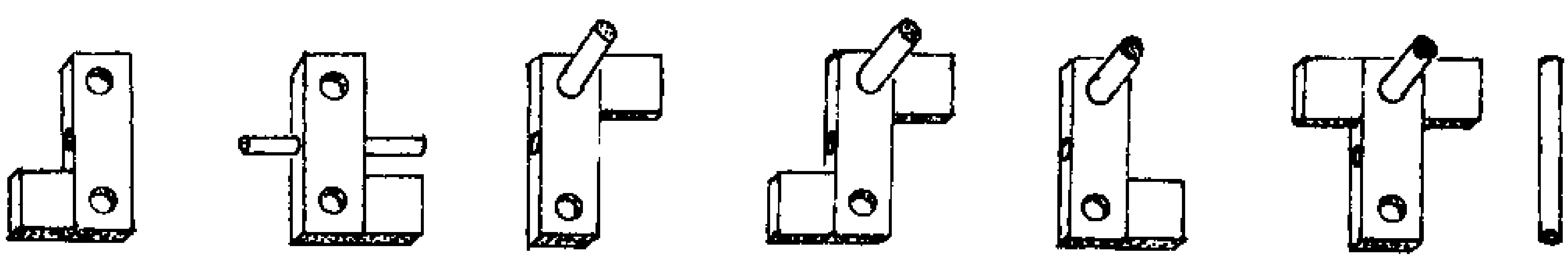
The largest and most diverse collection of puzzles ever assembled for public exhibition will be displayed at the Craft & Folk Art Museum, 5814 Wilshire Boulevard, Los Angeles, CA 90036 from November 25, 1986 to February 22, 1987. From April 6, 1987, to June 15, 1987, it will be at the MIT Museum, Massachusetts Institute of Technology, Cambridge, MA. From July 22, 1987, to September 27, 1987, it will be at the Hudson River Museum, Yonkers, NY. From October 19, 1987, to January 3, 1988, it will be at the Science Museum of Minnesota, St. Paul, MN. Thereafter, it will probably tour internationally into 1989. Comprised of 800 puzzles from around the world, the collection includes many rare and unusual puzzles. Jerry Slocum, from whose extensive collection much of the exhibition is drawn, is research curator. Jack Botermans, co-author of several puzzle books, is design curator. This exhibit is a very significant first in the world of puzzles. Don't miss it!

Page 32, The Standard Six-Piece Burr

Bill Cutler's computer analysis of the Six-Piece Burr was described in the Journal of Recreational Mathematics, Vol 10(4), 1977-78, and summarized in Scientific American, January 1978. Cutler's new address is: 405 Balsam Lane, Palatine, IL 60067.

Page 40, The Corner Block Puzzle

The information given is incorrect - it has more than a pair of solutions. An improved version with only one pair of solutions is shown below:



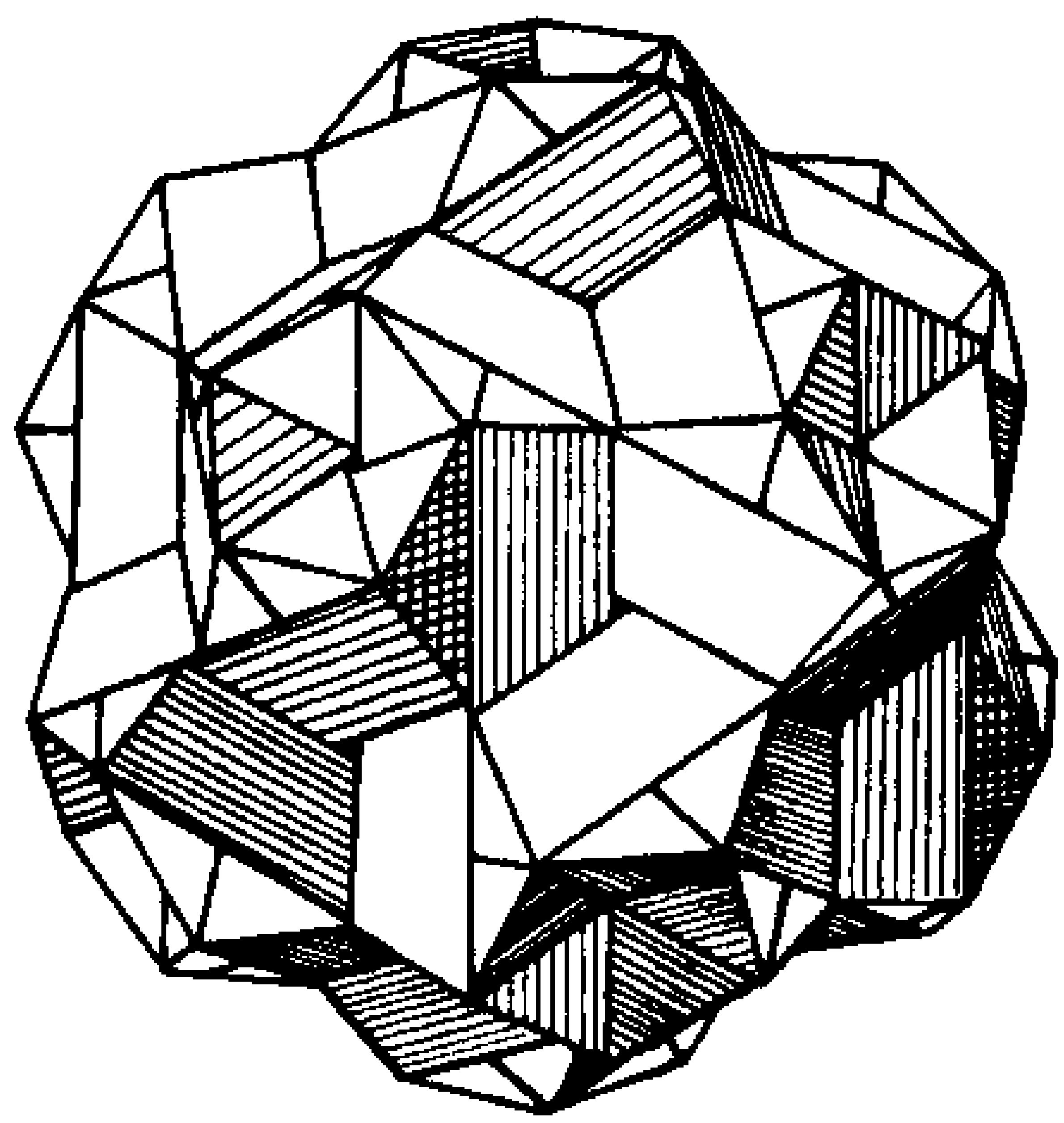
Improved Corner Block Puzzle

Page 1, Bibliography

Puzzles Old & New, by Jerry Slocum and Jack Botermans. Distributed in the U. S. by University of Washington Press, Seattle. May be ordered from: Jerry Slocum, P. O. Box 1635, Beverly Hills, CA 90213. $22.00 postpaid in the U. S. and Canada. $23.25 postpaid in California. $24.00 postpaid outside the U. S. and Canada. This large and beautifully illustrated book is a very fine addition to any puzzler's library.

Oxford University Press is publishing a new series of books on mathematical recreations, edited by David Singmaster. Soon to be published is a book on sliding block puzzles by Edward Hordern. A completely revised and improved edition of this book, Puzzle Craft, is scheduled for late 1987, with the probable title of: The Puzzling World of Polyhedral Dissections.

Part 4 - Wooden Puzzles



Jupiter

Part 4 - Wooden Puzzles

This section of Puzzle Craft is simply a listing and numbering of practically all puzzles which I have designed and/or made from 1968 to the present time (June 1985). It should serve as a handy reference list for the puzzle collector as well as anyone looking for puzzle designs to manufacture.

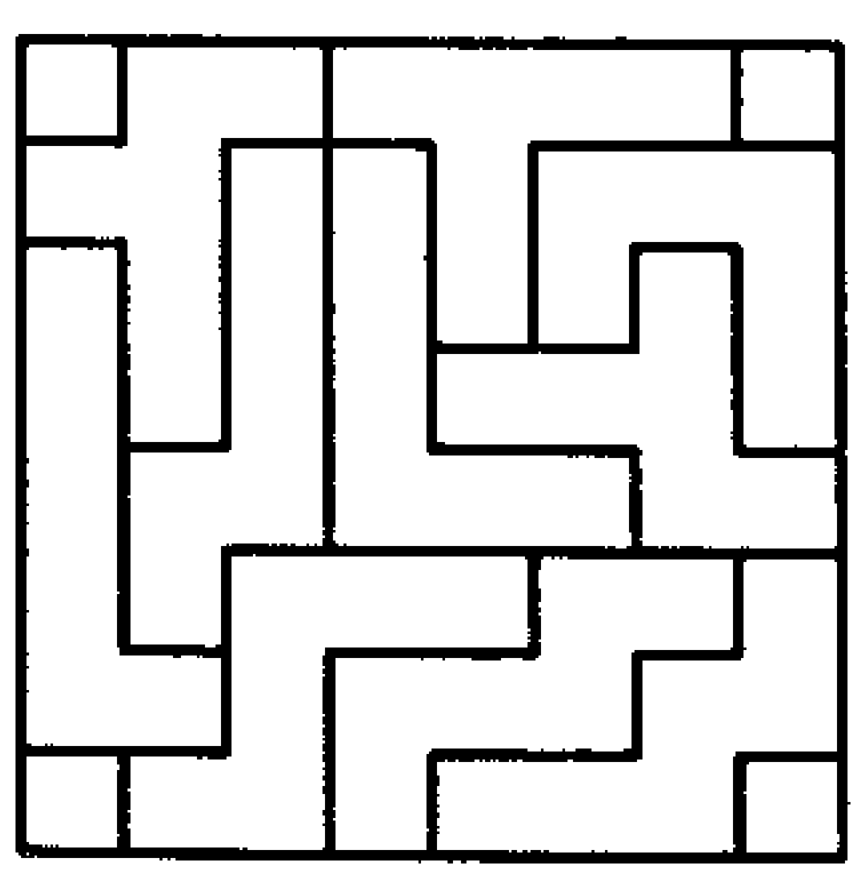
I have tried to indicate which designs are my own and which are in the public domain. One is never sure. Practically all puzzle designs are variations of something which has been done in the past, so how different must it be to be considered a new and original design? And how do you know that someone else did not think up the same idea years before? There has been very little information published on the history and development of puzzles, but I have tried to contribute what little I know as a start. I understand that others are interested in this subject, so perhaps more will be forthcoming in the future. Corrections and additions would be welcome.

Over all these years, using two different agents, I have managed to license only one puzzle in wood - #1-A, The Cube, now being made by Pentangle as their Wookey Hole. With this edition of Puzzle Craft, I am hereby announcing that any puzzles designed by me and described herein are freely available to anyone who wishes to make them, either as a hobby or business. The only exceptions are the Pentangle puzzle and those which are indicated as being patented or copyrighted, for commercial production of which please consult me.

For anyone planning to produce any of these puzzles for sale, I suggest you keep me informed of your intentions and progress, especially if you wish to be listed in future printings of Puzzle Craft as a source of puzzles. What I ask in return is that you sell Puzzle Craft or inform your customers that it is available from me.

This June 1985 printing of Puzzle Craft contains an entirely new Part 1 and 2, a Part 3 which was considerably revised and reprinted in December 1984, and a Part 4 which dates from April 1984 with some new additions and revisions. Because of this, there may be a few peculiarities in the page numbering.

(Reprinted October 1986 with corrections)

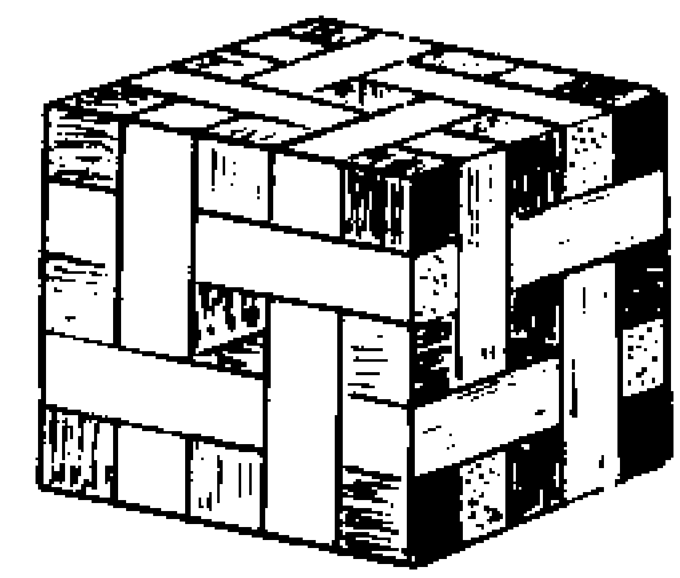


Cornucopia

Puzzles #1 through #41 are in approximate chronological order, depending on when they were first manufactured and listed for sale.

1. <u>Ortho-Cube</u> This was the first puzzle I designed for manufacture in wood, and appeared on my first brochure, printed in 1970. Made of 7/8-inch Birch. Produced in 1970 only, and about 20 sold.

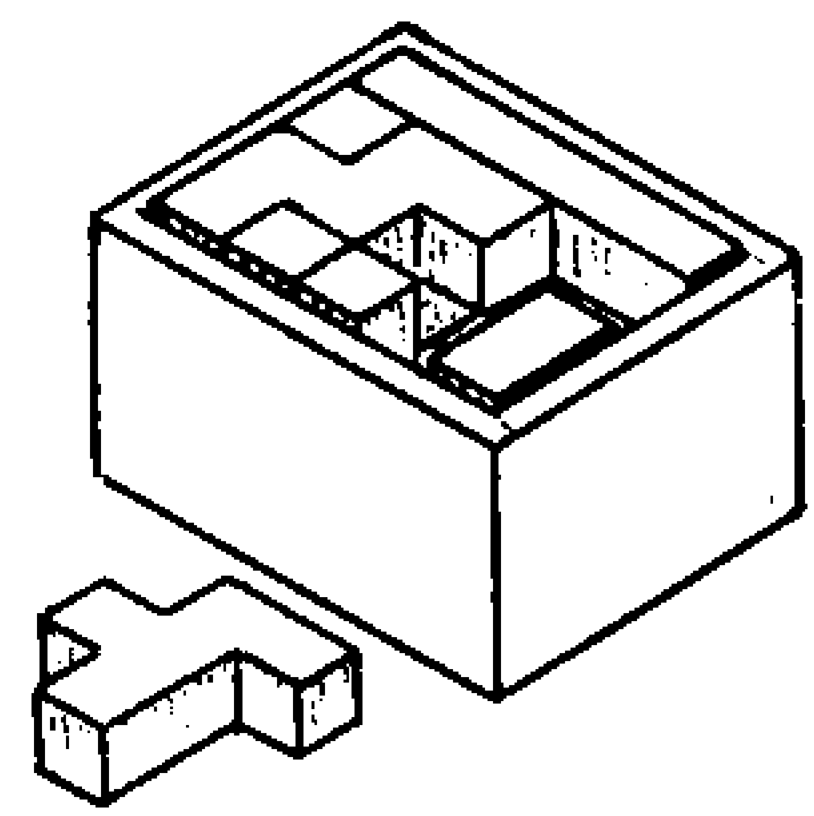
1-A. <u>The Cube</u> Same design as Ortho-Cube, but made of 3/4-inch stock in exotic woods. Twelve puzzle pieces, three kinds of pieces, four of each. Appeared in 1971 brochure. About 100 produced and sold, 1971-1972. This puzzle is now licensed to Pentangle in England, and sold under the name <u>Wookey Hole</u>.



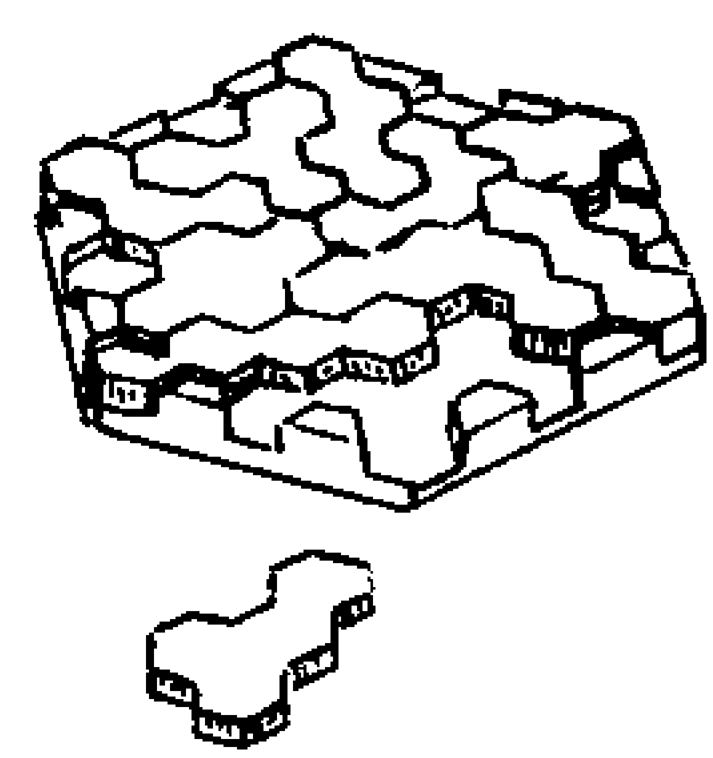
2. <u>Pentablock</u> This was simply a set of the twelve solid pentominoes in 7/8-inch Birch, in a 3x4x5 box. It is in the public domain, and not my design. See page 30. Appeared on 1970 brochure. About 20 produced and sold in 1970.

