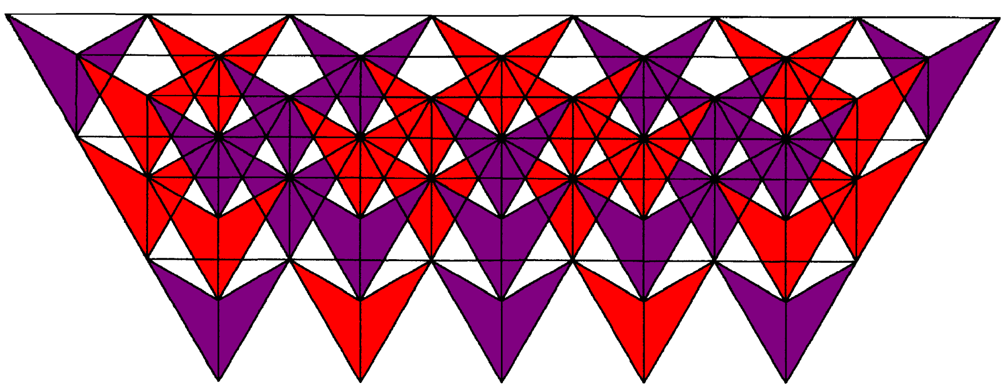
TetraLite Kites

Ultra-light Collapsible Multi-cell Tetrahedral Kites

Assembly Plans and Instructions Manual



Revision 3.03

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Important Note

READ THE INSTRUCTIONS **FIRST** SO THAT YOU **FULLY** UNDERSTAND THE ASSEMBLY BEFORE YOU BEGIN. USE CARE AND TAKE YOUR TIME IN ALL THE ASSEMBLY STEPS IN ORDER TO ACHIEVE NEATNESS AND UNIFORMITY. THE RESULTS WILL BE WORTH THE EFFORT IN BOTH APPEARANCE AND PERFORMANCE OF THE FINISHED KITE.

As you read through this manual please try not to be intimidated by the number of parts for a particular model of kite. Since there are only six basic components that are repeated throughout these kites, and the fact that they are all interchangeable parts, construction is much easier than it may appear at first glance. Much effort has gone into covering every detail of the assembly in this manual in order to make the procedures very clear to the reader, so please forgive any redundancies. Those of you with a lot of experience building kites may find this manual excessive! My apologies!

BE SAFE! AVOID HAZARDOUS AREAS AND NEVER FLY A KITE NEAR POWER LINES.

Acknowledgments

My sincere thanks to the following people:

Alexander Graham Bell for inventing the use of tetrahedrons in making kites and his beloved wife, Mabel Hubbard (the original "Ma Bell"?), who helped him so much (and also founded the Aerial Experiment Association which was the first research organization to be established by a woman).

John Dusenberry, mild-mannered Seattle optometrist and kite builder and flier for his tetrahedral kite construction techniques that inspired my innovations and led to the designs in this manual.

Ken and Suzanne Conrad of Great Winds Kite Shop, Seattle for their contributions of ideas over the years and for being a reliable source of kite making materials.

Members of the Washington State Kitefliers Association and the American Kitefliers Association that I've encountered (usually at Gasworks Park, Seattle) for their encouragement.

All the many nameless strangers, young and old, that I've met while flying tetras who said "ooh!" and "ah!", or just generally made me feel good in their appreciation of my kites.

-- Mark Snyder, TetraLite Kites

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About Tetrahedral Cell Kites

TetraLite kites utilize a combination of materials that provide ample strength, light weight, excellent flying properties, beauty and portability. They are light enough to fly in winds as low as two or three miles per hour and strong enough to withstand up to 15 mile per hour (for the smaller models), depending on size and configuration. Rising and soaring in thermal updrafts is quite common with these kites.

In the past most kite fliers have avoided tetrahedral kites because they usually shared the same common drawbacks. The weight to lift ratio of prior tetras, especially commercial versions, has been a discouraging factor, requiring strong steady winds in order to achieve a disappointingly low flying angle, or they just didn't have enough wind to fly at all. TetraLite kites take advantage of the somehow greatly overlooked inherent strength of the tetrahedron form by utilizing light weight components, giving them a rating of less than one-half ounce per square foot. TetraLite kites will fly along with all but a few of the lightest fliers.

Another problem commonly associated with tetras has always been ease of transporting and storage. Those that couldn't be disassembled required a lot of space, and those that could be disassembled required *major* disassembly (not to mention *assembly*). TetraLite kites are easily and quickly collapsible due to the use of a flexible connector system, allowing them to fold up like an accordion.

TetraLite kites have eliminated the traditional drawbacks previously encountered with tetrahedral celled kites, making them functional and beautiful additions to any kite collection.

Credit for the concept of using tetrahedral cells in kites goes to Alexander Graham Bell who, sometime after developing the telephone, used kites for testing materials for use in airplanes around the turn of the century. The kites he built incorporating tetrahedrons were configured in a number of ways.

The tetrahedron cell structure may be extended along all three axes to achieve varying degrees of stabilization and form in all directions. Each cell is inherently stable laterally, due to the sharp dihedral angle that provides good stabilization. The kites described in this manual are configured in a way that gives them excellent stability. The materials are light enough to give them excellent lift even in very light winds.

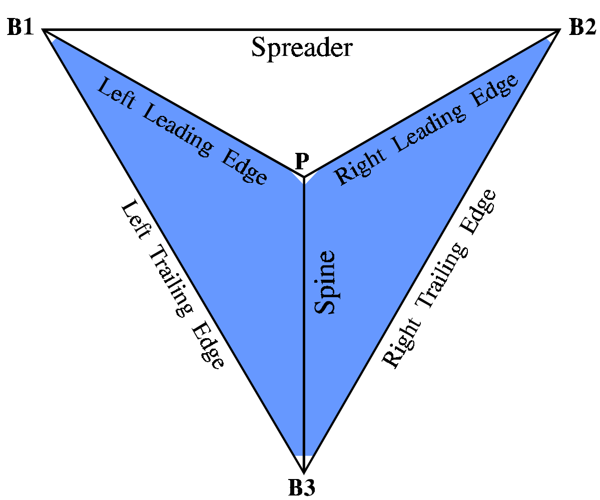

Figure 1

The Basics

Regardless of the number and configuration of cells, TetraLite kites consist of identical cells, the only difference being the flexible connectors. Depending upon their location in the structure, these connectors are three-, six-, nine- or twelve-way connectors. Each cell is made up of six sticks. Four of these sticks form the leading and trailing edges of the sails. One stick, called the spine, divides the cover into two sails and the remaining stick, called the spreader, holds the tips of the sails apart and determines the dihedral angle. All the sticks are held by friction in the flexible tubes that form the connectors.

By simply unplugging one end of the spreader stick (the only stick that doesn't touch the sail) on each cell, the flexible connectors allow the kite to be collapsed like an accordion into a flat package. Plugging the spreaders back into the connectors sets up the kite again for flying.

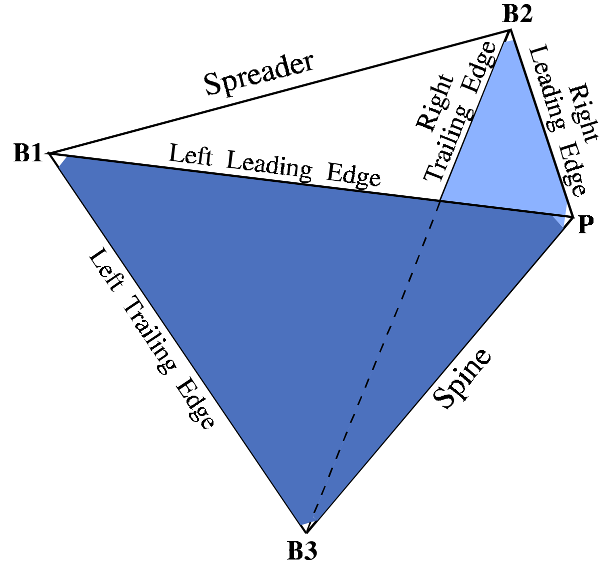

Figure 2

A regular tetrahedron is the simplest of all the regular polyhedrons made up of plane surfaces. It is a triangular pyramid having a base and three sides, all four surfaces being equilateral triangles of the same size. There are six edges and four corners (vertices). Let's examine a single cell.

