

Using String Figures to Teach Math Skills

Part 4: Vertical Nets and Tennis Nets

by

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James Murphy with 'Murphy's Mesh'

ABSTRACT

Today string figures are often viewed as useless relics of pre-literate societies. Few scholars appreciate the role they once played in the development of analytical thinking skills. In this article the author presents the last two string figure "systems" he uses to teach math skills to reluctant students. In the 'Vertical Net' system complexity is generated by iteratively weaving multiple loops stacked on the index fingers. In the 'Tennis Net' system loops are "braided" to generate highly ornate designs that rival the classic mesh figures of Pacific Islanders. A symbolic "circle notation" for recording the intricate moves is also introduced.

INTRODUCTION

The ultimate need for every human being is to organize the self. Everyone needs help in reaching their human potential. String figures are universal and touch the human in each of us. Learning them is a bit of a struggle until you have reached a certain level of ability. Most previous how-to books haven't caught on because they often present a series of "new" figures to learn. After mastering the first four or five figures the learner is daunted by the time and effort required for learning the next one.

My system, on the other hand, is based on just three figures and after you have learned the first ('Osage Two Diamonds') you will rapidly acquire the ability to make any number of diamonds. Then, when you learn 'Ten Men', you will be automatically empowered to make millions of different figures, many if not most of which will be new and heretofore not produced by anyone else. Then, after mastering the 'Inuit Net' you will literally be able to spend a lifetime making variations without ever having to learn from scratch a new figure ever again (if you so desire). My bet is that you will round out your string figure abilities with figures from the classic literature as well as new systems of your own devising.

The following material is from Chapter 4 of a book i am writing on how to teach math skills to reluctant students using string figures. The book is based on notes i prepared for a "String Figures" course i taught at La Guardia High School of Music and the Arts in New York City for over a decade. Excerpts from Chapter 1 (The Diamonds System) appeared in volume 4 of this Bulletin (Murphy 1997). Most of Chapter 2 (The Ten Men System) appeared in volume 5 (Murphy 1998). Portions of Chapter 3 (The North American Net System) were published in volume 6 (Murphy 1999). Excerpts from Chapter 4 (Vertical Nets and Tennis Nets) are presented here.

REVIEW OF CONCEPTS FROM PART 3

The overall goal of my work is to add complexity and richness to previously described string figure designs. In last year's article i introduced the concept of *iterating* a defined weaving sequence (i.e., repeating it over and over) as a means of adding "horizontal complexity." i also introduced the concept of *rolling*, a technique for "turning over" a partially completed figure so that the underside can be manipulated. Rolling, when combined with iterative moves, can lead to a multitude of stunning new designs rich in horizontal complexity, the prototype being my 'Inuit Bridge' (fig. 1).

Rolling is also an excellent technique for frustrating *inverse weaves* (weaves that "undo" or "cancel" previous weaves). In my Ten Men system i use *Universe* weaves (**A**, **B**, **C**, etc.) to frustrate the effects of inverse pairs (**a**, **a'**, etc.). But in my North American Net system, the effects of inverse

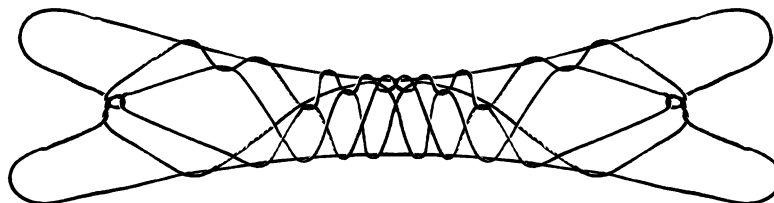


Fig. 1 - Inuit Bridge

weaves like I-1 (First Inuit Weave) and I-1' (First Inuit Weave Inverse) are negated by the introduction of a roll between them. The prototype figure here is my 'Cherokee Seven Stars' (fig. 2).