2-A. <u>Pentablock</u> (Improved) Same as above, except made of individual 3/4-inch cubes rather than sticks, and in a Plexiglass box. Appeared on 1975 brochure. About 10 produced and sold in 1975.

2-B. <u>Pentacube</u> Same as above, except made of 3/4-inch stock in 12 different exotic woods, one kind for each piece, and in a wooden box made of Blue Maho. Appeared on 1977 brochure. About 20 produced and sold in 1977.



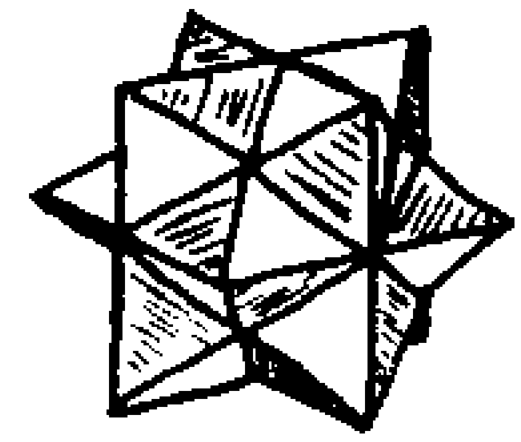
3. <u>Snowflake</u> The idea for the shapes of the ten puzzle pieces was not mine, but rather came from an article by Martin Gardner in <u>Scientific American</u>. My first version was copyrighted in 1970, and listed on 1970 brochure. Made of cast polyester, except for a few in epoxy, and very few in wood. About 50 produced and sold in 1970.



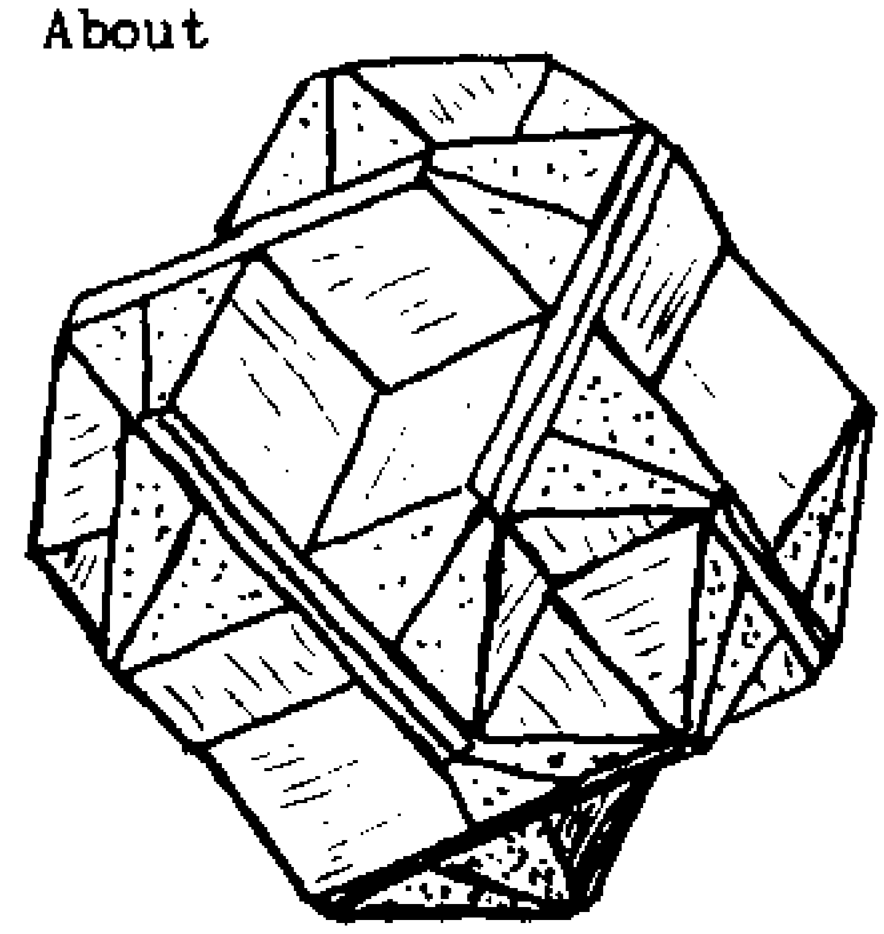
A new version with improved and expanded instructions was copyrighted in 1971, licensed for manufacture by Span Products, marketed by Small Wonders, and sold in the Museum of Modern Art. These were cast polyester, with an injection molded styrene base. About 500 were produced and sold, 1972-1973. The molds and some extra parts are now in storage at the Span factory in New Jersey.

An improved version, cast in Hydrastone, was listed on my 1978, 1979, and 1981 brochures. More recently a few were made in wood. See illustration on cover and description on page 25.

4. Sirius This familiar puzzle, with its six identical notched pieces, is in the public domain, and not my design. See description on page 41. My version was made of glued up pieces in three contrasting woods, using one-inch stock. Appeared on 1971 and 1972 brochures. About 100 produced and sold, 1971-1972.

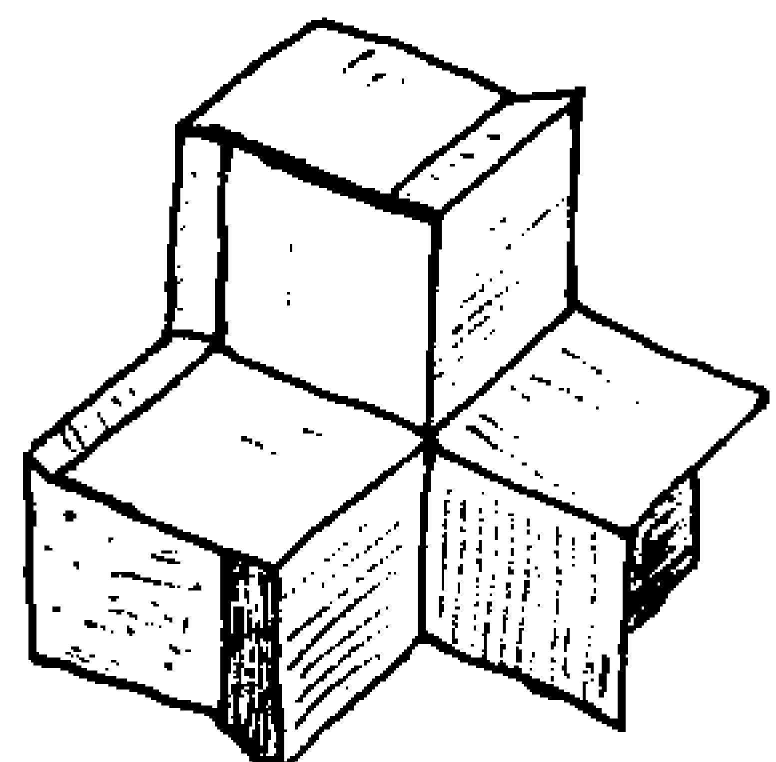


4-A. The Star Same as Sirius, except made of $1\frac{1}{4}$-inch stock in three contrasting exotic woods with color symmetry. Appeared on 1974 and 1975 brochures. About 400 produced and sold, 1974-1975.



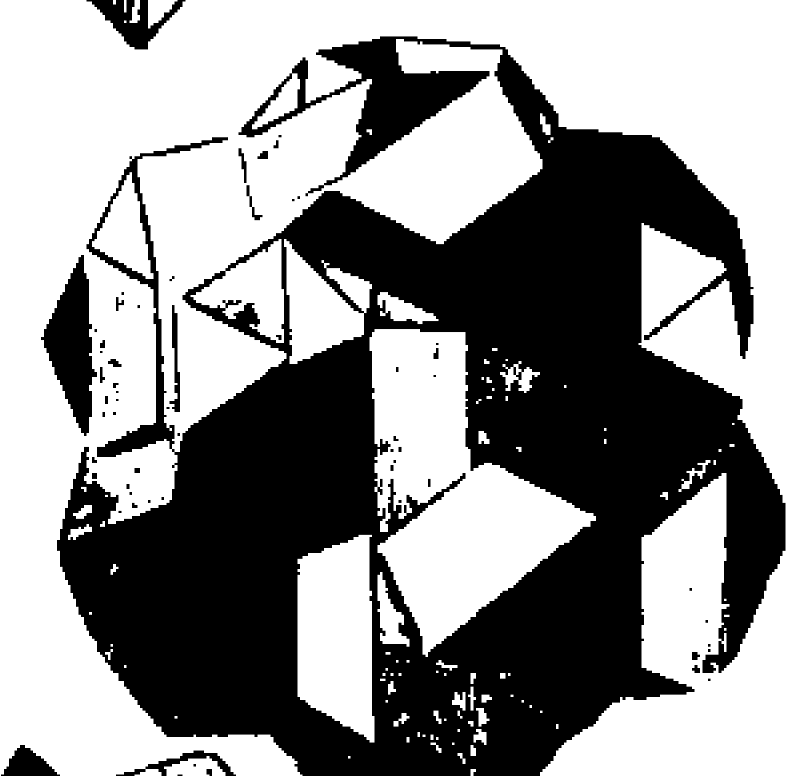
5. Scorpius (Also known as the Spider-Slider) This first version had six identically shaped symmetrical pieces. Designed in 1970. See description on page 51. Made of stained Basswood in 1970, about 10 produced and sold.

An improved version, made in four contrasting woods, appeared on 1971 and 1972 brochures. About 200 produced and sold, 1971-1974. Patented in 1974, Patent No. D-230288.

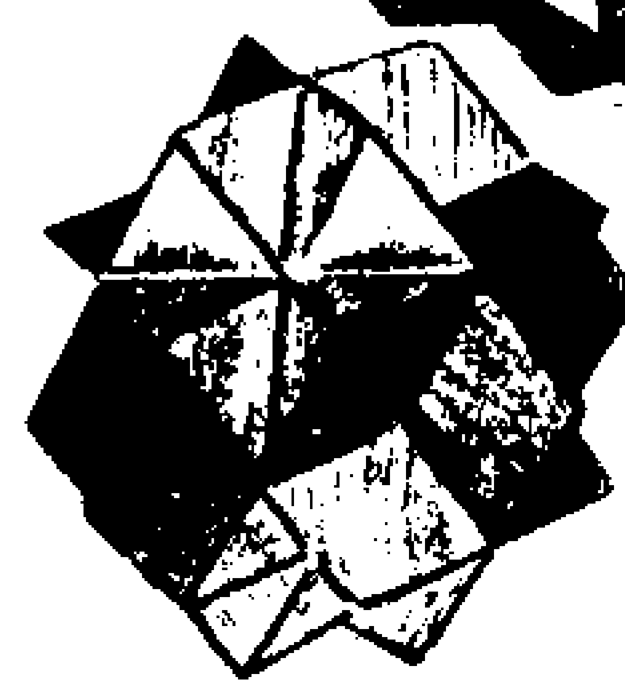


6. Four Corners Designed in 1971. Made in four contrasting exotic woods, with a simple color-matching problem. Appeared on 1971, 1972, 1974, and 1975 brochures. About 200 produced and sold, 1971-1975. See description on page 42.

6-A. Aries This is an injection molded version of the Four Corners puzzle, presently licensed to Skor-Mor (Union Bookbinding) as part of their Geo-Logic family of puzzles. Patented in 1975, Patent No. 3885794.



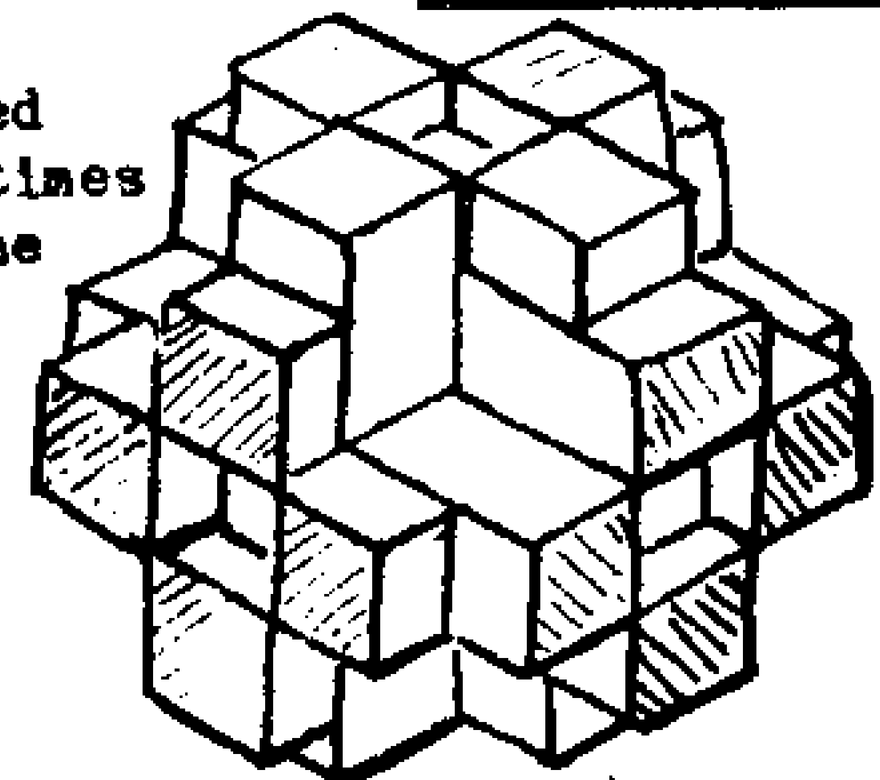
7. Jupiter (Also known as the Super Spider-Slider) Twelve identically shaped symmetrical pieces in six contrasting exotic woods. Correct assembly involved simple color symmetry problems. Designed in 1971. Patented in 1974, Patent No. D-232571. Appeared on 1971, 1972, 1974, 1975, and 1977 brochures. About 400 produced and sold, 1971-1977. See description on page 52 and photo on cover. Apparently a pirated French version is now on the market.



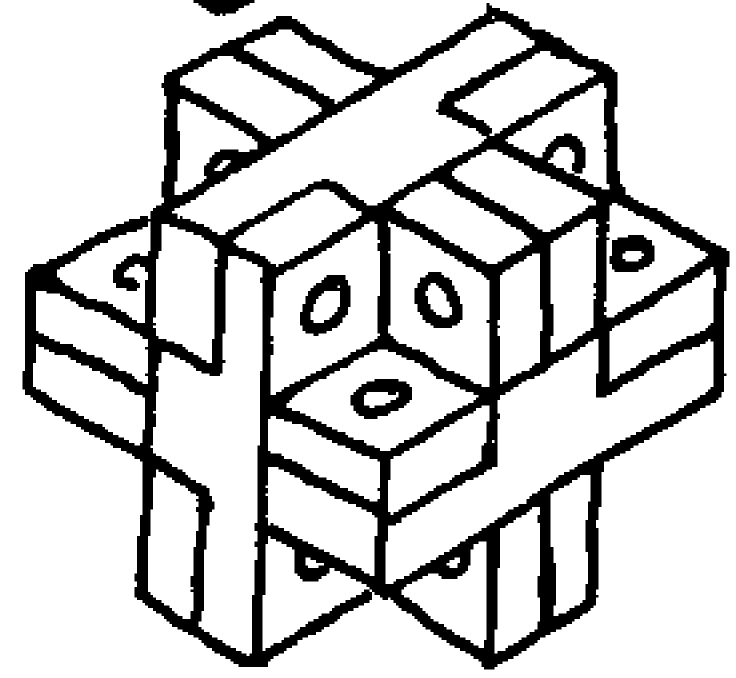
8. Nova Six identical pieces, with the assembled shape of the second stellation of the rhombic dodecahedron. Designed in 1971. Appeared on 1972 brochure. About 100 produced and sold, 1972-1974, mostly in Zebrawood.

8-A. An injection molded version of the Nova had pieces of a slightly different shape than the wooden version, but had essentially the same shape when assembled. Patented in 1975, Patent No. 3885794. Presently licensed to Skor-Mor (Union Bookbinding) as part of their Geo-Logic family of puzzles.