For the purpose of assembly we will use diagrams that view the structure as in Figure 1. This allows us to clearly see all the edges and corners. Figure 2 shows a perspective view. These diagrams (Figures 3-11) will help you visualize the basic structure of a single tetrahedral cell.

The six sticks that form the edges of each cell are named in Figures 1 and 2 to show their relative positions. The four corners (vertices) are also labeled B1, B2, B3 and P. The corners B1, B2 and B3 are on the "Base" of the cell, formed by the Spreader and the Left and Right Trailing Edge sticks. The corner labeled P is the "Peak" of the cell, formed by the intersection of the Spine and the Left and Right Leading Edge sticks. In flight, the peak is forward-most into the wind, the base is at the rear.

The sails are shown in position as shaded areas (Figures 1 and 2). For each cell, one piece of Mylar® is used to form both the left and right sails. It passes in front of the spine and is attached along the left and right leading and trailing edges, as described later in this manual.

In subsequent diagrams in these instructions, numbers will be used next to the cell corners to indicate the number of sticks connected together (3, 6, 9 or 12) at that point and, therefore, the type of connector to be used (3-, 6-, 9- or 12-way).

What You'll Need

Recommended Tools

X-Acto knife
Pliers
Fingernail clipper (keychain type)
Ruler
Straightedge
10" square cake cooling rack (see note in assembly Step 6, "Preparing the Sails")
Sail cutting and sail taping templates - 2 pieces 1/16" cardboard stock, about 20" by 13"
Jig for cutting sticks and tubing - 1x4" or 2x4" scrap wood about 15" long

Materials Needed

(Quantities depend on model of kite as explained later)

Note: Cost to build any model in Seattle as of August 1997 is about 97 cents per cell.

½ mil Mylar® film for sails
1/8” hardwood doweling
1/8” inside diameter, 1/64” wall PVC tubing
Nylon Cable Ties-Thomas & Betts TY-RAP® Part No. TY23 or Panduit PAN-TY® Part No. PLT1M-C
Scotch® Magic® Tape, ½” width
Varathane® or similar wood finish or white glue (may not be needed - see notes below)
10# test Nylon kite line (for bridle)

Notes About Selecting Materials

Mylar® - Use ½ mil (.0005”) thickness. If you substitute a greater thickness, the weight and performance of the kite will be adversely affected. We have not tested kites using thicker Mylar®. Mylar® comes in several colors and even with pre-printed color patterns. Be creative in mixing your sail colors or just use one color. Maintaining symmetry when using more than one color may be considered more pleasing, but is, of course not necessary. It’s mostly a matter of personal preference. All the sails are interchangeable, so you can always rearrange them if desired.

You will need one sail for each cell in your finished kite. Mylar® usually comes in 60” wide stock. Figure on getting about 12 to 14 sails per yard. By angling the Sail Cutting Template it is possible to reduce the amount of wasted material.

Doweling - The 1/8” hardwood doweling usually comes in three or four foot lengths. All sticks in TetraLite kites are cut to one foot lengths (except optional long spreaders described later), and using the method for cutting under “Cutting the Sticks”, they are cut without waste. Therefore, a three foot length yields three sticks and a four foot length yields four sticks.

Try to select doweling with good straight grain and no knots or defects such as thin spots or tapered ends. Dowel diameters vary from one manufacturer to another so, if possible, shop around to find a source of doweling that fits your tubing snugly. A good test for snugness is to insert the dowel about ½ inch into the tubing. Then, holding the tubing firmly between thumb and forefinger next to the end of the dowel, try pulling the dowel out of the tubing. If the dowel cannot be pulled from the tubing or requires a fair amount of pulling force to be removed, it passes the test and will not require a finishing coat on the ends. If it comes out with little or no resistance you will have to either use a coat or two of Varathane® (or similar wood finish or white glue, such as Elmer’s® glue) on the dowel ends or find another source of doweling. To remove the doweling from the tubing (when you have a proper fit), you should push the tubing off the dowel, that is, apply force to the end of the tubing towards the end of the dowel.

You may want to construct a tool for pushing the tubing off the sticks. This is simply a thin, flat piece of wood, plastic or metal with a 1/8 inch wide notch cut in it. Place the notch onto the stick and push against the end of the tubing with this tool to remove the stick.

Tubing - The tubing is cut into two lengths as described under "Cutting the Tubing" later. The "Long Tubes" are l¼" (1.25 inch) lengths and the "Short Tubes" are ¾" (.75 inch) lengths. This is a thin-walled tubing that can be found at large electronic parts outlets. It's use in electronics is as an insulator around soldered connections inside connector housings (to name one). The wall thickness should be held close to 1/64 inch to allow the degree of flexibility needed. Tubing we have used has a wall thickness ranging between .016 and .020 inch and inside diameters ranging from .118 to .133 inch.

Basically, the same notes for doweling apply to the tubing pertaining to snugness of fit, as manufacturer's actual sizes may vary slightly, and you may have to resort to treating the dowel ends with a wood finishing product or white glue.

Nylon Cable Ties - These are available at electronics supply stores and some hobby shops. They were originally designed for bundling wires in electronic equipment. They are available in quantities ranging from 100 to 1000. Consider buying a box of 1000 from a major electronics parts distributor if you think you might build several models, as the cost per piece in this quantity becomes much less, and there's no end to the other uses you will find for these handy devices. The manufacturer's parts mentioned above have tails that are approximately 3.9" long and 0.1" wide (refer to Figure 12).

Varathane® - This is only needed if the doweling and tubing sizes do not make a snug fit as described above under "Doweling". Optionally, you can use a similar wood finishing product or a thin coat or two of white glue. Try a test piece or two, to determine how much of any product you use on the dowels. If you use a white glue (such as Elmer's®), it should be thinned slightly with water, otherwise it tends to make too thick of a coating on the stick.

Warning: Be sure you have adequate ventilation and work away from open flames whenever using Varathane® or a similar wood finishing product.

Selecting the Model and Size of Your Kite and Generating a Parts List

Before beginning assembly you must obviously make a decision which model of kite you want to build. The diagrams in Figures 3 through 11 show some of the most practical design configurations, although you may wish to invent your own, in which case you should sketch your design in order to calculate the required numbers of parts. We've been flying the 34-cell model (depicted on the front of this manual, with the same color scheme, by the way) almost every year since it was built in 1980. This attests to the durability of these designs, as it still flies and looks great. And it still soars straight overhead in thermals. But we recommend starting with a smaller model so that you can get the feel for flying them (see the section on flying procedures near the end of this manual). Once you have decided on a design, create a parts list so you can determine the quantities needed. If you choose one of our standard models, the quantities are shown in Table 1, following the standard kite diagrams. If you design your own, be sure to see the section "Notes on Designing Your Own Kites" later in this manual.

The designs in Figures 3 through 11 represent some practical models that are known to fly well. We recommend building one of these as your first model. We also recommend that you don't build a model with fewer than seven cells, for example, a four-celled kite, because stability in flight seems to become too critical. This is apparently due to the fact that the center of mass is not far enough away from the stabilizing forces acting on the sails and the kite tends to roll and/or pitch more readily.

Generally, the larger the kite is, the better its stability. Our very first model was the 28-cell, and it should be noted that stability is so good at this size, it is all but forgotten. Instability seems to become slightly noticeable in kites with under about 16 or 12 cells. Also, keep in mind that, since the parts are interchangeable, you can add or subtract cells on your kites in order to try different configurations and numbers of cells.