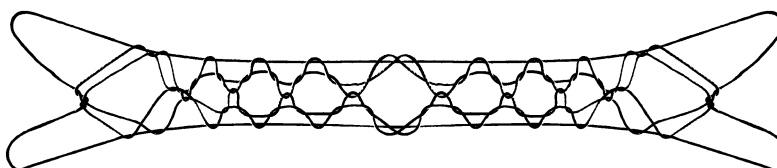


Fig. 2 - Cherokee Seven Stars

Hybridization is yet another method for making new designs. My 'Klamath Bridge' (fig. 3), introduced in last year's article, begins with a series of Ten Men weaves (a a c), but ends with a series of weaves borrowed from the North American Net system. Learning how to jump from one system to another is a key concept i routinely use to empower my students.

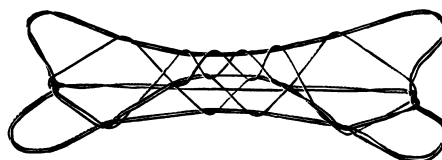


Fig. 3 - Klamath Bridge

Perhaps the most useful concept i introduced last year was that of using a North American Net weaving sequence as a "finishing" move: the instructions for making 'Cherokee Seven Stars' end with *Inuit Out*, meaning "make the Inuit Net from the beginning, as if you had Opening A on your hands." Finishing moves like *Inuit Out* intertwine the three loops that remain on each hand after completing long weaving sequences and reduce their number to two so that the design can be displayed using the *Power Lift* or *Caroline Extension*. They also "seal off" the complexity created in the center of the design and add interesting diamond-shaped design motifs to either end of the figure (see fig. 2). Finishing moves like *Inuit Out* can also be applied to 4-loop figures, as described in the appendix to last year's article (Murphy

1999:208-210). Again, this is a convenient way to reduce four loops to two so that the design can be displayed using a standard extension method. The procedure can also be applied to 5-loop figures, as described later in this article.

Unlike the prototype figures i introduced in my three previous articles ('Two Diamonds,' 'Ten Men,' and 'Inuit Net'), the prototypes introduced in this article ('Vertical Net' and 'Tennis Net') are not traditional figures extracted from the literature. Rather, the two prototypes are derivatives of the Inuit Net. Readers will recall that Inuit Net weaving sequence consists of six phases: forming the loom, first Inuit weave (I-1), second Inuit weave (I-2), shifting the loops, fixing the bottom, and cleaning the top. Figures like 'Inuit Bridge' and 'Cherokee Seven Stars' arose from my investigations of weaves that occur early in the sequence, primarily the first Inuit weave. The Vertical Net was developed while playing with the final weaves (fixing the bottom and cleaning the top). The Tennis Net, a purely artificial construct, arose while attempting to diagram how various loops shift, twist, and intertwine during the Inuit Net weaving sequence.

Before attempting to make the 'Vertical Net', the 'Tennis Net', and all their wonderful variations the reader must be well-acquainted with: (1) methods for building 3-, 4-, and 5-loop looms; (2) methods for rolling 3-, 4-, and 5-loop configurations; and (3) methods for finishing 3-, 4-, and 5-loop figures using the *Inuit Out* weaving sequence. All of these are reviewed below. The section ends with a review of how to do the *first Inuit weave inverse* (I-1'), and a review of how to apply the *Power Lift* and *Caroline Extension* to figures that end with *Inuit Out*.

LESSON 1: DNA LOOMS

Although most traditional string figures begin with Opening A, i often begin with a modified version that i call a *3-loop DNA Loom*. The only difference between Opening A and a 3-loop DNA loom is the parity of one or more string crossings. Also different is the way the loom is built: rather than starting with Position 1, a DNA loom starts with a single loop on each little finger. i call it a DNA loom because of the way the strings form a spiral or double helix as loops are added to the hands. Furthermore, the loop-adding procedure can be iterated (repeated) to give 4-loop and 5-loop looms. An L-DNA loom is formed by adding loops with the *left* thumb; an R-DNA loom is formed by adding loops with the *right* thumb. i tend to favor left-handed versions in my work.

3-loop L-DNA loom

- Begin by placing the loop on each little finger so that the near and far strings are parallel and do not cross.

- Create a second loop as follows: Insert the left thumb, *from above*, into the little finger loop and return with the near little finger string (rotate the left thumb toward you and up); insert the right thumb, from below, into the left thumb loop and extend.
- On each hand transfer the thumb loop to the index finger.
- Now create a third loop: Insert the left thumb, *from above*, into the index loop and return with the near index string (rotate the left thumb toward you and up); insert the right thumb, from below, into the left thumb loop and extend (fig. 4). To confirm that the loom is correctly formed, rotate your left hand 90° so that the fingers of your left hand point away from you. If none of the string touch the loom was formed correctly.