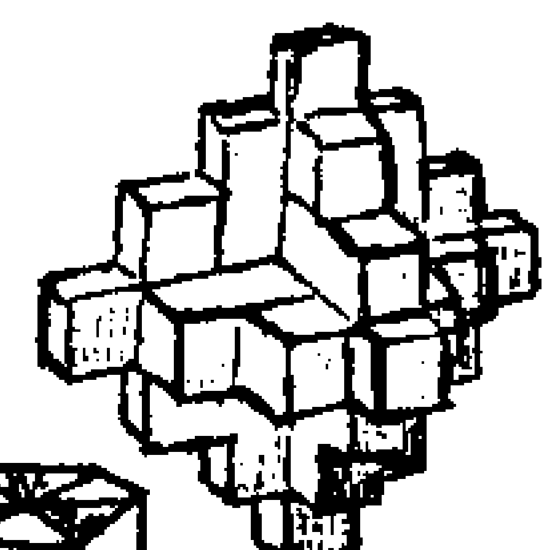
9. Square Knot A familiar twelve identical piece notched stick puzzle, patented by W. Altekruse in 1890, and sometimes therefore referred to as the Altekruse puzzle. Now in the public domain. See description on page 36. My version was made in three contrasting woods arranged in color symmetry. Appeared on 1974 and 1975 brochures. About 40 produced and sold, 1974-1975. (See also #57, 14-piece Square Knot.)

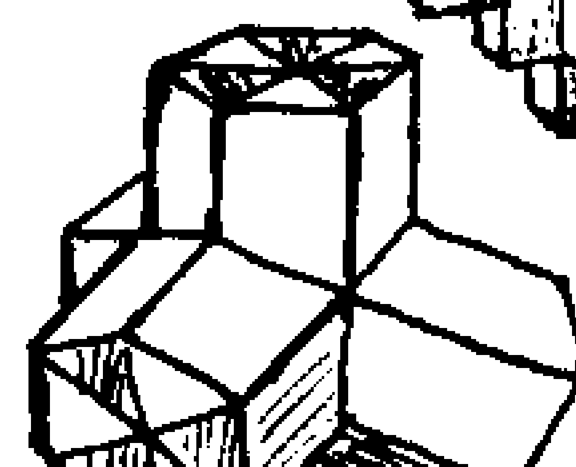


9-A. Frantix Of the numerous variations of the basic Square Knot puzzle, this is one of the more interesting. Designed in 1973. This puzzle was licensed to 3M Company and manufactured in injection molded styrene. A slightly modified wooden version of same is shown on the cover of PC. The wooden version was never produced. It has some interesting properties, including omnidirectional expansion to larger assemblies. It would have made a nice puzzle in wood, but with the number of pieces needed for the larger assemblies, would have been simply too expensive. Mass production with high speed machinery might bring the cost down to a reasonable level.



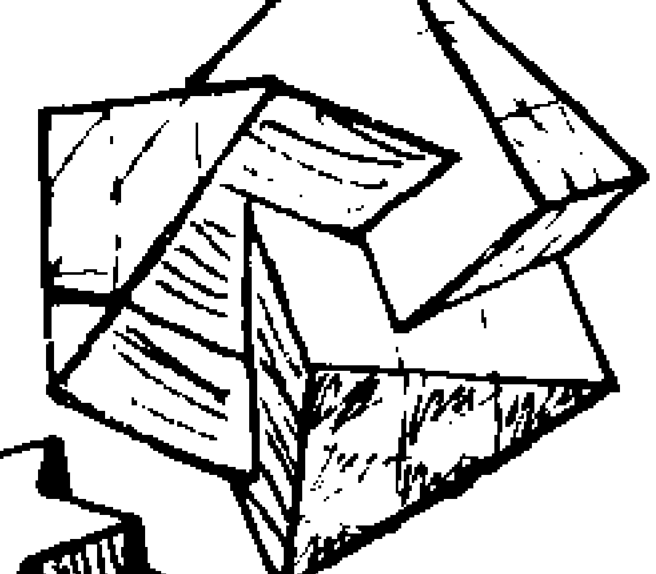
10. Giant Steps The possible variations of the basic Square Knot puzzle are practically limitless. This particular one has six augmented pieces, giving it a completely different appearance. Designed in 1973. Appeared on 1974 and 1975 brochures. About 20 produced and sold, 1974-1976, mostly in Butternut. (A good example of how to spoil a puzzle by making it simply more complicated for no particular reason.) See also #53, Little Giant Steps.



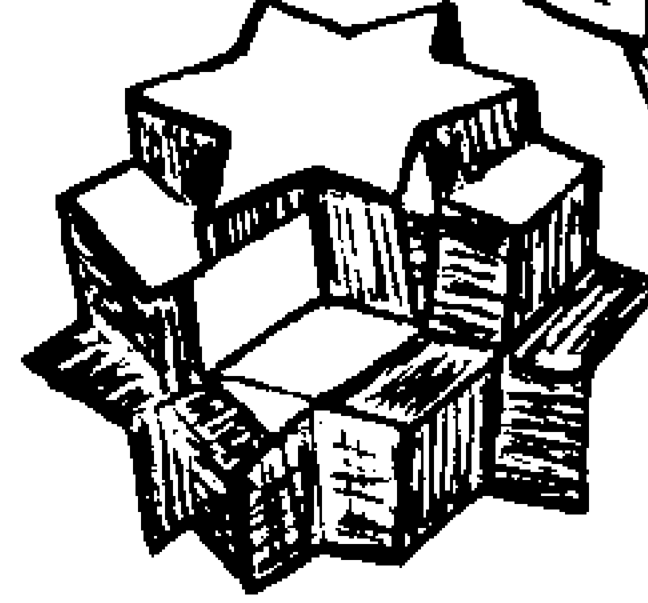


11. Hexagonal Prism Designed around 1974. Appeared on 1974 and 1975 brochures. Illustrated on PC cover, and described on page 44. About 60 produced and sold, 1974-1976, and 1983 to present.

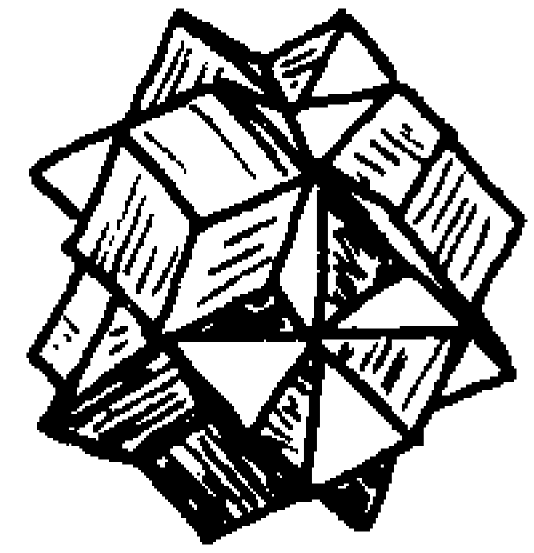
12. Triangular Prism Designed around 1974. Appeared on 1974, 1975, 1980, and 1981 brochures. Illustrated on PC cover, and described on page 44. About 100 produced and sold, 1974-1983, mostly in Honduras mahogany.



13. The General (Four Star) Designed around 1974. Appeared on 1974 and 1975 brochures. Described on page 45. About 20 produced and sold, 1974-1976, mostly in Honduras Mahogany.

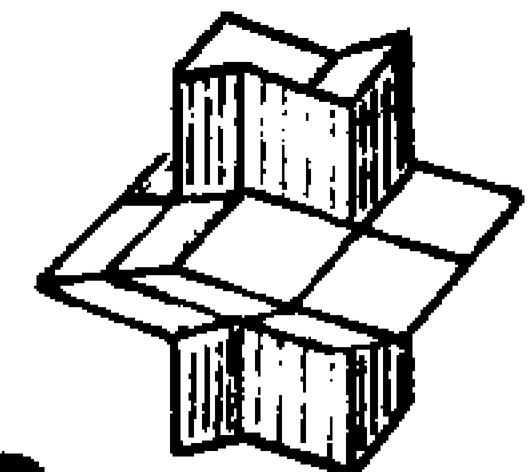


14. Super Nova Designed in 1974. Appeared on 1974 and 1975 brochures. About 20 produced and sold, 1974-1975.

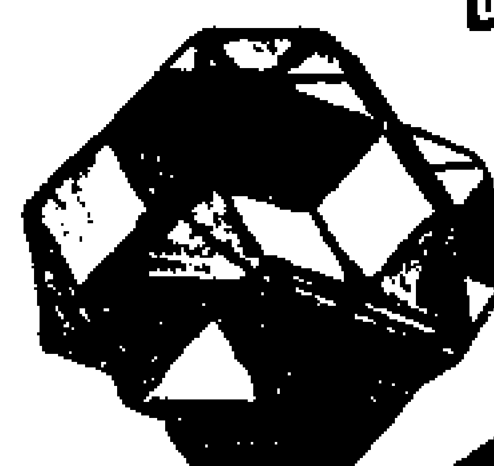


14-A. Second Stellation This is a reissue of the Super Nova puzzle, with improved workmanship, introduced on the 1981 brochure. See illustration on PC cover, and description on page 43.

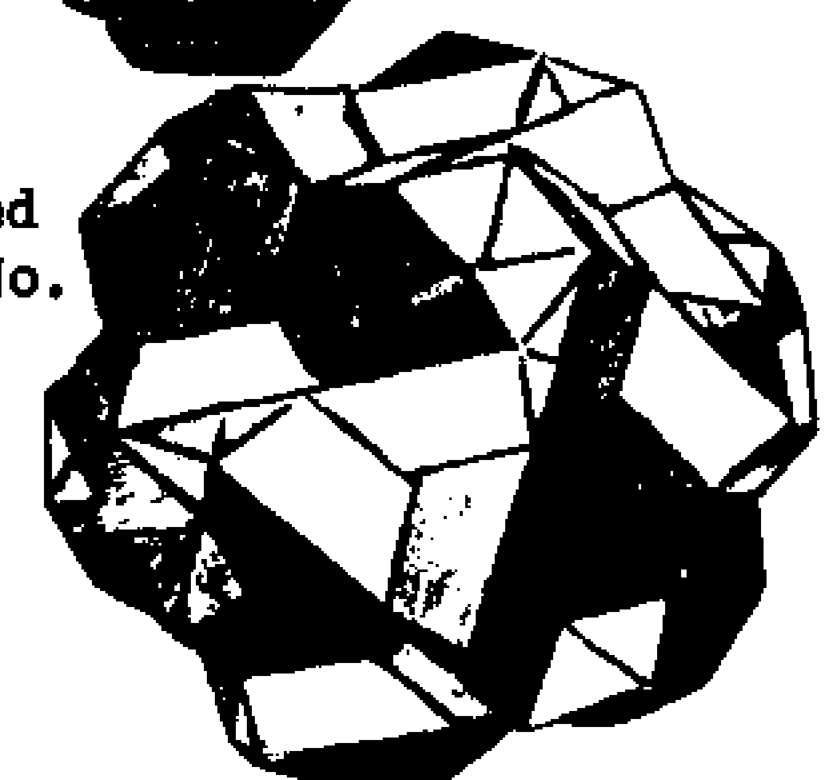
An improved version of the Second Stellation was introduced in 1983, made with triangular rather than square stock. It has a more symmetrical appearance, and the edges are less prone to wear and breakage. Altogether about 100 produced and sold, 1981 to present.



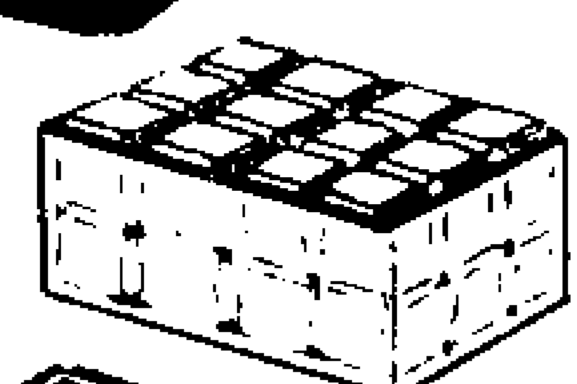
15. Triumph Designed in 1974. Appeared on 1974 and 1975 brochures, and on a 1983 newsletter.
See description on page 47. About 50 produced and sold, 1974-1976 and 1983 to present.



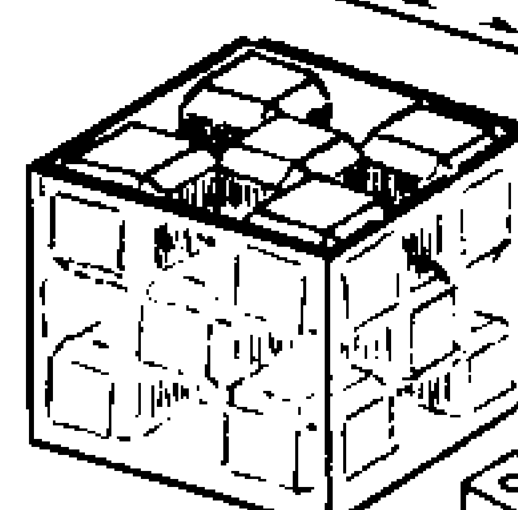
16. Dislocated Scorpius Designed around 1974. Appeared on 1974 and 1975 brochures. Patented in 1974, Patent No. D-230288. (See #5, Scorpius). For description, see page 51. About 20 produced and sold, 1974-1976.



17. Dislocated Jupiter Designed around 1974. Appeared on 1974 and 1975 brochures. Patented in 1974, Patent No. D-232571. (See #7, Jupiter). For description, see page 52. About 10 produced and sold, 1974-1976.



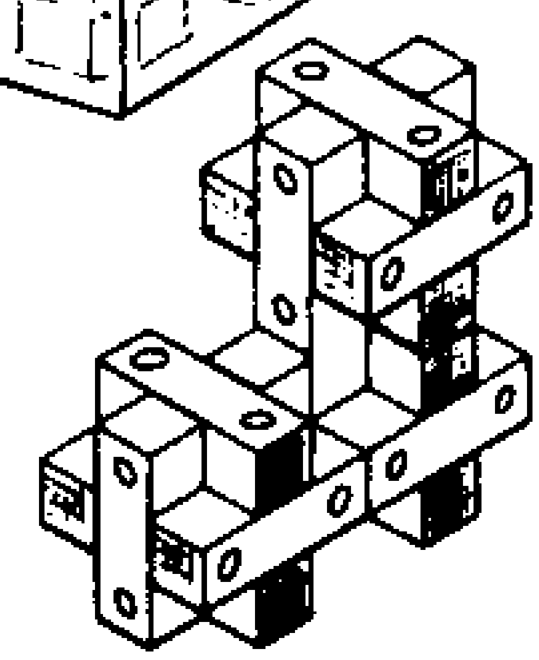
18. Abbie's Waffle A simple 6-piece cubic block type puzzle, designed and made by one of my daughters. Appeared on 1975 brochure. Numerous puzzle problems and figures were worked out for this puzzle, but they were never printed in the form of a proper instruction booklet, without which puzzles of this sort have little value. Probably about 10 produced and sold in 1975.



19. Pyracube Designed in 1974. Appeared on 1975 brochure. For description, see page 54. About 20 produced and sold, 1975-1976.