Standard Design Diagrams

Figures 3 through 11 illustrate several standard models. Each diagram shows the framework of the kite resting on its base (the back side of the kite while in flight) and views it from the front, with the peaks closest to the viewer, in the same orientation as Figure 1. The sails are not shown in these diagrams for clarity, but would be located on each cell as in Figure 1.

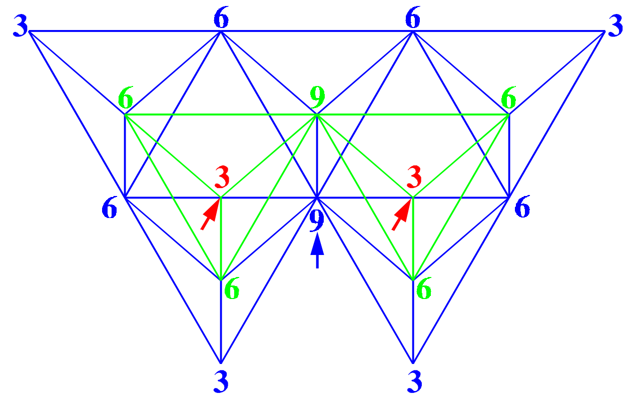

Figure 3 - Model 7

The diagrams are color coded, with blue denoting the sticks forming the back-most layer of cells, green the middle layer of cells and red being the front-most layer of cells (closest to the viewer). Note that the bases of the green cells attach only to the peaks of the blue cells and that the bases of the red cells attach only to the peaks of the green cells. Note also, that Model 7 (Figure 3) and Model 10K (Figure 5) have only two layers of cells, therefore have no red cells in those diagrams.

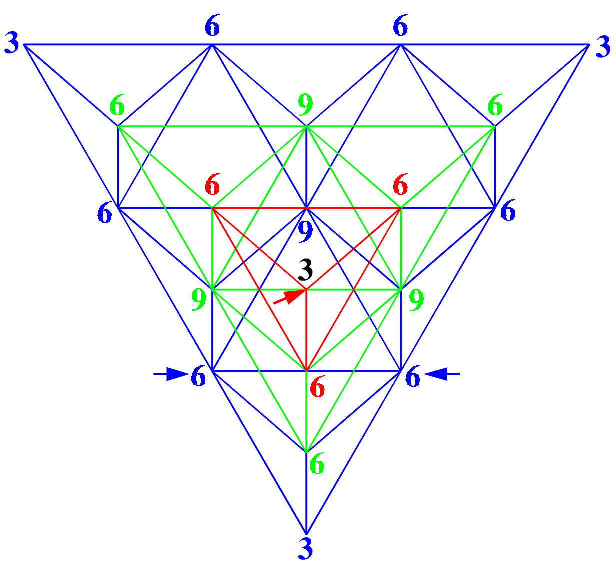

Figure 4 - Model 10

The connector types are designated by color coded numbers. Blue numbers denote the connectors on the bases of the blue cells. Green numbers denote the connectors at the peaks of the blue cells and the bases of the green cells. Red numbers denote the connectors at the peaks of the green cells and the bases of the red cells. Black numbers denote the connectors at the peaks of the red cells. Although Model 7 and Model 10K have only two layers and hence, have no red cells, the peaks of the green cells are still shown in red.

Notice that in some of these diagrams the red spreaders may partially or completely hide some of the blue spreaders, so be aware that they exist, as every cell must have a spreader.

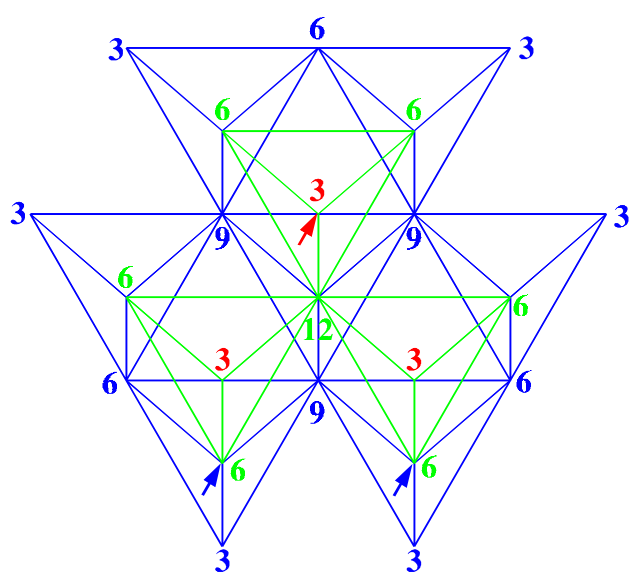

Figure 5 - Model 10K

To help you visualize the color coding system for the layers of cells, Model 16 is also shown in a perspective view (Figure 8) with a few of the connectors indicated. Compare Figure 7 with Figure 8. Notice that Figure 8 is like viewing Figure 7 from the left side of the kite and slightly elevated. Compare the relative locations of the red cells, the green cells and the blue cells. Note that the black number 3 on the peak of the red cell in Figure 8 is the same point as the right-hand red peak on Figure 7.

The arrows are bridling points, as will be explained under STEP 8 - "Attaching and Adjusting the Bridle" later in this manual.