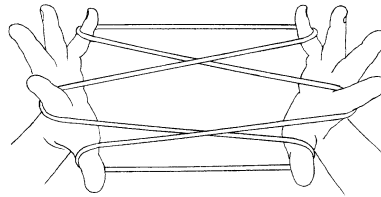


Fig. 4 - 3-loop L-DNA loom

4-loop L-DNA loom

- Begin by placing the loop on each little finger so that the near and far strings are parallel and do not cross.
- Create a second loop as follows: Insert the left thumb, *from above*, into the little finger loop and return with the near little finger string (rotate the left thumb toward you and up); insert the right thumb, from below, into the left thumb loop and extend.
- On each hand transfer the thumb loop to the middle finger.
- Create a third loop as follows: Insert the left thumb, *from above*, into the middle finger loop and return with the near middle finger string (rotate the left thumb toward you and up); insert the right thumb, from below, into the left thumb loop and extend.
- On each hand transfer the thumb loop to the index.
- Now create a fourth loop: Insert the left thumb, *from above*, into the index finger loop and return with the near index string (rotate the left thumb toward you and up); insert the right thumb, from below, into the left thumb loop and extend (fig. 5). To confirm that the loom is correctly formed, rotate your left hand 90° so that the fin-

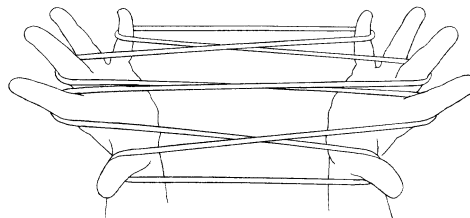


Fig. 5 - 4-loop L-DNA loom

gers of your left hand point away from you. If none of the string touch the loom was formed correctly.

5-loop L-DNA loom

- Begin by placing the loop on each little finger so that the near and far strings are parallel and do not cross.
- Create a second loop as follows: Insert the left thumb, *from above*, into the little finger loop and return with the near little finger string (rotate the left thumb toward you and up); insert the right thumb, from below, into the left thumb loop and extend.
- On each hand transfer the thumb loop to the ring finger.
- Create a third loop as follows: Insert the left thumb, *from above*, into the ring finger loop and return with the near ring finger string (rotate the left thumb toward you and up); insert the right thumb, from below, into the left thumb loop and extend.
- On each hand transfer the thumb loop to the middle finger.
- Create a fourth loop as follows: Insert the left thumb, *from above*, into the middle finger loop and return with the near middle finger string (rotate the left thumb toward you and up); insert the right thumb, from below, into the left thumb loop and extend.
- On each hand transfer the thumb loop to the index.
- Now create a fifth loop: Insert the left thumb, *from above*, into the index loop and return with the near index string (rotate the left thumb toward you and up); insert the right thumb, from below, into the left thumb loop and extend (fig. 6). To confirm that the loom is correctly formed, rotate your left hand 90° so that the fingers of your left hand point away from you. If none of the string touch the loom was formed correctly.

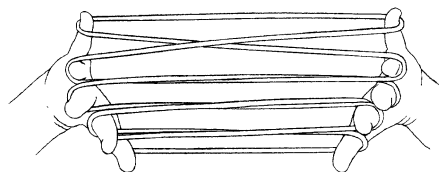


Fig. 6 - 5-loop L-DNA loom

R-DNA looms are formed by reversing “right” and “left” in the three descriptions given above.

ROLLING A FIGURE

Rolling is a technique for “turning over” a loom or a partially completed figure so that the underside can be manipulated. Rolling achieves a +1/2 rotation of the entire figure. Rolling a 3-loop figure is easy, but rolling a 4- or a

5-loop figure requires practice. To practice rolling, first build one of the L-DNA looms described above, then proceed as described below. The end result should match what you started with since the upper surface of a DNA loom looks the same as the bottom surface when rotated about a horizontal axis. (Note: this is not true for Opening A!).