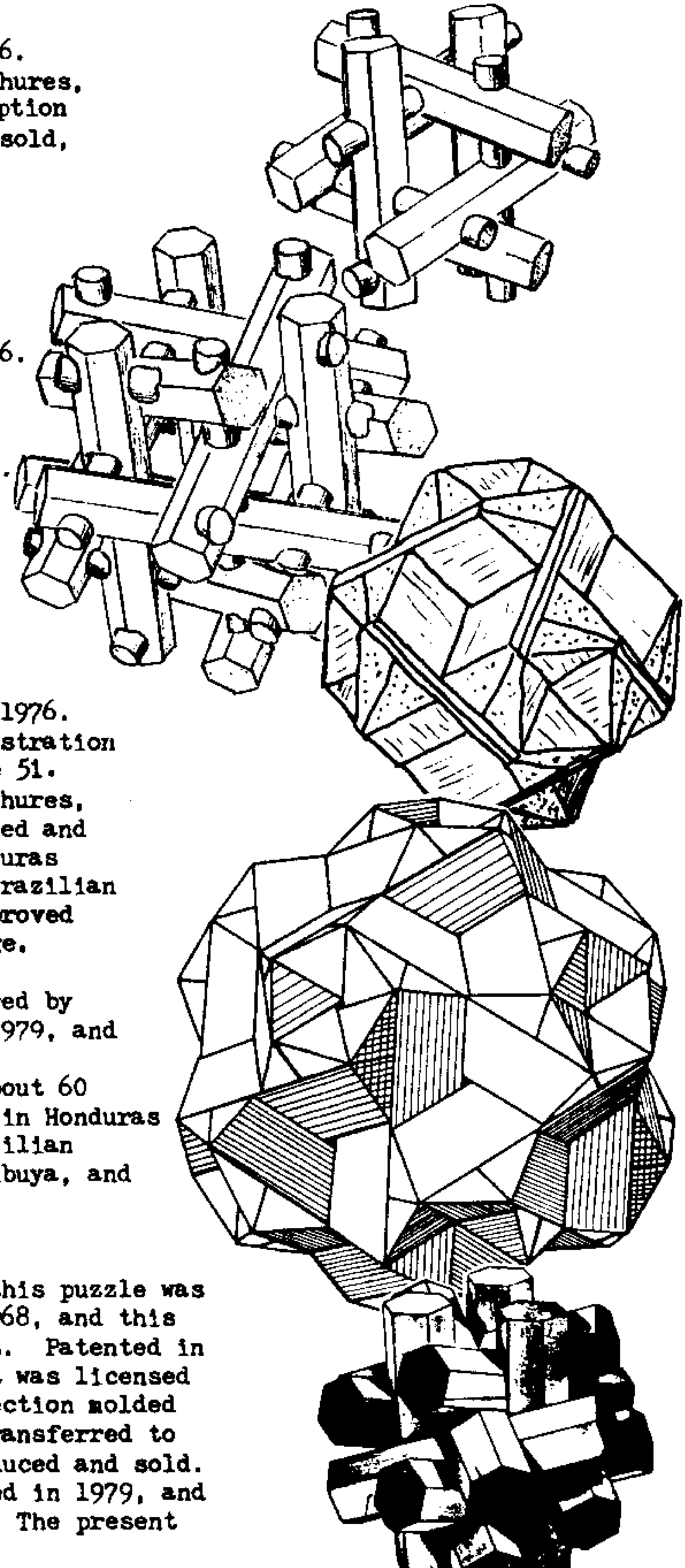
A variation on the Pyracube puzzle, created by Prof. W. van der Poel using spheres in place of edge-beveled cubes, appears in Creative Puzzles of the World, page 85.

See also #61, Setting Hen.



20. Pin-Hole Family Designed in 1976, and instruction booklet copyrighted in 1976. Appeared on 1977 brochure. See description on page 38. These were sets of puzzle pieces which could construct various puzzle figures, depending on the size of the set. About 50 sets produced and sold, 1977-1980.

21. Cuckoo Nest Designed around 1976. Appeared on 1977, 1978, and 1979 brochures, and also listed in 1983. See description on page 49. About 100 produced and sold, 1977-1983.



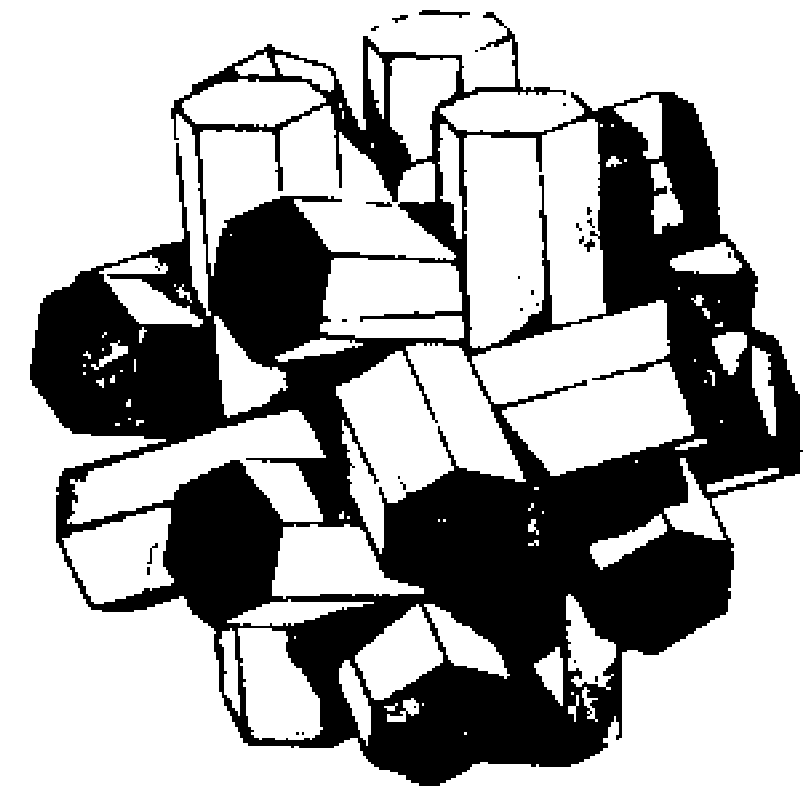
22. Locked Nest Designed around 1976. Appeared on 1977, 1978, and 1979 brochures. See illustration on PC cover, and description on page 49. About 50 produced and sold, 1977-1981.

23. Scrambled Scorpius Designed in 1976. Covered by Patent D-230288. See illustration on PC cover, and description on page 51. Appeared on 1978, 1979, and 1981 brochures, and listed in 1983. About 200 produced and sold, 1978 to present, mostly in Honduras Mahogany, but including about 30 in Brazilian Rosewood with doweled joints. An improved variation is now in the thinking stage.

24. Saturn Designed in 1978. Covered by Patent D-232571. Appeared on 1978, 1979, and 1981 brochures.
See description on page 52. About 60 produced and sold, 1978-1983, mostly in Honduras Mahogany, but including a few in Brazilian Rosewood with doweled joints, 4 in Imbuya, and 3 in Andiroba.

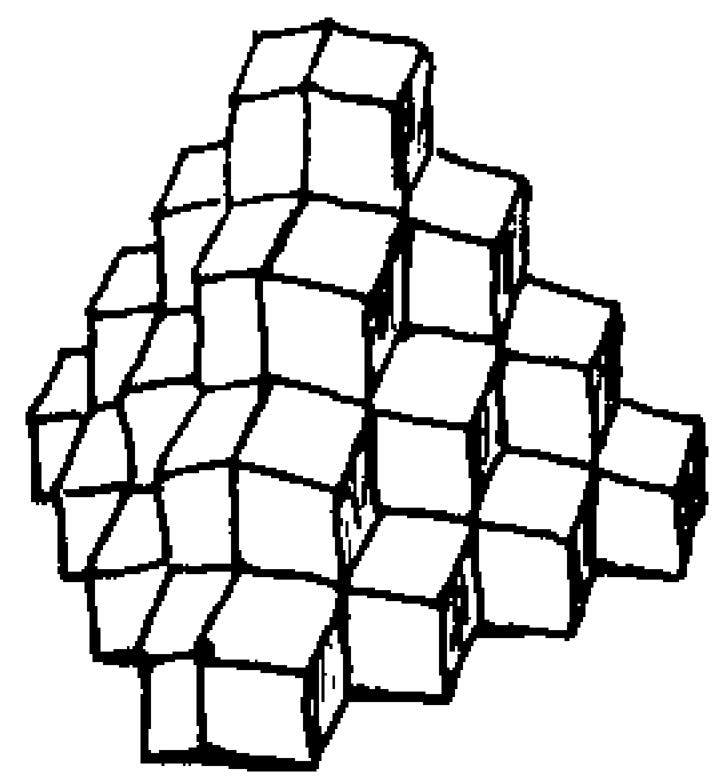
25. Hectix My original version of this puzzle was designed and cast in epoxy in late 1968, and this marks the start of my puzzle business. Patented in 1973, Patent No. 3721448. In 1970 it was licensed to 3M Company for manufacture in injection molded styrene. In 1976, the license was transferred to Avalon Hill. About 100,000 were produced and sold. Apparently production was discontinued in 1979, and all rights have reverted back to me. The present location of the mold is unknown.

25-A. Hexsticks This wooden version is practically identical to Hectix except that two of the pieces have one notch instead of two, and the pieces are slightly longer. See illustration on PC cover, and description on page 50. Covered by Patent No. 3721448. Designed in 1979. Appeared on 1979 and 1981 brochures, and listed in 1983. About 150 produced and sold, 1979 to present, nearly all in Birch.



A pirated version of this puzzle was at one time, and still may be, made by Tenyo.

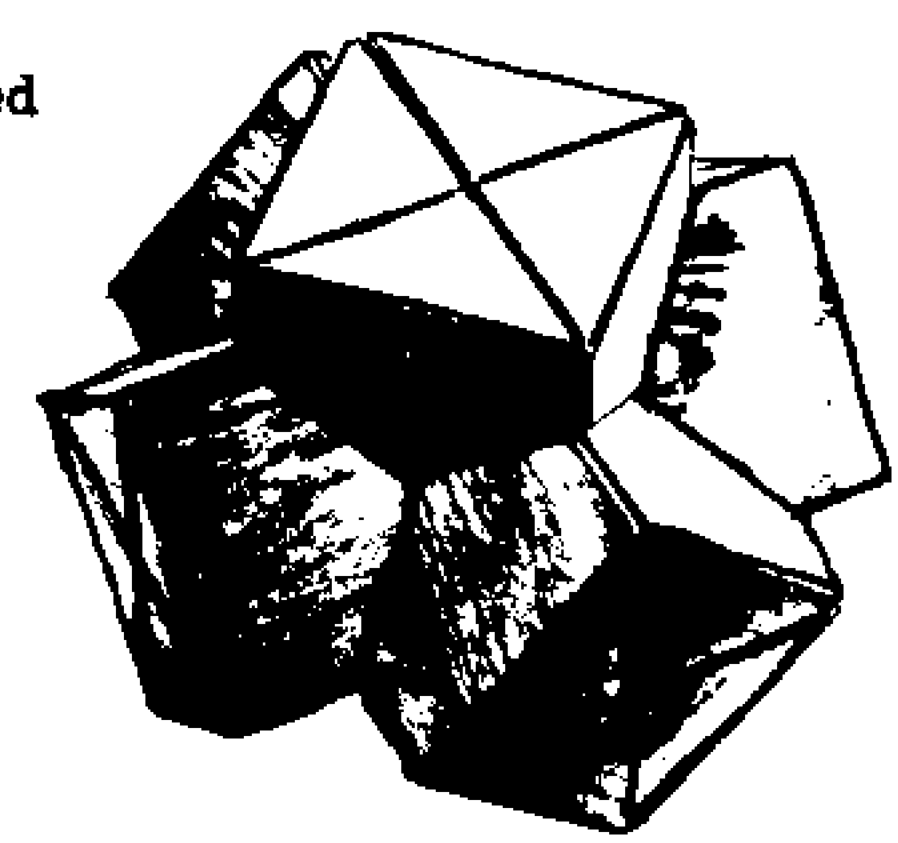
26. Four-Piece Pyramid Designed in 1976. Appeared on 1979 and 1981 brochures. See description on page 53. In 1976, a limited run of 12 of these were made from one-inch edge-beveled cubes of Honduras Rosewood, with doweled joints, of which all but one were sold.



A new version was introduced on the 1979 brochure, made of one-inch rhombic dodecahedra in Cherry.

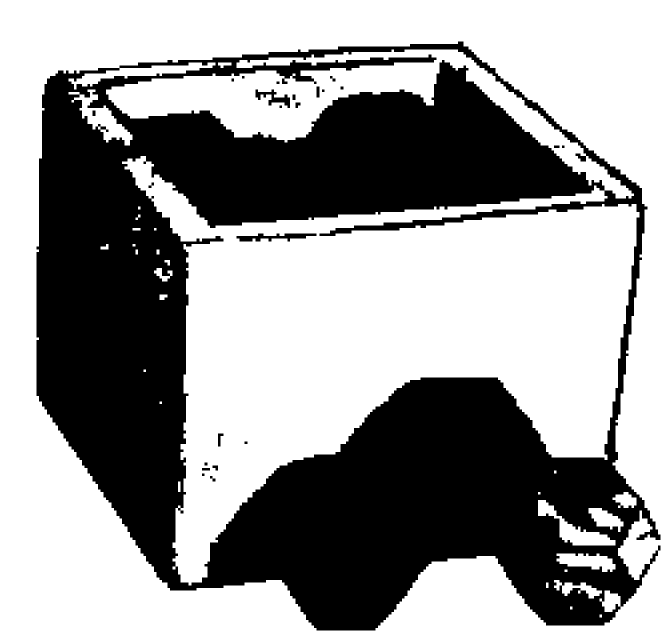
A much improved version was introduced on the 1981 brochure, made of $1\frac{1}{4}$-inch edge-beveled cubes of Honduras Mahogany, and a few were made in Mulberry. In all, about 50 produced and sold, 1979-1983. One of these is shown on the cover.

27. Three Pairs Designed in 1973. Originally intended for manufacture in plastic. Numerous minor variations were designed, such as rounded, octahedral, etc. My agent did not succeed in licensing any of them, and evidently all the models were eventually lost.



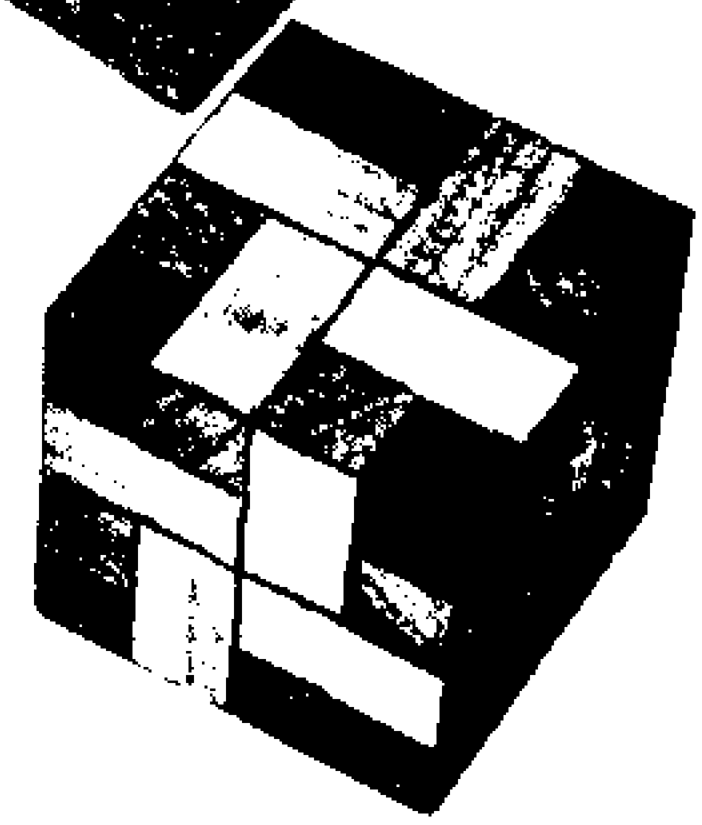
The wooden version appeared on 1979 and 1981 brochures, and listed in 1983. See illustration on PC cover, and description on page 48. Produced 1979 to present, about 150 in Honduras Mahogany, a few in Cherry, and very few in Brazilian Rosewood with doweled joints.

28. Truncated Octahedra Designed preliminary version in 1975, based on design by Kirsch. Redesigned and improved in 1979. Instruction booklet copyrighted in 1979. Appeared on 1979 and 1981 brochures. See See description on page 52. About 50 produced and sold, 1979-1983.

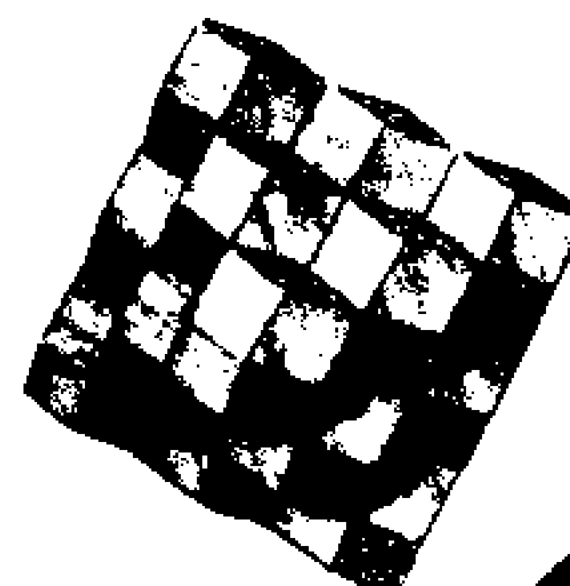


29. Half-Hour Designed in 1980. Appeared on 1980 and 1981 brochures. See description on page 28. In additior to the constructions shown on page 29, David Barge of 87 Elm St., Oneonta, NY 13820, has created about 700 more.