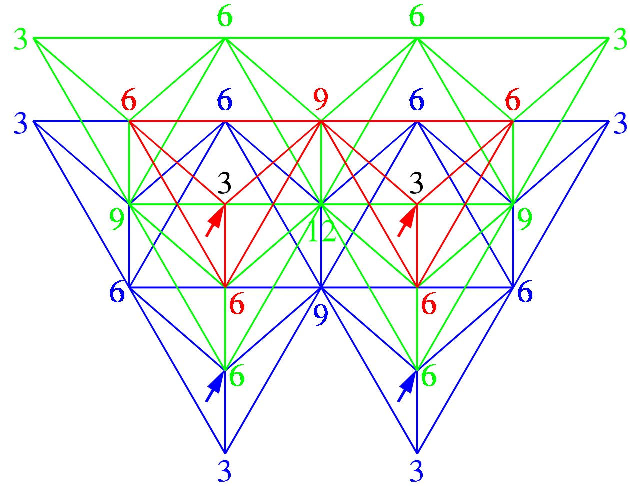

Figure 6 - Model 12

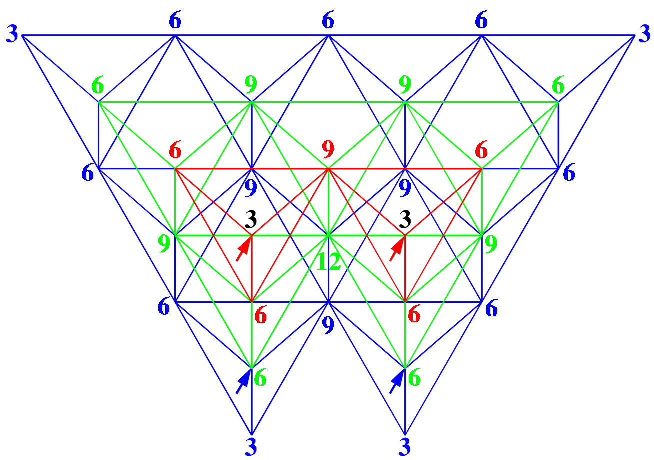

Figure 7 - Model 16

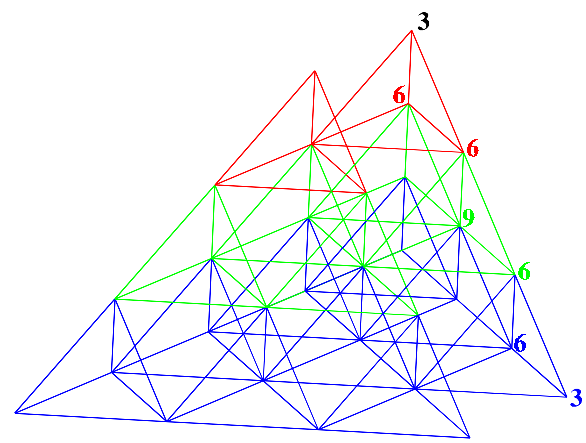

Figure 8 - Model 16 Perspective View

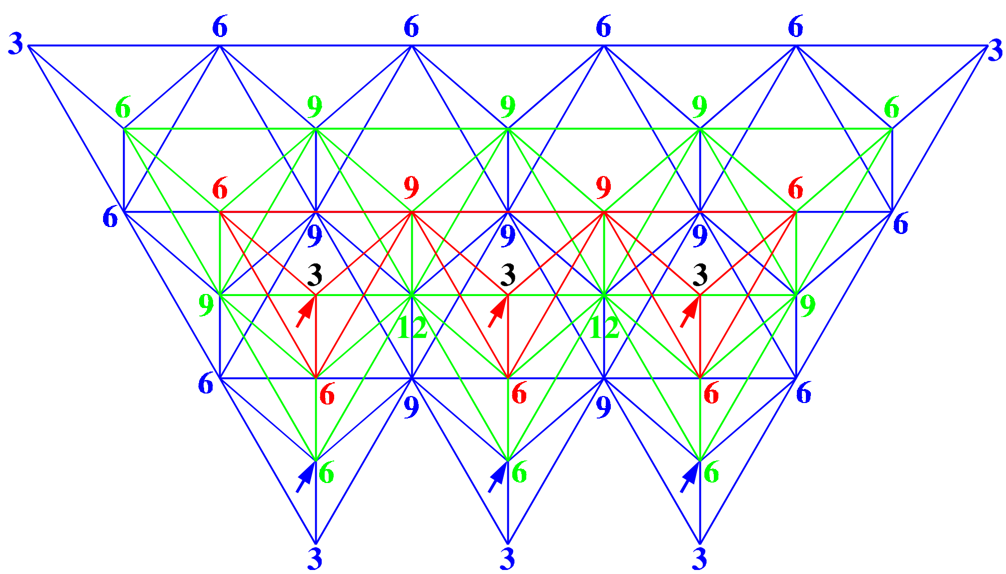

Figure 9 - Model 22

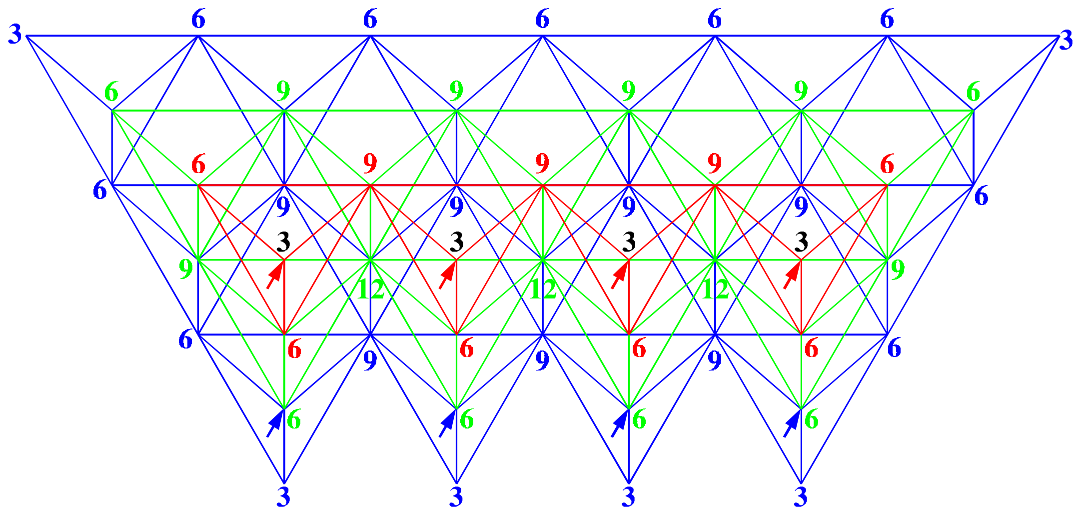

Figure 10 - Model 28

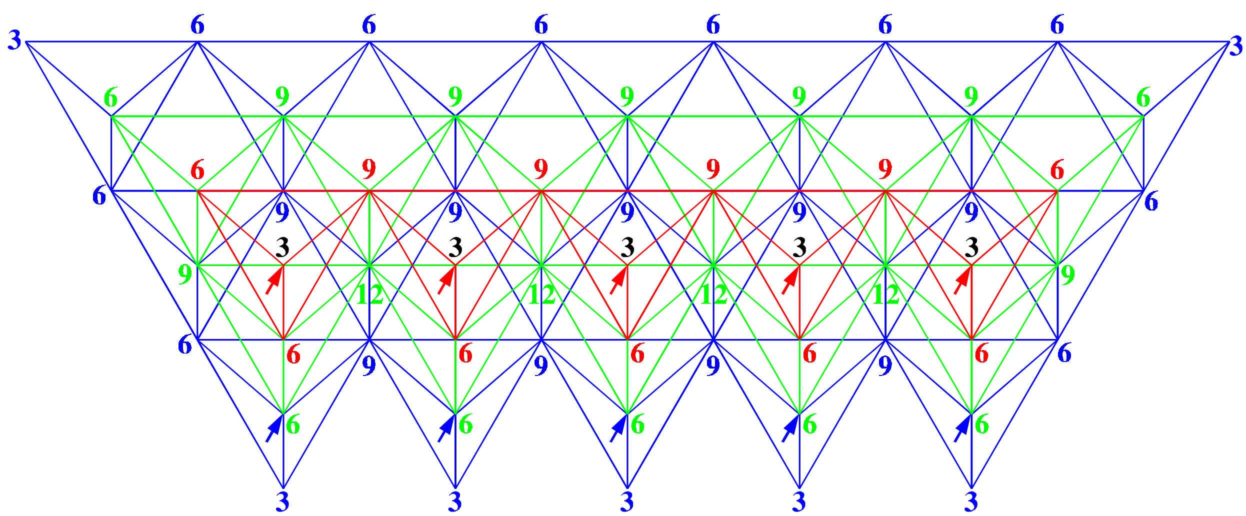

Figure 11 - Model 34

		Connector Types							
Model	**Sticks**	**3 Way**	**6 Way**	**9 Way**	**12 Way**	**Long Tubes**	**Short Tubes**	**Ties**	**Sails**
7	42	6	8	2	0	38	8	16	7
10	60	4	12	4	0	56	8	20	10
10K	60	9	9	3	1	54	12	22	10
12	72	8	12	4	1	66	12	25	12
16	96	6	15	8	1	89	14	30	16
22	132	8	18	12	2	122	20	40	22
28	168	10	21	16	3	155	26	50	28
34	204	12	24	20	4	188	32	60	34

(Note: Total number of connectors equals number of ties)

Table 1 - Quantities of Parts Required for Standard Models

Notes on Designing Your Own Kites

If you design your own kite it will become apparent that every cell must be attached to either three or four other cells, otherwise the structure would not be rigid when assembled.

Draw a diagram similar to the ones in this manual in order to compute the numbers of parts necessary for its construction, especially the connectors. Here's how to calculate part quantities:

Number of sails equals number of cells.
Number of sticks equals number of cells times six.
Number of ties equals number of connectors.
Number of short tubes equals number of 3-way connectors plus number of 9-way connectors.
Number of long tubes equals number of 3-way connectors, plus number of 6-way connectors times three, plus number of 9-way connectors times four, plus number of 12-way connectors times six. Written algebraically, long tubes = (3-way) + 3(6-way) + 4(9-way) + 6(12-way).
You should be able to get 12 to 14 sails out of a yard of 60" wide Mylar® stock.
You will need 12 pieces, ¾" long or 9 inches (.75 feet) of ½" wide Scotch® tape per cell.

You may extend the structure in your own designs to create extra large kites with more than just three layers. The largest size possible for these kites is not yet known, but theoretically a point would be reached when the kite would collapse under its own weight. That would be a very large kite, indeed, since the tetrahedron is such a strong structure.