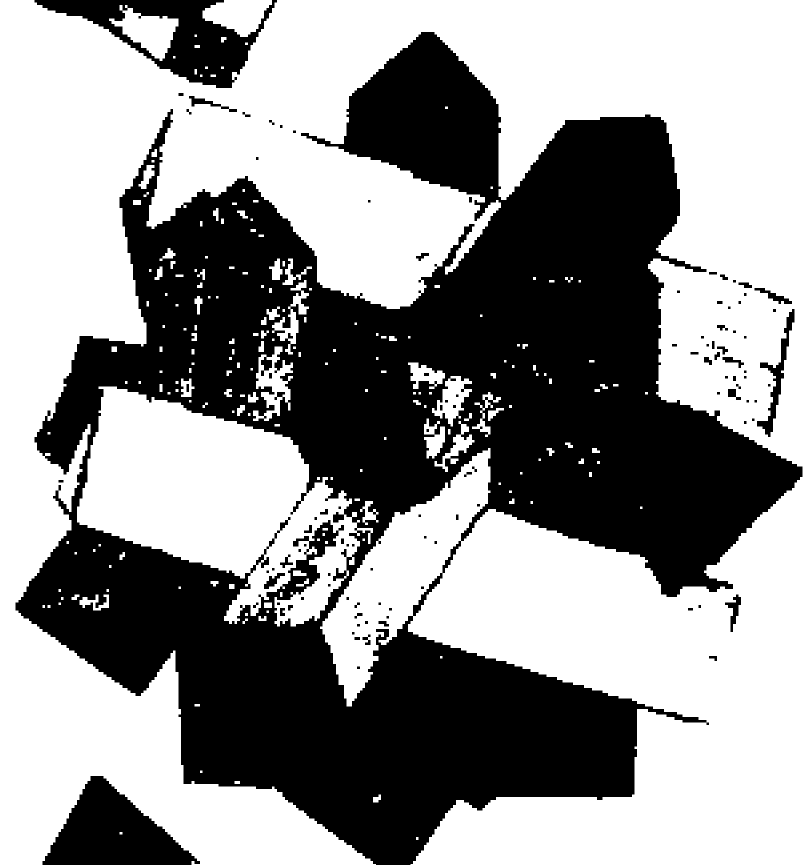
About 50 were produced and sold, 1980-1983, in Cherry. More recently, about 20 were produced and sold in six contrasting fancy woods, with a box of Blue Maho. An especially nice one in Cherry has just been made for a puzzle article scheduled to appear in the September issue of Woodworker's Journal (1985).



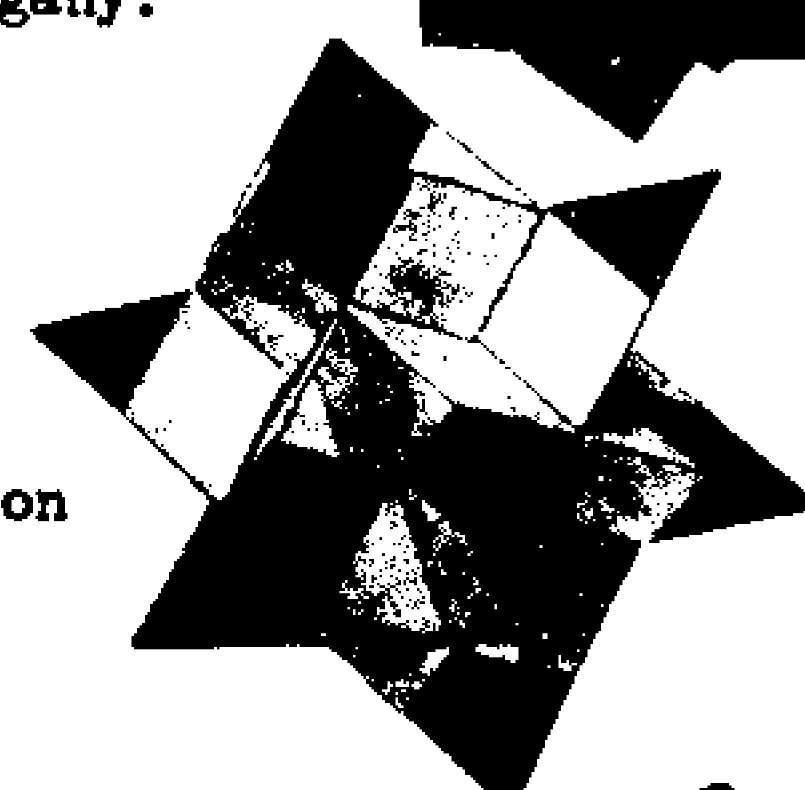
30. Convolution Designed in 1980. Appeared on 1980 and 1981 brochures. See illustration on cover, and description on page 31. Produced and sold about 50, 1980-1983, mostly in Cherry and Rosewood.



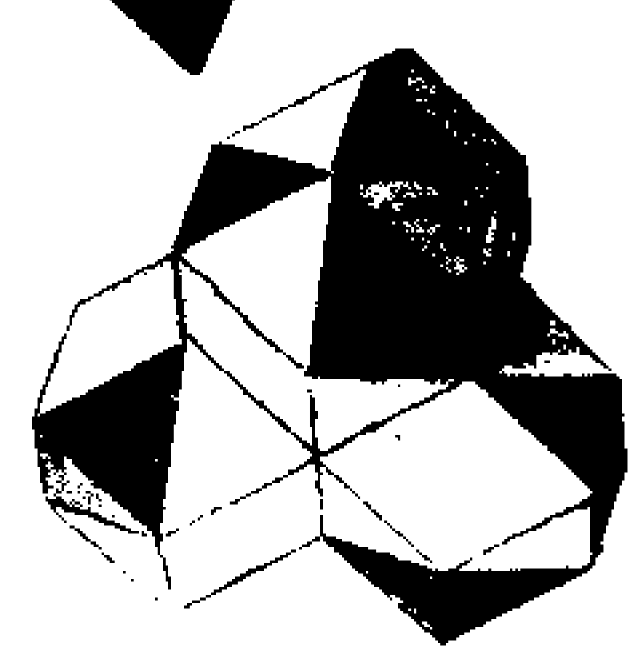
31. Octahedral Cluster Designed in 1980. Appeared on 1980 and 1981 brochures. See illustration on PC cover, and description on page 54. Produced and sold about 40, 1980-1983, mostly in Primavera or Limba.



32. Broken Sticks Designed in 1980. Appeared on 1980 and 1981 brochures. See illustration on PC cover, and description on page 44. About 50 produced and sold, 1980-1983, mostly Honduras Mahogany.

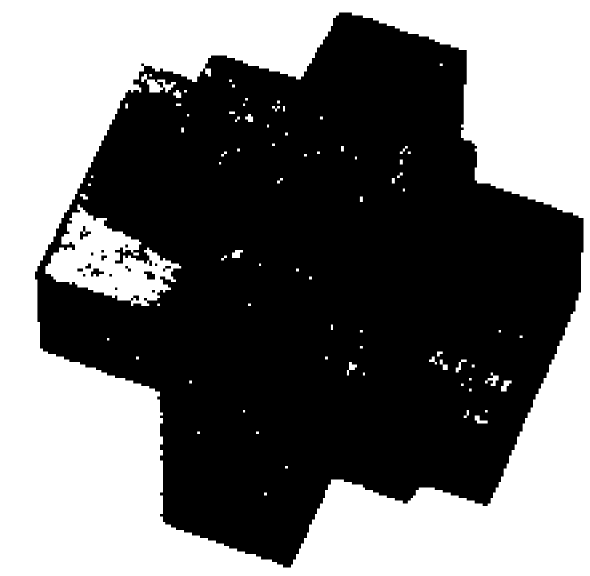


33. Twelve Point Designed in 1980, but actually only a minor variation of the Second Stellation puzzle. Appeared on 1981 brochure, and listed in 1983. See illustration on PC cover, and description on page 43. About 50 produced and sold, 1981 to present, mostly in Mahogany and Rosewood.

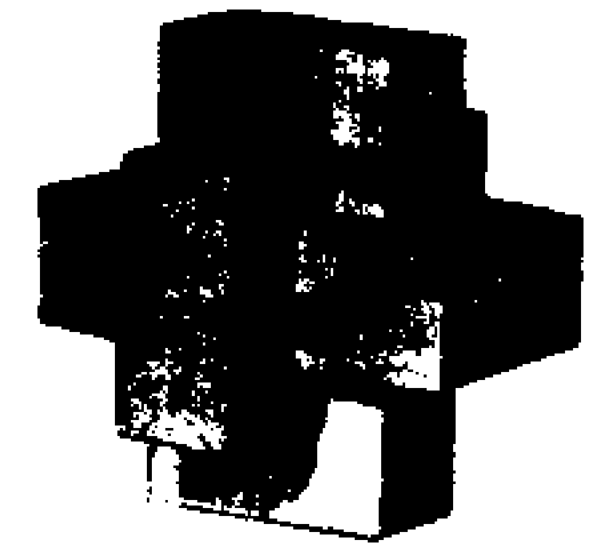


34. Augmented Four Corners Present version developed in 1980, and appears on 1981 brochure, but the design dates from around 1973, at which time evidently a few variations were made in exotic woods and sold. See illustration on cover and description on page 46. About 60 produced and sold, 1981-1985, mostly in Cherry and Rosewood.

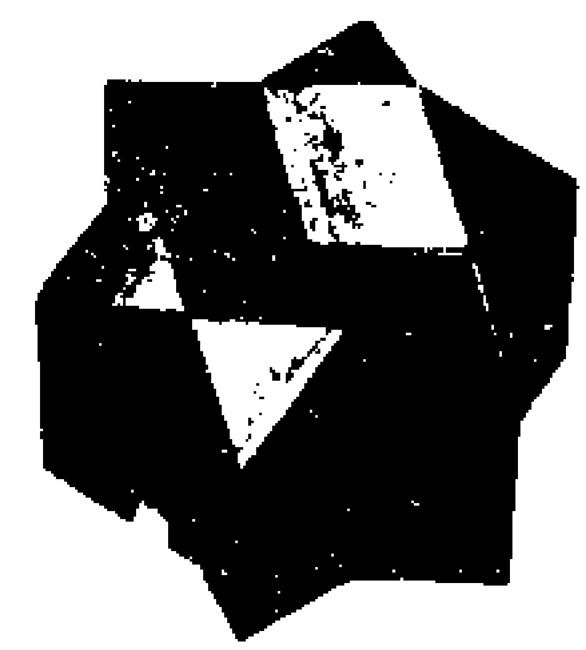
35. Burr #305 This conventional burr was one of the 314 possible combinations listed by Bill Cutler in his computer analysis of solid notchable burrs, and he deserves most of the credit for it. All I did was select it out as being the most interesting of the lot, which I remain convinced it is. The process by which this was done is explained in the description on page 33. Appeared on 1981 brochure and listed in 1983. About 60 produced and sold, 1981 to 1985, all in Cherry except for three in Rosewood. See illustration on cover.



36. Coffin's Improved Burr Designed in 1979. Appeared on 1981 brochure. On the instruction sheet for this puzzle, I proposed a contest to see who could come up with the most interesting new and original burr design. which I would then reproduce. This was my entry. Bill Cutler won with his Baffling Burr. About 50 Coffin's Improved and 14 Bill's Baffling Burr produced and sold, 1981-1985.

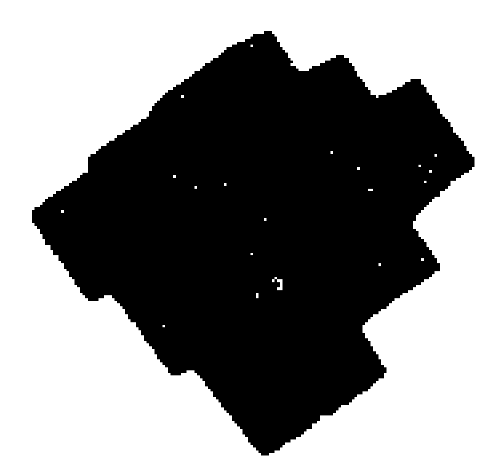


37. Star-of-David Designed in 1981. Appeared on 1981 brochure. See illustration on PC cover, and description on page 47. This was the first of the so-called "Puzzle Club" series of puzzles. About 50 produced and sold, 1981-1983, all in Honduras Mahogany.



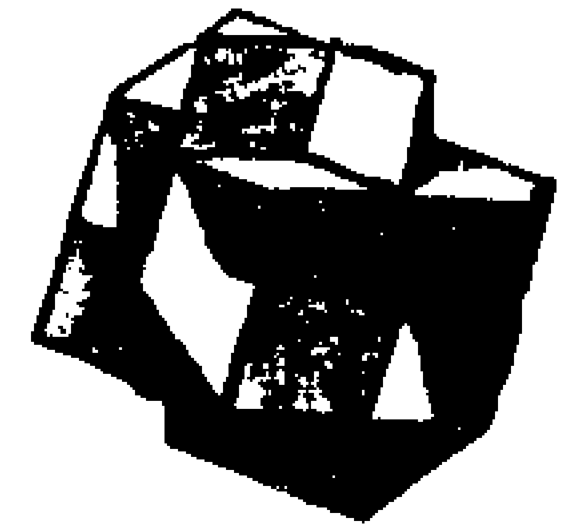
38. Three-Piece Block This puzzle has an interesting history. It was designed in 1980, at the request of an advertising agency. The isometric view of the base happens to be the logo of a corporation. I produced 300 of these for that corporation, to be used in some sort of public relations operation. I have retained all rights to the design.

In 1981, this puzzle was listed as the second in the "Puzzle Club" series. It was sent disassembled, with no instructions. Many persons reported being unable to solve it, indicating they had no idea what shape it was supposed to make, and apparently unaware that it was shown on the cover of the 1981 edition of Puzzle Craft. About 50 produced and sold, 1981-1983. Those sold in late 1983 came with a base.



39. Rosebud Designed around 1980. Announced in a supplementary mailing in 1982 as the third in the "Puzzle Club" series.

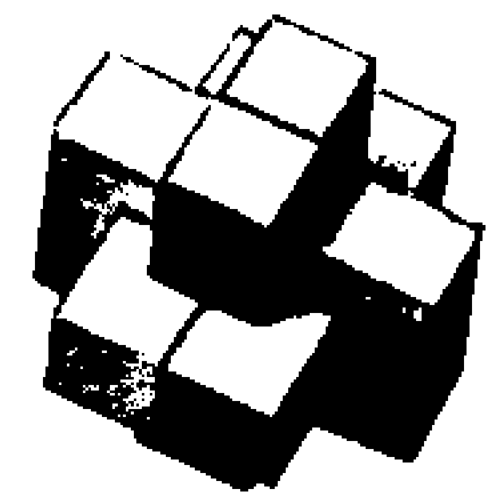
See description on page 48. Two versions were produced, one in hardwood (Cherry and Mulberry) and one in fancy wood (Rosewood and Tulipwood). Altogether about 40 produced and sold, 1982-1983.



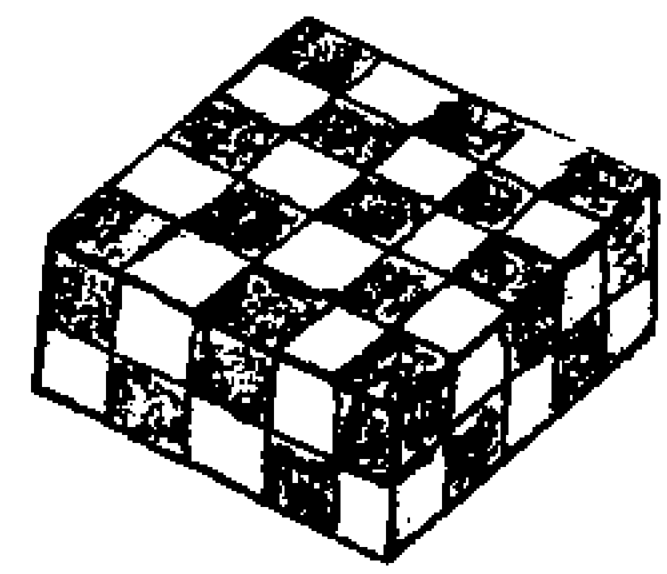
39-A Rosebud Assembly Jig The Rosebud puzzle was shipped disassembled, with vague instructions. From reports received, probably far less than half were ever assembled in the Rosebud solution. I developed an assembly jig for quick and

(39-A) easy assembly in my shop. In 1983, I announced this jig for sale, together with explicit instructions. About a dozen sold so far.

40. Interrupted Slide Designed in 1979. Announced in a supplementary mailing in 1982. This unnotchable six-piece burr is described on page 34. Twenty-eight of these were made from one board of rare Golden Bilinga. When the wood ran out, production ended. They were all shipped disassembled, without instructions. From the few reports back, my guess is that over half have never been assembled, and may never be.