As the structure is extended in any given direction, keep in mind that stability will improve along an associated axis, but will decrease along the other axes. In other words, as a rule, major extensions should preferably be done more or less proportionally in all directions. On the other hand, the great inherent stability of these kites does make them quite forgiving in this regard. Remember that these kites lend themselves to experimentation due to the fact that they can be taken apart and the parts can be re-used in a new configuration.

Assembling Your Kite

Summary of Assembly Steps

STEP 1. Cutting the Tubing to Length for the Connectors
STEP 2. Assembling the Connectors
STEP 3. Cutting the Sticks
STEP 4. Assembling the Framework
STEP 5. Making the Sail Templates
STEP 6. Preparing the Sails
STEP 7. Mounting the Sails
STEP 8. Attaching and Adjusting the Bridle

STEP 1. Cutting the Tubing to Length

Using a straightedge or ruler make a straight line at least l¼ inch long on a suitable surface such as a scrap of 1x4" or 2x4" (you can use the same piece described later under "Cutting the Sticks" if you like). Make a perpendicular mark across this line and carefully measure and make another mark ¾ inch from the first mark. Also, make another mark l¼ inch from the first mark. To cut the tubes, line up the end of the tubing with the first mark and lay the tubing straight along the line. Then cut the tubing at the ¾ inch or l¼ inch mark to make either a short or long tube. Cut the tubing using an X-Acto knife or other very sharp knife. Be careful to cut the ends squarely, first positioning the tubing and the knife, then pressing straight down. Cut the required number of short tubes (¾ inch) and long tubes (1¼ inch). Cut the long tubes first since they can be trimmed to make a short tube in the event of an error.

STEP 2. Assembling the Connectors

The kite uses a system of wooden dowels held together by flexible connectors made from the tubes cut in Step l. The connectors into which the dowels are inserted and held in place by friction are of four types: three-way, six-way, nine-way and twelve-way. They join together respectively, three, six, nine, and twelve dowel ends at the connection point where they are used. The tubes are held together with a Nylon tie to form the connectors. A long tube (l¼ inch) makes two connections in any connector. A short tube makes a single connection in connectors with odd numbers of connections (three-way and nine-way). Thus, the three-way connectors are made from one long and one short tube, the six-way connector uses three long tubes, the nine-way connector uses four long and one short tube and the twelve-way connector is made from six long tubes. Figure 12 illustrates the assembly of a 3-way connector. The 6-, 9- and 12-way connector assemblies are the same except for the numbers of long and short tubes.

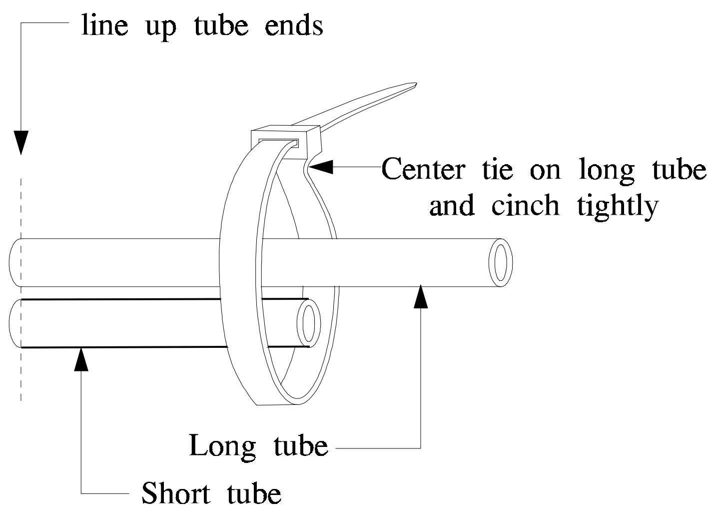

Figure 12

During assembly the ends of all tubes are lined up evenly and the nylon tie is positioned at the center of the long tubes. In three-way and nine-way connectors the short tubes are lined up with one end. In the nine-way connector be certain the short tube is on the outside of the bundle of long tubes so the tie can firmly hold it in place, rather than having to rely on just the friction between the tubes. Note that the ties are ribbed on one side along the tail. This side must face inward toward the tubes in order for the tie to work properly. The tail of the tie is inserted through the head. This is a one-way operation, that is, when once started, the tie can only be tightened and can't be taken apart except by cutting.

Begin by starting the tail through the head of the tie. Cinch the tie loosely at first so you can insert and line up the tubes and center the tie. Then cinch the tie tightly using a pair of pliers to pull the tail of the tie while holding the connector in the other hand. If you pull too hard you might break the tail off the tie. If this should happen, it is best to replace the tie even if it seems to be holding, because the tie may have been weakened. Trim the tail of the tie flush with the head using fingernail clippers.

STEP 3. Cutting the Sticks

The 1/8” hardwood doweling usually comes in three or four foot lengths and must be cut to exactly one foot lengths. The best method is to make a jig for quickly measuring. Use a length of 1x4” or 2x4” scrap wood, a little longer than 1 foot and attach a small piece of wood near one end for use as a stop. Draw a pencil line (at least 1 foot long) along the wood to use as a guide. Measure and make a mark exactly one foot from the stop across and perpendicular to this line.

To cut the dowels, hold them against the stop and along the line and put the blade of an X-Acto knife across the dowel at the 1 foot length mark. Apply a little pressure with the knife as you roll the dowel in order to score it all the way around. Once scored, the dowel can be cleanly and easily snapped off at the score without wasting any length.

The size of the PVC tubing may not allow for a good fit. In the event that the doweling and tubing do not make a snug fit, the dowels may need a coat or two of Varathane® or similar wood finish product or white glue such as Elmer’s® (thinned to a proper consistency with water), on their ends. (See “Doweling” and “Varathane®” under “Notes on Selecting Materials”.) To apply, dip one end of the sticks about one quarter of an inch into the finish and stand the sticks, wet ends up and apart from each other in a tin can or jar to dry. Then repeat for other ends. 20 to 30 dowel ends can be done at once (more if you use more cans or jars).

STEP 4. Assembling the Framework

For purpose of demonstration this step will show the assembly of the 10-cell model. Other models are similarly constructed.

Figures 13, 14, and 15 show the framework in layers of cells, in order from the back of the kite to the front. In Figure 14 the green numbers indicate connectors that are the same green numbered connectors shown in Figure 13. Likewise, the red numbers on Figure 15 indicate connectors already in place after assembly of the section in Figure 14. The entire assembly can be visualized as Figure 15 attached to the peaks on Figure 14, which in turn is attached to the peaks on Figure 13.

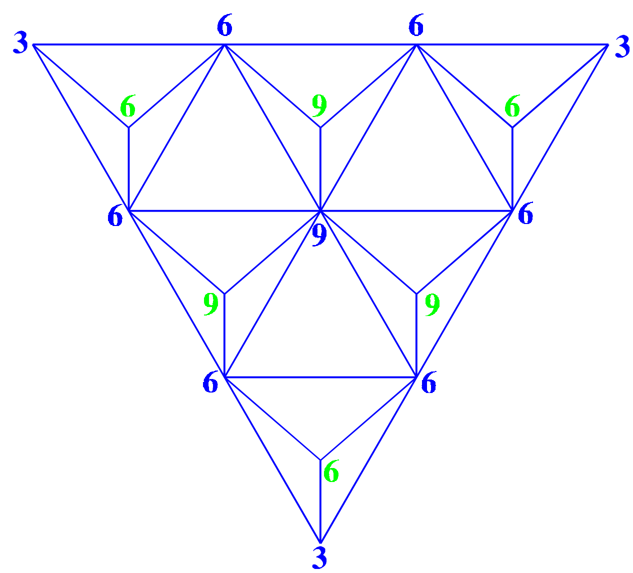

Figure 13

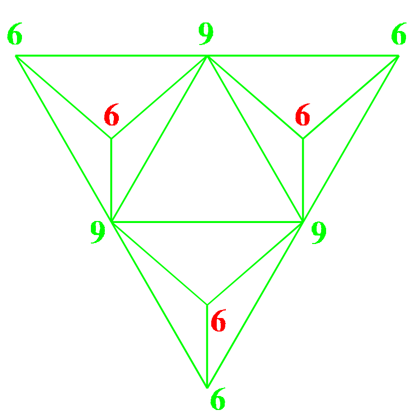

Figure 14

When inserting a stick into a connector be sure to push the stick into the tube as far as possible toward the tie at the center of the connector. Also, try to pick a tube end that allows the most direct connection for the final direction of the stick, that is, avoid crossing the tubes over one another. You may

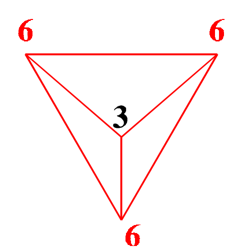

Figure 15

have to remove some sticks and reroute them to different tube ends in some connectors, especially the larger 9-way and 12-way connectors in order to obtain the best and most direct fit. In the 9- and 12-way connectors you should expect a compromise on one or two tube ends, that is, they will have to bend a bit around the body of the connector a bit, thereby not allowing the stick to be inserted quite as far as the others. This is normal and will work just fine, but if you find that more than two tube ends on a single connector are distorted, you should definitely rearrange the connection.

Removal of a stick is made easier by pushing the tube end back off the end of the stick. If you only pull the stick the tube distorts and tends to grip the stick more tightly like “Chinese handcuffs”. It is advised that you make a tool for stick removal as described earlier in “Doweling” under “Notes About Selecting Materials”.

The assembly in Figure 13 consists of six tetrahedral cells that form the back side of the kite when in flight. Remember, you are viewing the structure as in Figure 1, therefore, during assembly, the base of each cell is the triangle formed by its spreader stick and the left and right trailing edge sticks. Assemble these six triangular bases first using the indicated type of connectors. Then form the peak of each cell by adding the spine and the left and right leading edge sticks and using the indicated connectors. The peaks thus formed are then connected to the sticks that form the bases of the three cells shown in Figure 14. Next, add the sticks and connectors that form the peaks of the cells in Figure 14. Then as before, add the sticks that form the bases of the cell in Figure 15. Then complete the frame by adding the sticks and connector that form the peak of the cell in Figure 15.

Carefully check the frame assembly and if necessary, reroute and exchange tube ends to obtain more direct connections to the sticks before mounting the sails.

Note: You might be tempted to make the sails first and mount them during assembly of the frame, but we strongly recommend that the frame be assembled and checked completely first. Re-routing sticks to the connectors is much easier without the sails in place.

STEP 5. Making the Sail Templates

You will need two templates for the sails. One is used to cut the sails to the proper shape and size. The other is used as a jig for folding and taping the sail edges to form channels for the sticks at the leading and trailing edges of each cell in the kite.

Two patterns are provided with this manual and are used to create the Sail Cutting and Sail Taping Templates. Since both templates are symmetrical in the horizontal and vertical axes, only one-quarter of the template’s shape need be provided in order to lay them out. (This also allows us to provide full scale patterns on 8-1/2 x 11” pages.)

The procedure for laying out and cutting both templates is basically the same. The Sail Cutting Template construction will be described here first. The Sail Taping Template

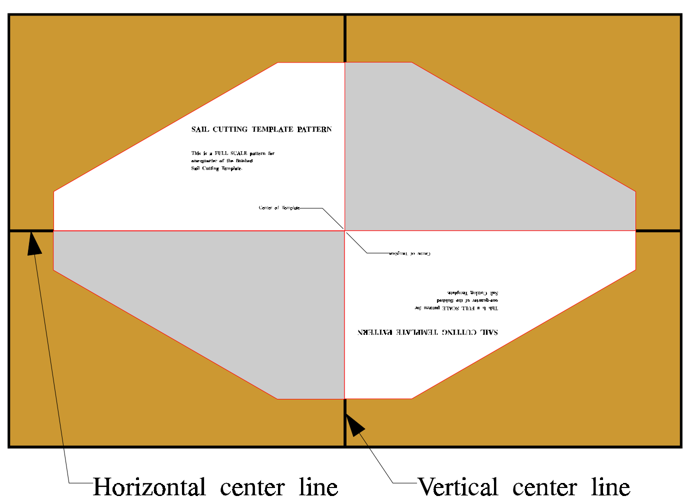

Figure 16

construction is the same with two exceptions; it requires eight notches (two along each of its edges) and a hinge, described below.

Begin the Sail Cutting Template by marking two center lines, horizontally and vertically, on the cardboard stock. Make sure these lines intersect exactly perpendicular (90°) to each other. This intersection becomes the center point of the template. Cut out the pattern provided along the lines that mark its perimeter. Next, place the pattern on the cardboard and position it so that the corner marked "Center of Template" is at the intersection of the center lines and the edges of the pattern are lined up with the center lines. Then, holding the pattern in place, mark all the corners of the pattern. Using a straightedge, connect these points to create an outline of the pattern on the cardboard. Flip the pattern over as required, to mark the points for the remaining three quarter sections and again draw lines connecting the corner points to complete the full size template outline. Figure 16 shows the cardboard stock with the template pattern in the four positions. The shaded pattern positions indicate the reverse side of the pattern. The center lines are also indicated. When you have finished marking the full outline, cut the template out of the cardboard. The Sail Cutting Template is finished at this point.

Lay out and cut the Sail Taping Template in the same manner described above for the Sail Cutting Template. The only difference being the extra cuts to make the notches along its edges.

For the Sail Taping Template, a hinge must be created along the longer (horizontal) center line, for the purpose of removing the Mylar® sail once it has been taped (see "STEP 6. Preparing the Sails"). To make the hinge, cut the Sail Taping Template in half along the long center line and tape the halves back together again to form a sturdy hinge. Be sure the edges are tight against each other and the ends of both halves are aligned when making this hinge. If you use care, you may cut the template not quite all the way through, ensuring a perfect hinge. If you do this, be sure to reinforce the hinge with tape. You may choose to use a heavy duty tape such as duct tape or packaging tape to make a stronger hinge.

STEP 6. Preparing the Sails

Lay the Sail Cutting Template over the Mylar® stock on a suitable surface and cut around the perimeter with an X-Acto knife. If you wish, you can try cutting more than one sail at a time, but be sure to maintain ample pressure on the template to keep the Mylar® from slipping out of place. In fact, the Mylar slips so easily we recommend you cut one at a time to keep the edges even.

The sails are held in place on the frame of the kite by forming their edges into channels through which the sticks pass. Using the Sail Taping Template, the edges are folded and taped in three places on each edge forming the channels. Carefully center the template on the sail, hinged side down against the sail, and fold one of the edges of the sail up and over the template. Apply one piece of tape ¾" in length at the center tape cut-out of the template. Next, tape the opposite edge (the edge parallel with the first) at its center tape cut-out, keeping the sail material just taut. Repeat the process for the remaining two edges of the sail. Then apply tape at the remaining four cut-outs and the four places near the "sharp" (acute) corners of the sails. These tape placement points are indicated on the Sail Taping Template Pattern that was originally used to lay out the template. Remove the sail by folding the template and sail along the hinge of the template. This allows the sail to slide off the template.

Note: The tape for the sails should be cut before beginning the taping process and made readily available by lightly sticking the pieces on the edge of a drinking glass or cup. In this manner the tape is ready to apply with one hand while the fold is held in place with the other hand. See the following note.

Note: An excellent method to achieve uniformity of the tape size and ease of tape cutting and dispensing is to use a standard 10” square cake cooling rack and run long strips of tape perpendicularly across the wires of the rack. (The rack we use has wires spaced at about 11/16” - close enough to ¾”.) The tape can then be rapidly cut into many uniform pieces by running an X-Acto knife across the tape strips and along, and against, the same respective sides of each of the wires. The tape pieces are then easily taken from the rack as needed.