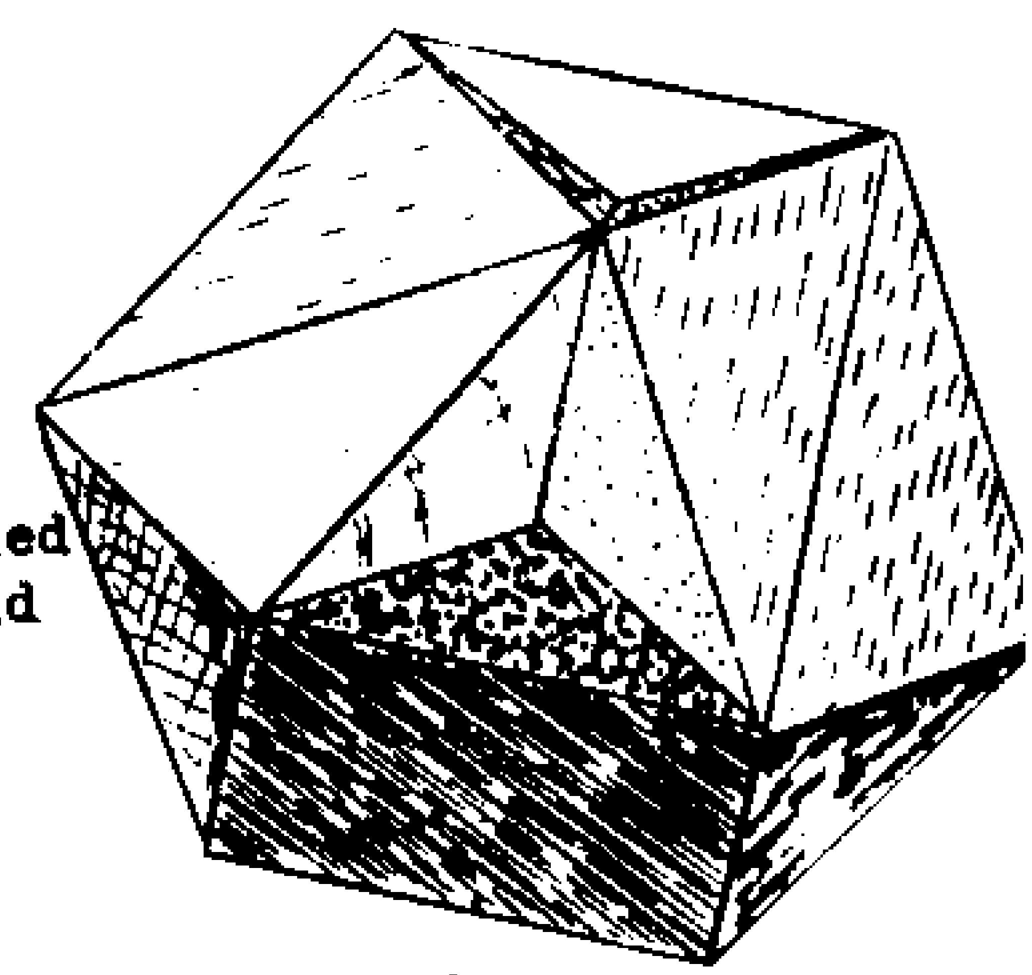


41. Unhappy Childhood Designed in 1983, in a joint endeavor with Mike Beeler. I proposed the puzzle, and he did all the rest with the aid of a computer. It is illustrated on the cover and described on page 30. It is also mentioned in the puzzle article in the Fall 1984 issue of Abacus. About 50 were produced and sold in 1983-1984 using various exotic woods, with a box of English Brown Oak.



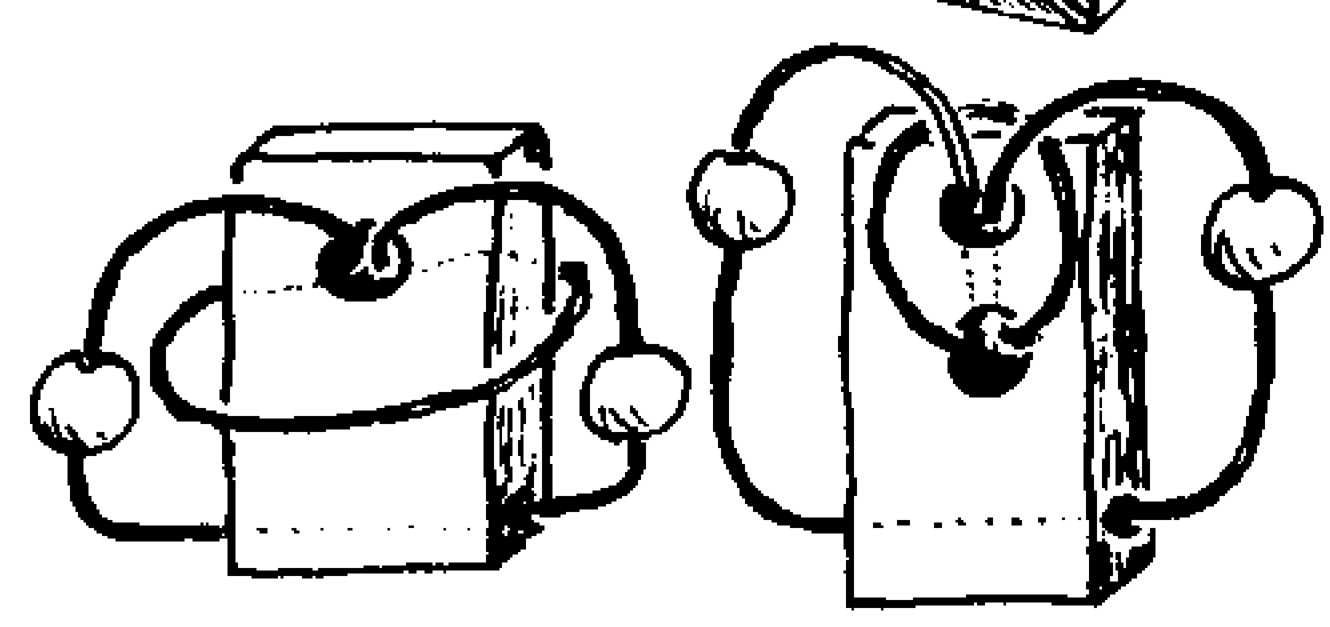
That concludes the listing of puzzles which were announced on brochures and "Puzzle Club" newsletters from 1970 through 1983.

The next listing is of puzzles made and sold during this same time period, 1970-1983, but never advertised, so their quantities were generally fewer. Not all such puzzles are listed here, because many were one-of-a-kind productions or experimental models which were never recorded. Every now and then someone shows me one made many years ago which I had completely forgotten. Usually they are but minor variations of designs listed in this book, and no purpose would be served by trying to list them all.



42. Seven Woods Designed in 1971. Probably about 20 produced and sold around 1971. The design is shown in on page 42. . This particular version used six different woods for the end blocks plus a seventh in the center, hence the name. The object was to match the woods in assembly. The instruction sheet identified the woods and told a little bit about them, so it could be called a natural history toy or very simple puzzle.

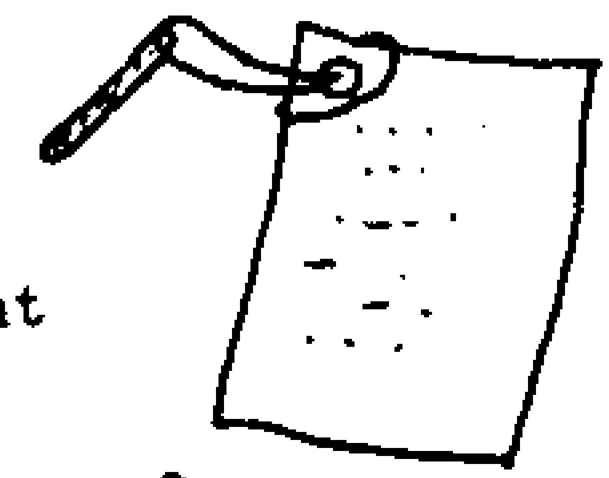
43 and 44. Sleeper-Stopper and Super Sleeper-Stopper Designed in 1972, but based on a familiar topological puzzle in the public domain. See description on page 13. Made in a combination of fancy woods, light and dark, to mark the two sides. Incidentally, it was the need for a good quality bead for this puzzle that prompted me to design and construct



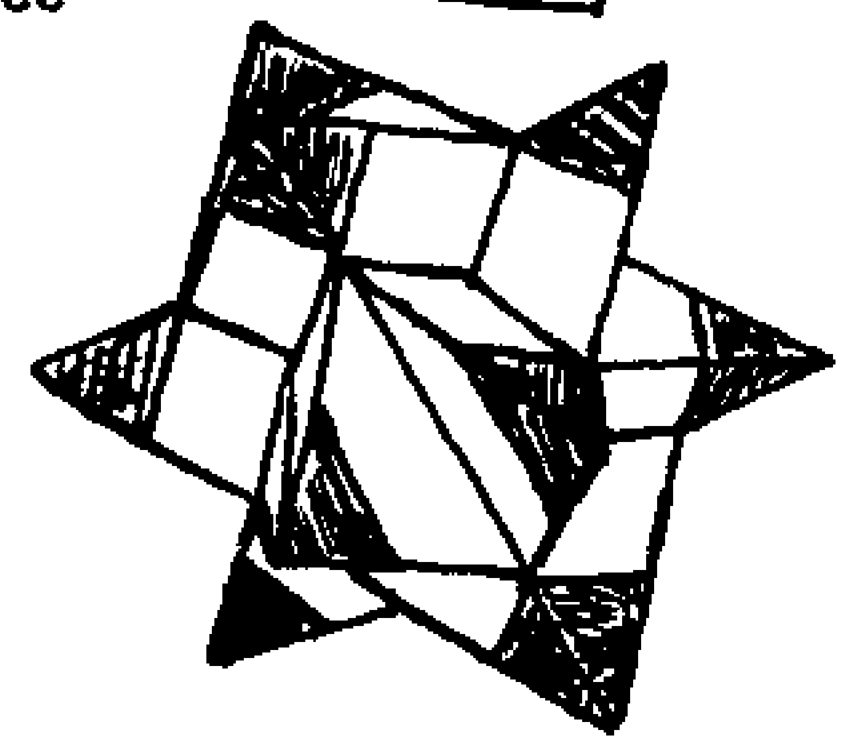
a bead making machine. It was so successful that for two years practically all we did here was make beads, buttons, and wooden jewelry.

About 150 S-S and SS-S were produced and sold, mostly at craft shows, 1972-1974. Recently a box of about 30 unfinished ones was uncovered, so they were finished and sold too.

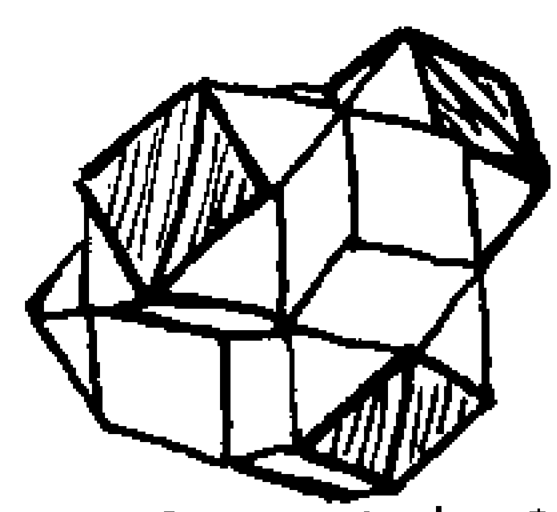
45. Buttonhole A familiar old puzzle of unknown origin, in the public domain. Possibly invented by famous puzzle inventor Sam Loyd. We produced these in large numbers from scraps of exotic woods, to be sold by my kids at craft fairs for 30¢ each. We had as many as fifty different kinds of wood. Ours came with an instruction sheet which had a buttonhole punched in it, with puzzle attached. See description on page 12.



46. Vega Designed in 1971. This puzzle had the same assembled shape as #33, Twelve Point puzzle, but the six puzzle pieces were identical and symmetrical, hence a much simpler puzzle. Made in two contrasting exotic woods. See description on page 46. About 30 produced and sold at craft fairs, 1972-1975.

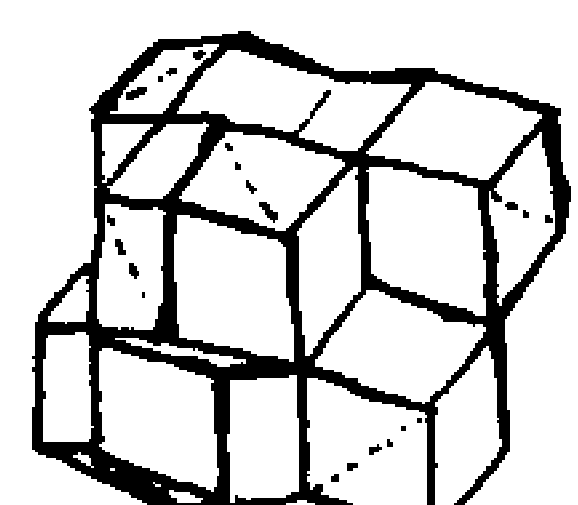


47 and 48. Cluster-Buster and Truncated Cluster-Buster Designed in 1973. Six identical pieces assembled in two halves to form an interlocking solid with only one sliding axis. Intended for manufacture in plastic (but could have been made in wood). Various models with minor variations were made, included truncated versions, spherical, cored out, etc. Licensing efforts were not successful, and most of the models were lost. See description on page 46.



(Truncated C-B)

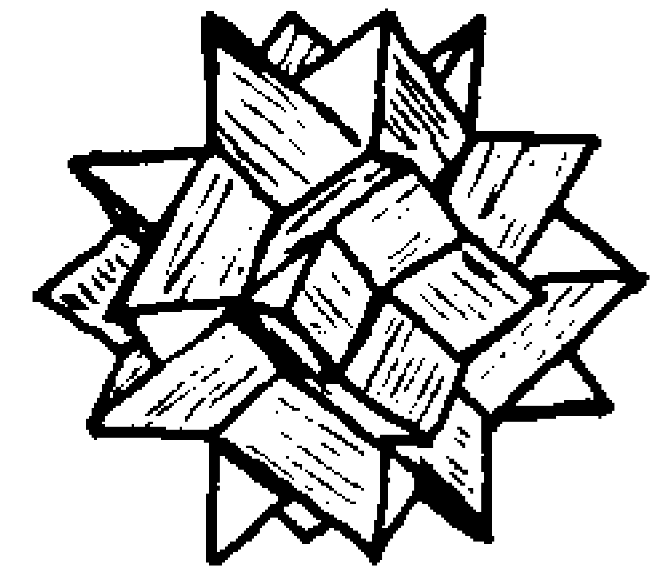
49. Improved Cluster-Buster This version was designed for production in wood, year unknown, and no more than a few were made. It has three dissimilar pairs of pieces, making it slightly harder to assemble than the original C-B. One interesting feature of all the puzzles in this family is that in order to disassemble them, you must examine them carefully to find the one sliding axis, and then place three fingers of each hand in just the right places, hence the name. They are rather attractive in fancy wood, and recently I used the last of my supply of Zebrawood to make two of them, one of which is shown on the cover. Description on page 46.



50 and 51. Superstar and Little Superstar Designed in 1968. Originally intended for manufacture in plastic. A modified version of the Little SS became the Tauri puzzle in the Skor-Mor Geo-Logic series, and is covered by Patent No. 3885794.

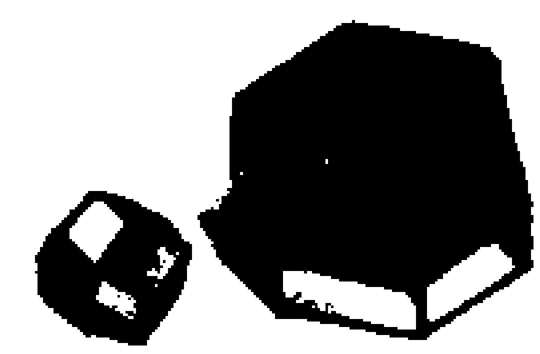
TAURI™, the ILLUSION OF SPINNING Geo-Logic™ Puzzle, for ADULTS of all ages.

(50 and 51) The wooden version of this puzzle, to which the name Superstar was later assigned, has six identical pieces and the assembled shape of the third stellation of the rhombic dodecahedron. About 10 were produced and sold at craft fairs around 1972-1975, all in Honduras mahogany. (Not to be confused with #73.)