Take care in this step to tape the sail edges squarely, neatly and uniformly. Place the tape the long way along the sail edges. At first glance, you might not think this is enough tape to hold the sail edges, but our oldest kites (18 years, as of 1997) are still holding together! If a tape does fail, it is a simple matter to replace it while on the kite.

STEP 7. Mounting the Sails

The sails are mounted by running the leading and trailing edge sticks through the respective leading and trailing edge channels of the sail.

The easiest method for installing the sails is simply to remove the leading and trailing edge sticks one at a time and slide them into the sail channels and then reconnect the sticks to the frame. Start by unplugging the ends of the two leading edge sticks where they meet the spine (at the peak of the cell). Slide the sail onto one leading edge stick, then the other, being certain that the sail passes in front of the spine. Then re-connect these two sticks. Next, remove one of the trailing edge sticks, slide it through the respective channel of the sail and re-connect it. Do the same with the remaining trailing edge.

Here’s another method that requires good dexterity and lots of patience and practice. This method requires that only one end of each of the edge sticks be unplugged and may just serve to frustrate the builder. It’s a bit tricky, but I’ve included it for those who wish to try. To mount a sail on any cell of the fully assembled framework, disconnect the ends of each of the leading and trailing edges where they connect to the spine. Fold the sail in half along its long axis (the same axis that is hinged on the sail taping template) such that the taped side becomes the inside. This brings the leading and trailing edge channels close together. Now bring together the loose ends of the leading and trailing edge sticks for one side of the cell and guide them a short distance into the respective channels on the sail (easier said than done!). Similarly, guide the sticks on the other side of the cell into the respective channels on the other side of the sail (be sure the sail goes in front of the spine!). The sail will be rather bunched up at this point. Work the sail onto the sticks on both sides until they are all the way on, spreading the sticks apart as you go. Then reconnect the sticks into their connectors. As you do this step you will notice that the sail may have to be tugged here and there in order to get it in the proper position to allow the sticks to be reconnected. Also, the sail tends to slightly adhere to the connector tubing on the spine when it is nearly installed and you may have to wrestle it around a bit. We recommend the first method be used, since this second method only becomes a real time-saver after much practice, and the time saved is not very substantial.

Repeat the process (whichever you use) until all the sails are installed. At first it may appear that the sails on cells near the center of the kite might be more difficult to install. In reality it is only slightly more difficult to work on the inner cells, and not really a problem. You may find it easier to install the sails on the more central cells first and work your way towards the outside, but this is not required, as any sail may be installed or removed anywhere on the kite, at any time.

STEP 8. Attaching and Adjusting the Bridle

The bridling system varies on the different standard models. In general, the peaks of the forward-most cells and the points two spine lengths down from those peaks are used as bridling points, as shown in Figures 3, 6, 7, 9, 10 and 11. The only exceptions to this among the standard models are Models 10 and 10K, which will be described later.

Admittedly, experimentation has been limited on TetraLite tetras, but this is simply because not much adjusting has been required in order to achieve good results. On our initial kites, usually the bridle did not require further adjustment from the original guess! Please don't be discouraged by the ramblings of this section on bridling, as it's mostly just our thoughts on the subject. In practice, even without these thoughts to go on, the average kite builder will have little or no trouble settling on a bridle configuration that works.

Bridling is quite forgiving on tetrahedral kites. On the smaller models it becomes a bit more critical as far as the "angle of attack" is concerned. The angle of attack is the angle of the spines relative to the ground and is determined by the length of the upper bridle legs compared to the lower bridle legs. Making the angle of attack adjustable is recommended and may be accomplished by using a bridle configuration as will be described for the Model 34.

One commonly held idea is that a tetrahedral kite need only be bridled on the leading peaks. This may be true of most tetras due to their (usually) excessive weight that keeps the lower part of the kite down, but experimentation with TetraLite kites has shown that these lightweight models need more control of the angle of attack by forcing the bottom down into the wind by using additional lower bridle points. Also, they become susceptible to nosing over into a headlong dive without lower bridle legs. With lower bridle points, a nose-dive can be checked by increased tension on the flying line.

As a guideline for bridling, suggested bridle points have been marked with arrows on Figures 3 through 7 and 9 through 11 for the standard models. Upper leg bridle points are denoted by red arrows and lower bridle points by blue arrows. The bridle legs are simply tied around the center of the corresponding connectors. This may be done by making a loop on the end of the bridle leg line using an overhand knot and then passing it around the connector and feeding the other end of the line through the loop.

The following representative bridle configurations have been shown to work very well, and can serve as a general guide. Other models can be bridled similarly. Bridling must be done with the kite fully set up to be certain that the tension is even between each bridle leg. Keep in mind that these examples are not the only ways to achieve a good bridling system.

Model 7 - Attach three bridle legs at the points indicated by the arrows on Figure 3. Tie them together at a point that results in the two upper bridle legs having a length of 26 inches each and the lower leg 42½ inches from the respective points of attachment.

Model 10 - Make the upper leg 29 inches long and the two lower legs 47 inches long, attached to the points indicated in Figure 4.

Model 10K - Make the upper leg 29" and the two lower legs 39" in length attached to the points shown in Figure 5. This model is a bit different from the others, in that it has three peaks, two of which are on a spinal plane in front of the other peak. If you are considering a design of your own, this kite represents a novel configuration. In case you've been wondering what the "K" in the model number stands for, it was called that because its shape suggests a keystone.

Model 12 - Using the bridle points shown in Figure 6, make the upper legs 37" and the lower legs 49" long.

Model 16 - This is basically the same kite as the Model 12, with four cells added along the upper rear of the kite. The bridling may be done in the same manner.

Models 22 and 28 are mentioned following Model 34, since only the length and number of bridle lines are different. The procedure is basically the same.

Model 34 - The following is an example of an adjustable bridle: Start bridling this kite by cutting and attaching ample lengths (7 feet or more) of bridling line to each of the ten bridle points shown in Figure 11. Mark the two upper bridle legs that are attached to the left-most and right-most peaks with a felt pen at 52". Then bring the five upper bridle legs together, maintaining equal tension on all five, to the point where the marks intersect and tie them together using a simple over-hand knot. This is not as easy as it sounds. The best way to do it is to start by grasping all five lines between your thumb and index finger on one hand, then with the other hand pull the marked legs in the required direction to bring the marks together next to your fingers. Then pull the remaining legs to take up the slack until the tension is equal on all five legs between the peaks and your hand. Now the knot must be tied exactly on the marks. With the tension correct you can move your hand toward the kite to relieve the tension on all five lines. Then, keeping the lines in their relative position by holding them together with your other hand near the marks, slide your first hand along the legs towards the kite, so you have enough room to work with the lines at the marks. This operation usually takes a few tries to get the tension equal, and it might be helpful to have someone help you to tie the knot. In any case, tie the knot firmly but not so tight that you can't undo it. Then check the tension and , if it is not equal, untie the knot and adjust the lines until they are even. (It gets a little easier every time you do it.)

Do the same for the lower bridle legs, marking the left-most and right-most legs at 65". After you have both the upper leg and lower legs tensioned and tied tightly, trim of the excess lines at a point about three inches from the knots (you'll need this extra length to tie another knot on both bundles of line).

Now we'll create the adjustable part of the bridle. To do this, tie a length of the type of line you'll be using for your flying line (30# test minimum is recommended) as close as possible to the knots on both upper and lower bridle legs, such that the finished distance between the two original knots are 8 to 9 inches apart. Next, make a loop of the same type of flying line. The size of this loop is not critical, but should be a minimum of about 6" inches long when pulled into a straight line. Put this loop around the line segment tied to the bridle legs and pass it through itself. To secure this loop to any point along the line segment, snug the loop down on the line and then grasp both sides of the loop and pull them apart until the line segment kinks and pops into a knot. You are now ready to attach your flying line to the loop using a swivel. To adjust the bridle, undo the adjusting knot by pulling on the line segment on each side of the loop. This pops the knot back out, allowing you to slide the loop along the line segment.