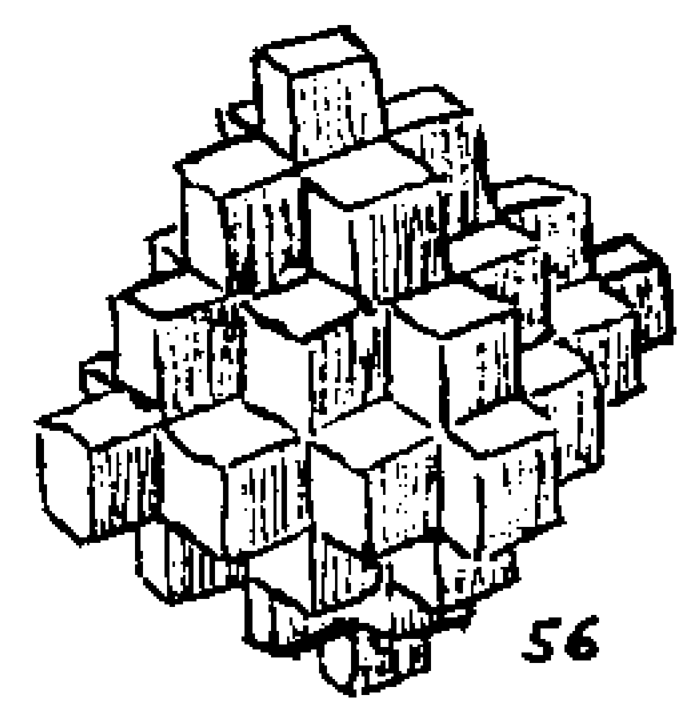
52. Pennyhedron and Minihedron The story of the origin of this puzzle is told on page 56. See also the illustration on the cover of PC. Our three daughters made and sold probably a few dozen sets of these around 1971-1973.

A new and improved edition of this puzzle set was listed on my 1984 flyer, and many variations were made, too numerous to list, all in very limited numbers.

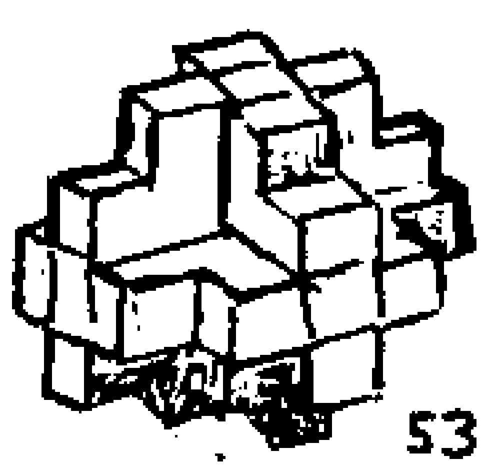


After this puzzle appeared in Fine Woodworking, two different woodworkers, both in California, asked for permission to make and sell it, which I gave them, but I have heard nothing more.

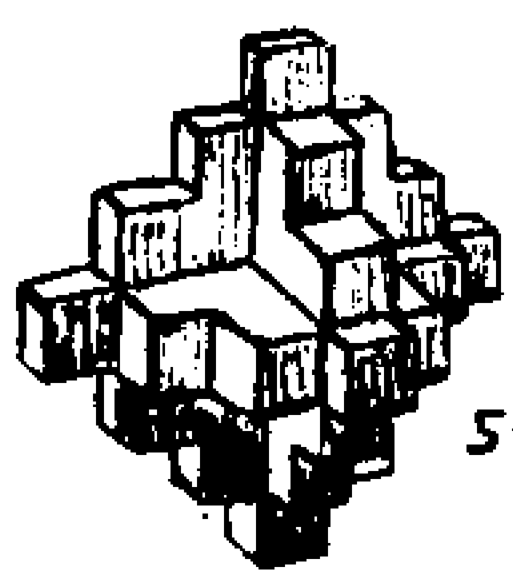
53-56. Little Giant Steps, Defiant Giant, Pagoda, and Giant Pagoda. These are all variations on the Altekruse puzzle (see #9, Square Knot), made by adding blocks here and there to change the appearance of the assembled puzzle and make it more difficult. They are all listed and illustrated on an instruction sheet dated 1973, so must have been designed and made then. No more than a few of each were made and sold.



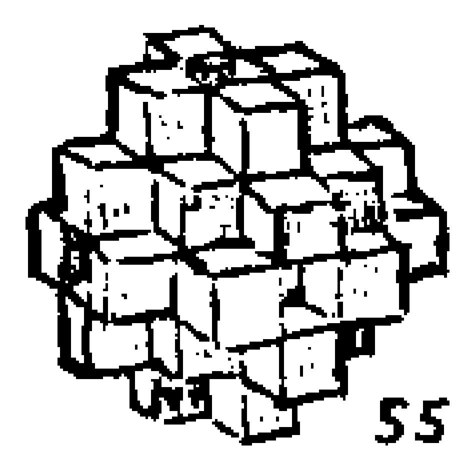
56



53



54

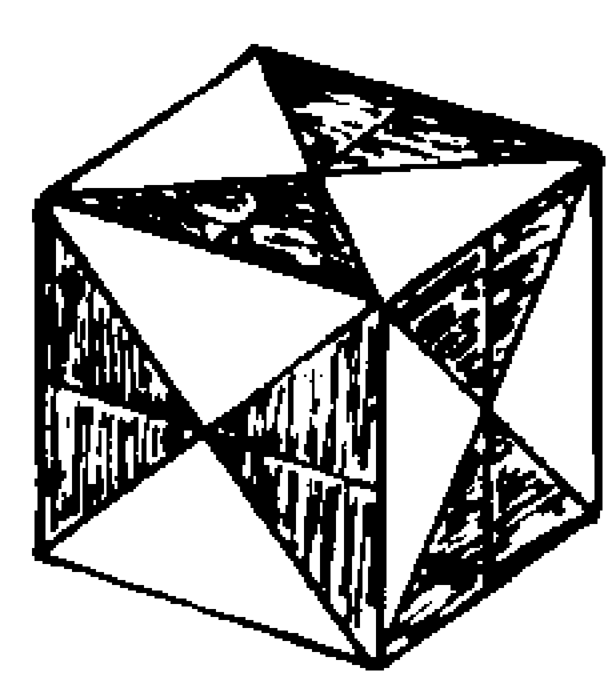


55

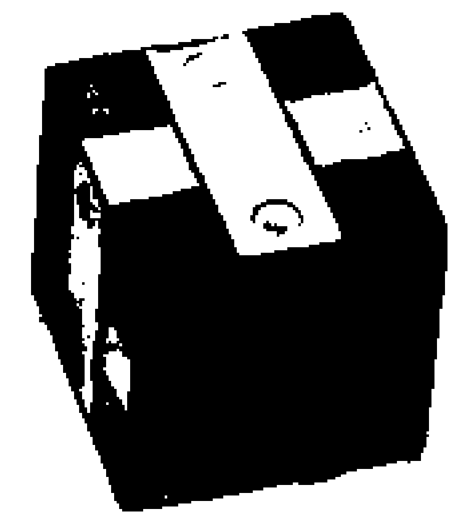
57. 14-Piece Square Knot An account of the joint discovery of this puzzle variation by Marjorie Hoffman and myself in 1973 may be found on page 37. About 20 produced and sold, 1973-1975.

(not illustrated)

58. Diagonal Cube Designed around 1971. It is described on page 45 and illustrated on the cover. A few were produced and sold around 1971, and a few more in 1983-1985, usually in two contrasting fancy woods. The one on the cover is Breadnut and Zebrawood.

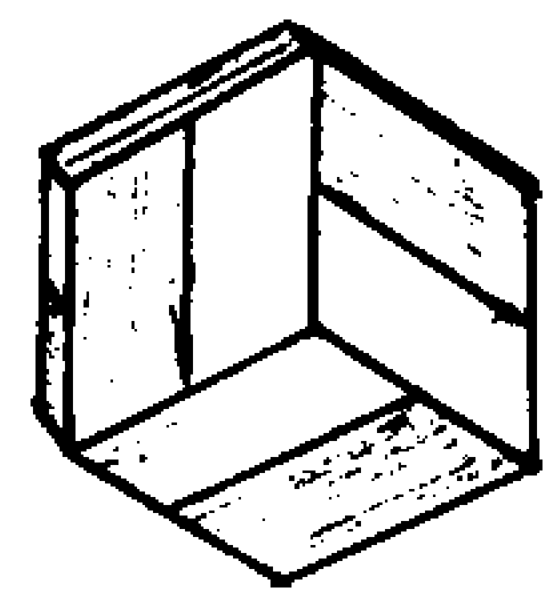


59. Corner Block Designed in 1980. See illustration on PC cover. This puzzle was created simply by attaching eight corner blocks to a Pin-Hole puzzle made up of one Bar and five Elbows. The hope was to find a design which had only one solution, but this was never achieved. For some unknown reason, the solutions always seem to occur in pairs, as is the case with this particular design. It is possible that this objection might be overcome, since a complete analysis never was made, in which case it would be a much more satisfactory puzzle.



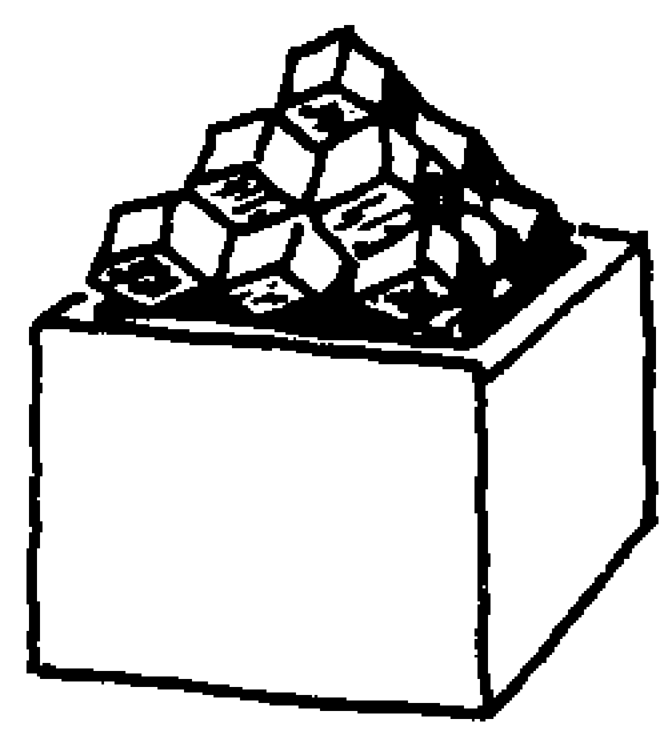
That concludes the listing of old puzzles. The next listing is of new puzzles for 1984.

60. Garnet Designed in 1984, but based on an earlier (1971?) design which had six identical pieces. It is described on page 58 and illustrated on the cover. An improved 1985 version with greater accuracy of fit is the mirror image of the one shown here. Further design improvements are being investigated by computer at this moment. The most recent innovation is to include the extra piece so that both listed solutions are possible. A fascinating family of puzzles.



61. Setting Hen Designed in 1984. Described on page 55. About 30 were produced and sold in 1984-1985. In most of these, four different kinds of wood were used for the four pieces, with a box of Blue Maho.

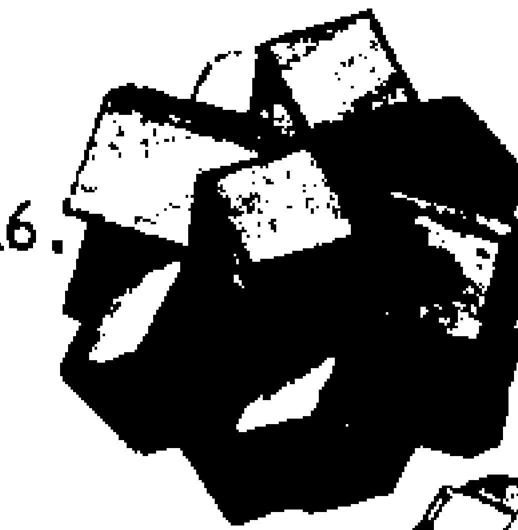
This is a good example of a design with many possible variations, too numerous and insignificant to mention. Many probably lie forgotten somewhere in my shop.



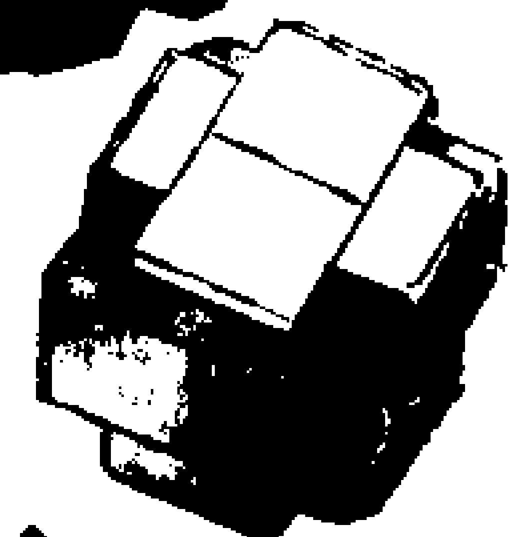
62. Nine Bars Designed in 1983. Resembles #21, Cuckoo Nest and #22, Locked Nest, and halfway between them in size, complexity, and number of pieces. Shipped disassembled and with no instructions, (But here are some hints: think of it as a three layer sandwich. The bottom and top layers are like Cuckoo Nest. The three longer bars form the new second layer. The plain bar and the two small cross bars must be assembled first to form the bottom layer, after which the rest is easy. There is only one solution.) (Not illustrated). Mentioned on page 49.

That concludes the listing of practically all puzzles which have been made and sold. The next listing is of a few selected puzzle designs which have never been produced for sale, for various reasons.

63. Pseudo-Notched Stick Designed around 1971. See illustration on PC cover, and description in PC-2, page 16. Not a very sophisticated puzzle, but an amusing novelty. Would be easy to make, once set up.
(Recent update: About 25 produced and sold in 1985.)



64. Expanding Puzzle Designed around 1971. The six identical pieces all move away from each other in unison, creating the effect of an expanding mechanism. More of a toy than a puzzle. Many variations possible. The model shown at right, and on the cover of the 1981 edition of Puzzle Craft was probably the only one made. It was sold to a collector in New Hampshire.

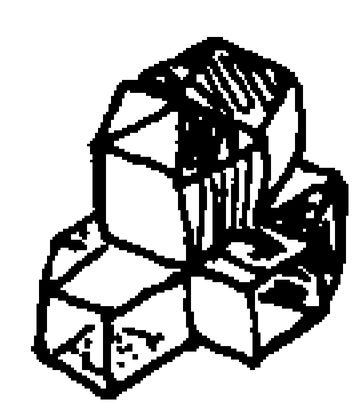


65. Notched Pentagonal or Rhombic Sticks These are discussed on page 50. Believe I made three models, including the one shown at right and on cover of 1981 Puzzle Craft. Can only locate two here now so must have sold the third.

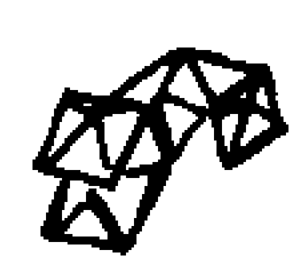
66. Crystal Blocks Designed in 1970. Originally intended for manufacture in plastic. The six puzzle pieces consist of a total of 22 rhombic dodecahedra joined together different ways. The number of possible geometrical or animated constructions which can be made with these pieces is virtually unlimited. It could thus be regarded as a three-dimensional equivalent of the Snowflake puzzle. Many of the puzzle problems were completely analysed by Mike Beeler, with the aid of a computer. They range from easy to extremely difficult. (not illustrated)

That concludes the listing of all puzzles I have produced or designed and which I consider worth listing. The last listing is of puzzle ideas which have never got beyond the drawing board.

67. Peanut Puzzle The original Peanut Puzzle was designed in 1973, and was intended for manufacture in plastic. One version of it consisted of three kinds of pieces, two of each, for a total of six. It constructed a variety of geometrical figures, similar to the Crystal Blocks above, the difference being that all the pieces were interlocking with each other. Licensing efforts were unsuccessful.

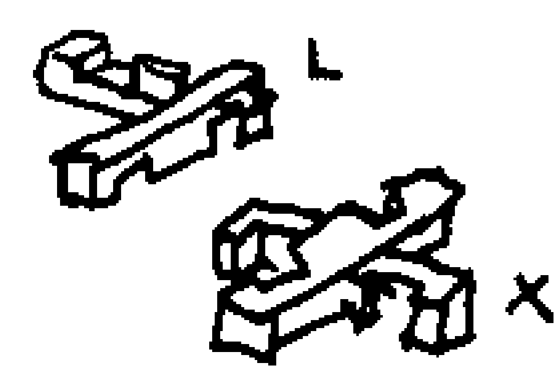


A new version of the Peanut Puzzle is now contemplated in wood. Mike Beeler has just completed an analysis of the proposed design, and by the time this booklet is printed, it may be off the drawing board and in the shop.



(Recent update: See description on page 59. After Beeler's brilliant computer analysis of this delightful puzzle, and after all the necessary special sawing and gluing jigs were carefully made, no sets were ever produced for sale. The main reason is that they would be very expensive because of the shop time required to make them accurately. Future plans are uncertain.)

68. Variations of Square Knot Some have already been on pages 37 and 38, and also page 93. Yet the list goes on.



Another possible variation on the Altekruse would be to glue some of the pieces together in pairs. This would have the advantages of making the puzzle slightly more difficult and interesting, especially for those who have already mastered the standard version, and also might make it less of a test of dexterity. A study is needed to determine the optimum design.

Another way to make the puzzle more difficult is to have two types of notches - deep and shallow, which must always mate with opposites. I worked on this for days, but could not find any combination that did not produce multiple solutions or none at all.

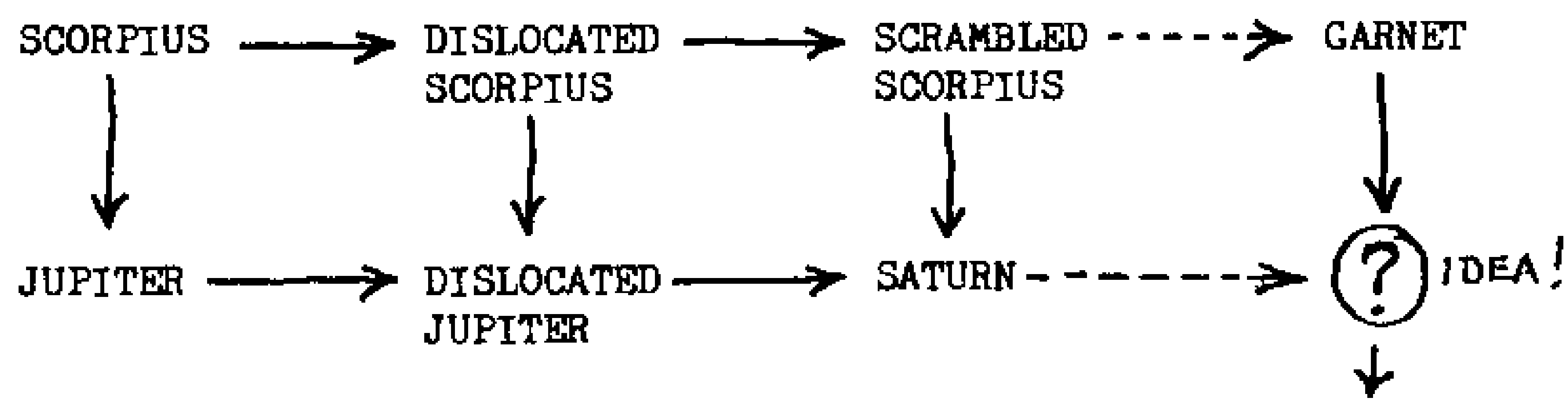
One of the most intriguing possibilities would be to make the sticks of rhombic rather than square cross-section. Once you had the special notching tool required, this would be easy to make. A good exercise for some one would be to completely analyse this, and determine the optimum design from among the many possible combinations.

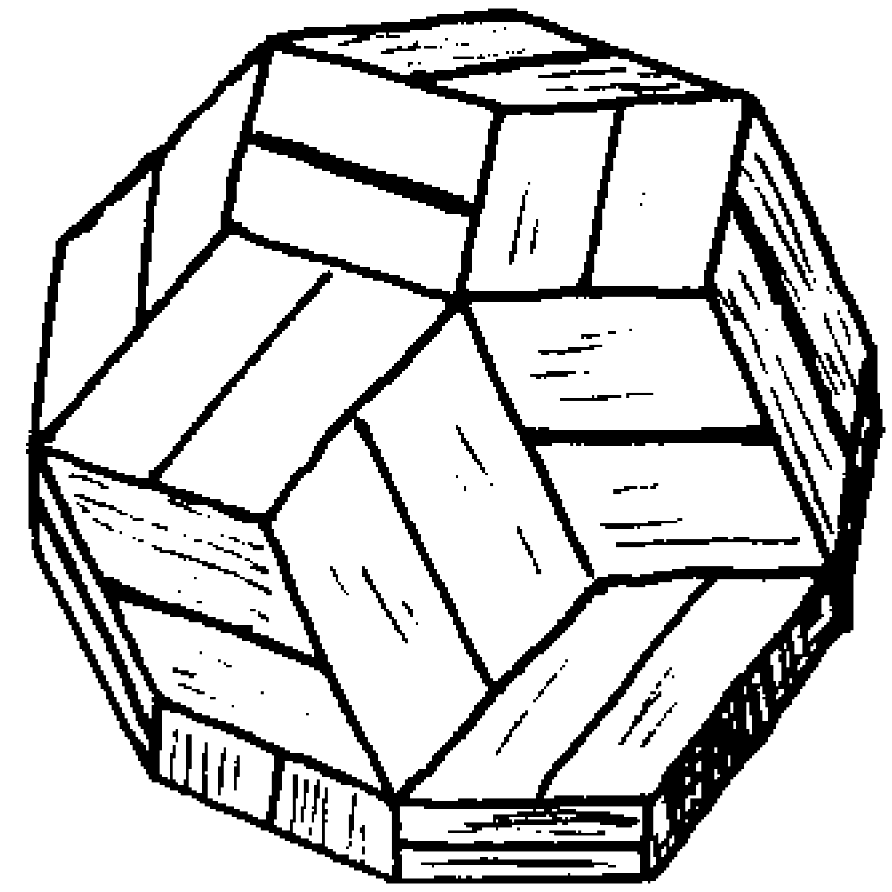
69. Variations of Scorpius and Jupiter These both had identical symmetrical pieces, which somewhat detracted from their interest as puzzles. One way to overcome this would be to make them flattened (oblate) or elongated (prolate) rather than essentially spherical in shape. Furthermore, there are two different ways this could be done - either by changing the linear dimensions of all the parts but maintaining the angles, or by varying the angles as well. The latter would be the more elegant transformation, and I propose a Jupiter puzzle transformed as the ultimate woodworking challenge, for someone who has all the tools and skills, and perhaps a year or two to spare. (not illustrated!)

70. Improved Saturn The Saturn puzzle was intended to have only one solution. After it was in production, multiple solutions were discovered. (We still don't know how many). Furthermore, a design having all dissimilar pieces rather than pairs of pieces might be more interesting. I have one such design in my files, but it has never been completely analysed for other solutions. This is an extremely tedious process, but perhaps someone will find a way to do it by computer. One possible objection to such a puzzle is that it would be extremely difficult, and in my opinion puzzles of this degree of difficulty do not have much general appeal. However, there is a neat way to overcome this. What made the Jupiter puzzle so popular was the use of six contrasting exotic woods arranged in color symmetry. If multiple woods were used in the proposed design, arranged in color-matched pairs, the solution becomes much easier, and probably more interesting too.

71. Variation on Hexsticks If some of the Hexsticks pieces were to be glued together in pairs, similar to the Altekruse variation discussed at the top of this page, it might be more interesting. A complete analysis should first be made of the many possible ways of doing this, which I have not even begun, so here is another challenging exercise for someone. (Note that new kinds of pieces with new notchings would probably be used).

72. Design No. 72 There is really very little that is totally new in the world of puzzles. Every puzzle design described in this booklet can be shown to have been derived from some previous design - my own or someone else's. Tracing the family lines of puzzles is not only a fascinating study in itself, but often it leads to new ideas. A case in point is shown in the diagram below:





(Recent update: As of this printing - June 1985 - the long sought for ideal combination has not yet been discovered and may not exist. See discussion on page 59 and illustration on cover. This is one of three experimental models made. One will be in the forthcoming international puzzle exhibit.)

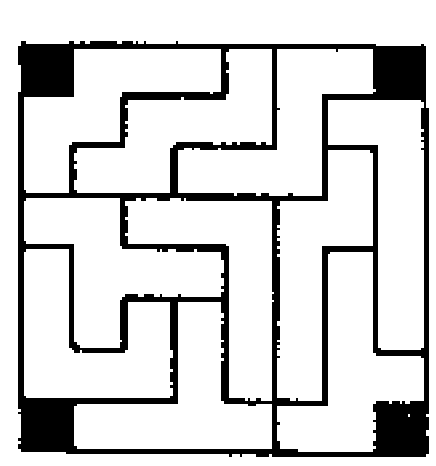
New Additions for this Printing:

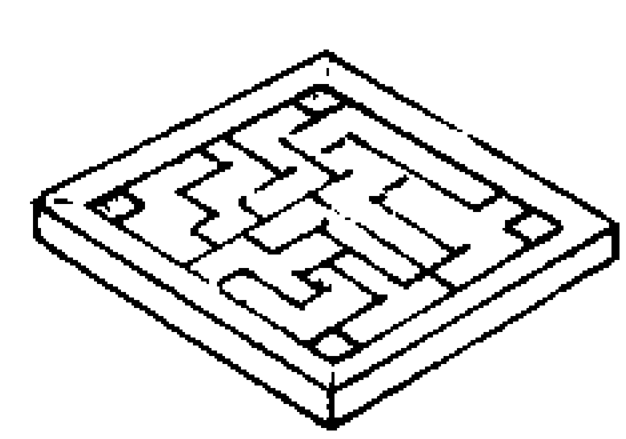
73. Third Stellation Designed in 1985. See description on page 60 and illustration on cover. It is fairly difficult and expensive to make well, so only about three have been produced and sold, in mahogany.

74. Square Face Designed in 1985. See description on page 57 and illustration on cover. Since these were made mostly to use up some scrap pieces, only about three were produced and sold, in mahogany.

75. Split Star Designed in 1985, but actually only a variation of another puzzle already listed here and designed in 1984 (but can you figure out which one!). It is mentioned on page 60 and illustrated on the cover. It is made of 48 identical blocks which must be glued accurately and sanded by hand. I have made seven of them from a choice board of Applewood, with a tung oil finish. One of these will be in the international puzzle exhibit. I have no plans for making any more.

76. Cornucopia Designed in 1985, in a joint endeavor with Mike Beeler. See description on page 25. This is the only one of my puzzle designs that is in production and available at this moment. Write for more information. See also the October 1985 issue of Scientific American.





Summary

1. List of puzzles that would be easiest to make, with modest investment in tools, for the home hobbiest or someone starting out in the puzzle business:

Interesting	Less interesting	Not very interesting
#35, Burr 305	#57, Sq. Knot	#2, Pentablock
#38, 3-pc Block	#59, Corner Block	#10, Giant Steps, etc.
#29, Half-Hour	#20, Pin-Hole	#18, Waffle
#41, Unhappy Ch.	Other burrs	

2. List of puzzles more interesting than those above, but somewhat harder to make:

#21, 22, 62, Cuckoo Nest family
#25, Hexsticks
#30, Convolution
Variations of Altekruse

3. Intriguing puzzles which may look hard to make, but are actually fairly easy once you have all the right equipment in place:

#11, Hexagonal Prism
#14, Second Stellation
#15, Triumph
#23, Scrambled Scorpius
#34, Augmented Four Corners
#61, Setting Hen

4. More intriguing puzzles, but harder to make well than those above:

#12, Triangular Prism
#24, Saturn
#26, Four-Piece Pyramid
#27, Three Pairs
#33, Twelve Point
#37, Star-of-David
#39, Rosebud
#60, Garnet

Note: Not included in the above lists is the Snowflake puzzle, which I would rate as "interesting." It was never successfully made in wood, but might be. The casting process in Hydrastone is slow but very simple, once you have the RTV rubber mold. Any child could do it. It is inexpensive, non-toxic, and a delight to work with. Other puzzles might be made with it also. Disadvantage: it breaks if dropped.

5. A checklist of unfinished business and problems to be solved:

An improved Corner Block puzzle.
Peanut Puzzle set with booklet of puzzle problems.
Altekruse puzzle with glued pieces.
Altekruse puzzle with rhombic sticks.
Flattened or elongated Scorpius and Jupiter.
Improved Saturn in multiple woods.
Variation of Hexsticks with glued pieces.
An improved Design #72.
New version of Scrambled Scorpius in multiple woods.

Some Comments on Puzzle Design in General

In trying to formulate guidelines as to what constitutes a "good" puzzle or an "interesting" puzzle, one must be careful not to be too dogmatic. A glance through any comprehensive puzzle book or collection reveals considerable diversity of opinion on this subject. We touched on this in the chapter on puzzle patents.

Sprinkled throughout the Puzzle Craft booklets and in some of the instruction sheets, I have mentioned a few rules which I find useful when trying to design new puzzles or improve old ones. This can be carried too far, though. Too many rules are apt to hinder rather than aid the creative process. Designing what the inventor may consider to be very sophisticated puzzles can easily become and end in itself, which may bring a great deal of satisfaction to the inventor, but no one else.

During the early 1970's, we sold many of our puzzles at craft fairs. I then had the unique opportunity to sit behind a booth and study the reactions of the public, confronted by a table literally covered with puzzles of every sort (while my daughters handled demonstrations and sales). Observations: (1) Most persons who bought puzzles did so as gifts for someone else, and were not particularly interested in puzzles themselves. (2) The puzzles were bought mostly on the basis of external appearance. Thus, puzzles like Vega and Jupiter were always good sellers. For low priced ones, puzzles like Hexsticks and the Burr puzzles sold well, because they looked like puzzles. (3) Well made plastic puzzles, whether injection molded or cast, will not sell alongside competing wooden ones. (4) Some persons can't resist the temptation to idly manipulate puzzle pieces while conversing or distracted in some other way, and they will nearly always choose familiar shapes like blocks or notched sticks. Conclusion: To be commercially successful, a puzzle usually needs to be more than just a puzzle. Think of it also in terms of a toy, gift item, art object, handicraft, pastime, and whatever else. And then think of all the exceptions to even these rules.

The puzzle market, just like many other markets, is subject to bouts of faddishness. I was often asked if my puzzles were Soma or Instant Insanity, and when I replied that none of them were either, some persons would be disappointed. Now those puzzles are nearly forgotten, and the same persons are asking for Rubik's Cube. I guess it is the dream of every entrepreneur to get in on the ground floor of one of these big sellers. I wouldn't mind that!

We were always learning something new at craft shows. At one of the first ones, I had made up just a couple of Hectix puzzles in wood, twice normal size. A patron was intrigued, and asked with a quizzical smile, "How did you ever think of that?" After that, I always tried to make some puzzles that would cause persons to ask that. That was how we got started in "polyhedral" designs. We used to call them "AP-ART, the sculptural art that comes apart."

Of all the puzzles we sold from our booth, though, the one which consistently brought the most amusement to the most people was, believe it or not, the 30¢ Buttonhole puzzle. People still remember and comment about it. A few of them are still attached to the same jacket or sweater we put them on over ten years ago!

Anyone who has been to juried professional craft fairs knows that there usually isn't much there for youngsters. Kids used to crowd around our booth so much that sometimes neighboring exhibitors were annoyed. We let them select almost any puzzle they wanted, and play with it to their heart's content. I learned more from watching them than I did from adults. I always regretted not having more puzzles in a price range they could afford. Some kids would get discouraged in a minute, and expect help with everything (a typical product of some schools in this area!), while others would spend hours quietly puzzling away, until their parents came and led them away.

We were often asked by adults buying puzzles for children what age the various puzzles were suited for. This opened the door to one of our favorite tricks. Our youngest daughter, who was then around seven or eight years of age would be mingling with the crowd. I would take our most complicated looking puzzle apart (usually Jupiter, but any would do) and say: "Anyone who can put it together can take it away." Most adults would shy away in fear of embarrassment. Margie in the meantime would have worked her way up to the booth. She would quickly put it together with a bored look on her face, tuck it under her arm and smugly walk away. By this time, of course, the crowd realized it was a joke on them. We worked that one over and over. Children that age learn very quickly, and almost any child could have been taught to do the same.

The first Hectix puzzles were molded at a plant nearby. After they had produced about 20,000 of them, they found they had a problem assembling them all, so I made a deal with them and told them to ship them to my "factory." The "factory" turned out to be some picnic tables set up on the lawn, and the work force consisted of all the kids in the neighborhood. They all learned quickly, with no dropouts, especially when I paid them 2¢ per puzzle assembled. The youngest was six years old. We finished the job in ten days.

The Puzzle in the Blue Box

Just about everyone must have some special treasures they remember from childhood. Perhaps they were toys or games, and there just may have been a puzzle or two. Some of mine were puzzles. It seems reasonable to assume that a few of today's puzzles just might become tomorrow's treasures. But which ones? That must be the ultimate challenge in puzzle design.

Lately I have been setting aside a few puzzles to be saved, perhaps to be enjoyed someday by my grandchildren. I would tell you which ones they were if only I could make up my own mind. One of them is very special. It is in a blue box, tied with a ribbon. It is so intriguing and wonderful (and durable!) that I know it will be saved and treasured long after all the others are lost and forgotten.

The trouble is that the blue box exists only in my imagination, and we can only guess what's inside. Wouldn't it be funny if it turned out to be something like just an ordinary old six-piece burr?