Model 22 - This kite may be bridled like the Model 34, except mark the upper legs at 41" and the lower legs 55".

Model 28 - This kite may be bridled like the Model 34, except mark the upper legs at 47” and the lower legs at 61”.

As a general guideline for the smaller models (under 22 cells), the point where the upper bridle legs come together should be between 25” and 40” from the central peak (or central two peaks in the case of kites with even numbers of peaks). The lower bridle legs must, of course, be of a length that will ensure a reasonable angle of attack.

Another good guess for most tetras is to aim for a flying line attachment point that causes the upper bridle legs to angle about 20° below the plane formed by the peaks and their associated spreaders and trailing edges when the bridle is held taut. The flying line attachment point should be between 3½ to 4½ feet from the nearest central peak.

Don’t be afraid to experiment with the bridling. We encourage you to try different bridle systems. As previously mentioned, these kites are quite forgiving when it comes to bridling. You stand a fair chance of improving any of the above configurations, if you spend some time experimenting. But also remember, “If it works, don’t fix it!”

Flying Your Kite

Setting Up the Kite

After completing the assembly you will probably have to collapse the kite to transport it to your flying location (or just to see the collapsible feature in action). See the following note and “Collapsing the Kite”.

Note: When setting up or collapsing the kite, access to the spreaders is easiest if the kite is resting on the spines at the front (where the bridle lines are connected. If the wind is blowing, it is also helpful to point the kite into the wind so that the sails offer the least resistance. This helps keep the wind from blowing the kite around on the ground. Then, start at either the left or the right side and work toward the opposite side of the kite, connecting or disconnecting one end of each spreader.

To set up the kite insert the free ends of the spreaders into their respective connectors, spreading the vertical sections out as you go. When inserting a stick be sure it goes into the connector as far as possible. If the stick seems to bind try pulling the tubing onto the stick. Grasp the stick near the connector with both hands, using your thumbs and middle fingers. This leaves your index fingers free. Then, pull the tubing onto the stick using your index fingernails. Before launching the kite it is a good idea to check that all the sticks are completely inserted into their connectors. When all the spreaders are in place, position the kite on the ground such that it is sitting on its trailing edges and the spines are facing into the wind. In this position the wind pins the kite onto the ground.

Collapsing the Kite

When unplugging the spreaders the tubing should be pushed off the sticks rather than trying to pull the sticks out of the tubing. Pulling the stick may cause the tubing to tighten around the stick like “Chinese handcuffs” holding the stick even more firmly. Grasp the stick as described before in “Setting

Up the Kite" and push on the end of the tubing with both index fingers to slide the tubing off the stick. Refer to "Doweling" under "Notes About Selecting Materials" for details of the stick removal tool.

As you collapse the kite be sure the spreaders clear the sails and other parts of the framework. Remove the spreaders completely, if desired for more compact storage and to avoid the possibility of storing the spreaders while stressed into a bend. Bent sticks can be straightened by carefully bending them back a little at a time along the stick until worked straight.

Flying Procedures, Suggestions and Techniques

Use a good quality nylon line with a swivel for attaching the flying line to the bridle. 20# test is good for kites with up to twelve cells. Use 30# test or more for larger kites.

Avoid flying the larger models (16 cells and up) in winds greater than around 10 mph. These kites were originally designed to fly in the lightest winds possible. The smaller models will withstand steady winds of up to 15 mph, however it can be a bit scary. Also, try to avoid gusty conditions when the wind speed varies considerably from moment to moment. Stick breakage due to strong winds is (as far as we know) rare and, for the most part, not a catastrophic event. Usually the kite will still fly, often without a noticeable difference in performance.

Use a reel that allows line to be paid out rapidly. Turbulence or gusts may (rarely) flip a tetrahedral causing it to dive. The best way to check the dive is to relieve the tension on the flying line completely. This allows the kite to flip back over, stopping its descent, after which tension on the line should restore the kite to the proper attitude. Another reason to be able to pay the line out rapidly is that, during launching, these kites can glide backwards if allowed to, making it easy to get them out a long way in a short amount of time. This is particularly useful when the wind is known to be sufficient to sustain flight well above ground level, but only very light near the ground. By alternately letting the kite glide out, then checking the glide and pulling it up, one can attain the altitude necessary to get into the stronger wind. The larger models are better at gliding backwards than the smaller models.

If you find yourself flying in a thermal with the kite directly overhead, you must be careful to keep the line tension at a minimum while the kite is headed into the wind (you can all but let go of the line since it's hanging straight down from the kite!). Too much tension will pull the nose down and cause the kite to dive. If this happens the best thing to do is run as fast as you can, keeping the line slack (not too much of a problem, since the kite is coming straight down). once you get far enough away you can put tension back on the line to right the kite and stop the dive. Here's a method of sustaining thermal flight: When the kite is directly overhead and starting to circle (if it is so inclined), a slight tug on the line will head it back into the wind. You can let it turn all the way around, or nearly so, and then apply tension in order to fly downwind a bit. Then let up on the line to allow the rate of downwind travel to decrease until you decide to apply more tension on the line and turn the kite back into the wind. Thermal flying requires a bit of practice, a fair amount of concentration and patience and a light touch.

Learn to land the kite by reeling it right up to your hand rather than letting it hit the ground. This reduces the chances of breaking sticks and becomes easier with practice. If it appears that a crash cannot be avoided a slack line will give the kite a better chance to float to the ground instead of "powering" into the ground. The good side of breaking sticks (as good as that could be, anyway) is that they are very inexpensive and easily replaced in seconds. Carry a few extra sticks when you go flying. As you become more practiced you will need fewer replacements, if any. Repair any tears in the sails with transparent tape. Sails and sticks usually only suffer damage when the kite is on the ground or sitting around the house getting stepped on or other similar accidents.

Using Long Spreaders

TetraLite kites are made with 12” spreader sticks as standard. Optionally, longer spreaders (up to 18”) may be used. These longer spreaders allow the kite to be flown in lighter winds, since they flatten the dihedral angle and increase lift. Stability of the kite is reduced when long spreaders are used, but the effect is noticeable mainly when the kite is close to the kite flier. Therefore, launching and landing requires a bit more practice and concentration because the kite tends to swing more from side to side when closer to the flier. A tug on the line while the kite is pointing nearly straight up helps to keep it in control. It should be noted here that the bridle may need to be adjusted when using long spreaders.

Long spreaders increase the overall width of the kite. Besides changing the appearance dramatically, long spreaders put the sails more directly into the wind. This limits the wind speed that the kite can handle. If the wind is strong enough to break a spreader the result is usually not as catastrophic as a stick failure in other types of kites. Generally, the first (and usually, *only*) stick to break will be the spreader closest to the center of the kite because it takes the most stress. When this happens, the kite retains symmetry keeping it stable, looses some dihedral angle reducing the effective sail area which in turn decreases the possibility of breaking more sticks, *keeps flying* and changes the appearance of the kite. And, if anyone asks, you can just grin tell them, “I meant to do that!” (This has actually happened to me while flying the Model 10K with 18” spreaders. The resulting form wasn’t bad and it flew so well I didn’t bother bringing it down for repair!)

Long spreaders are not recommended for tetras with more than twelve cells, because the stresses from the additional effective sail area will most likely break sticks. We recommend trying long spreaders only after you have some experience flying with normal spreaders.

Other variations such as altering the length of the spines, leading edges or trailing edges are possible, but necessitate altering the size and shape of the sails. We leave these modifications up to the reader/builder, if they should feel so inclined as to try this type of experimentation.

Happy flying!

Thank you for purchasing this manual!

We hope you enjoy building and flying TetraLite kites. If you have any questions, suggestions or comments, please feel free to contact us. We are glad to hear from you!

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