Rolling a 3-Loop Figure

- Transfer the thumb loop to the middle finger, inserting the middle finger from above (this introduces a $+1/2$ rotation).
- Pass each thumb away from you under all the strings, pick up the far little finger string and return with it, then drop the little finger loop (this is merely a way of transferring the little finger loop to the thumb while simultaneously introducing a $+1/2$ rotation).
- Transfer the middle finger loop to the little finger, inserting the little finger from below.
- Transfer the index loop to the thumb, inserting the thumb from below, then retransfer this loop to the index, inserting the index from above (this introduces a $+1/2$ rotation). The entire figure has now been rotated a half turn away from you. If you started with a 3-loop L-DNA loom (fig. 4) you should once again have fig. 4 on your hands.

Rolling a 4-Loop Figure

- Transfer the thumb loop to the top of the middle finger, inserting the middle finger from above (this introduces a $+1/2$ rotation).
- Pass each thumb away from you under all the strings, pick up the far little finger string and return with it, then drop the little finger loop (this is merely a way of transferring the little finger loop to the thumb while simultaneously introducing a $+1/2$ rotation).
- Transfer the upper middle finger loop to the little finger, inserting the little finger from below.
- Transfer the index loop to the thumb, inserting the thumb from below, then retransfer this loop to the ring finger, inserting the ring finger from above (this introduces a $+1/2$ rotation).
- Transfer the middle finger loop to the thumb, inserting the thumb from below, then retransfer this loop to the index finger, inserting the index finger from above (this introduces a $+1/2$ rotation).
- Transfer the ring finger loop to the thumb, inserting the thumb from below, then retransfer this loop to the middle finger, inserting the middle finger from below. The entire figure has now been rotated a half turn away from you. If you started with a 4-loop L-DNA loom (fig. 5) you should once again have fig. 5 on your hands.

Rolling a 5-Loop Figure

- Transfer the thumb loop to the top of the middle finger, inserting the middle finger from above (this introduces a $+1/2$ rotation).
- Pass each thumb away from you under all the strings, pick up the far little finger string and return with it, then drop the little finger loop (this is merely a way of transferring the little finger loop to the thumb while simultaneously introducing a $+1/2$ rotation).
- Transfer the upper middle finger loop to the little finger, inserting the little finger from below.
- Transfer the index loop to the thumb, inserting the thumb from below, then retransfer this loop to the middle finger, inserting the middle finger from above (this introduces a $+1/2$ rotation).
- Pass each thumb away from you under both middle finger loops, transfer the ring finger loop to the thumb, inserting the thumb from below, then retransfer this loop to the index finger, inserting the index finger from above (this introduces a $+1/2$ rotation).
- Transfer the upper middle finger loop to the ring finger, inserting the ring finger from below.
- Transfer the remaining middle finger loop to the thumb, inserting the thumb from below, then retransfer this loop to the middle finger, inserting the middle finger from above (this introduces a $+1/2$ rotation). The entire figure has now been rotated a half turn away from you. If you started with a 5-loop L-DNA loom (fig. 6) you should once again have fig. 6 on your hands.

INUIT OUT FINISHING MOVES

Finishing moves reduce the number of loops on each hand to two so that the design can be displayed using the *Power Lift* or the *Caroline Extension*. Since i often use the entire Inuit Net weaving sequence as a finishing move, i invented a special term for this procedure: *Inuit Out*. Inuit Out means “make the Inuit Net from the beginning, as if you had Opening A on your hands.” Inuit Out can also be applied to 4- and 5-loop figures if the extra loops are first combined with other loops to give double or triple index loops. The standard (3-loop) Inuit Out sequence is reviewed below, as well as the modifications you must make to apply the procedure to 4- and 5-loop figures.

(3-LOOP) INUIT OUT

The Loom

- Begin with a partially completed figure in an Opening A-like configuration (i.e., the figure has a thumb loop, at least one index loop, and a little

finger loop, and the near thumb and far little finger strings are transverse or “straight across” strings). *Note:* If you’re just practicing, begin with a simple 3-loop loom (either Opening A, or a 3-loop DNA loom).

First Inuit Weave (I-1)

- Pass each thumb away from you *over* the near index string and *under* the far index string, then pick up the near little finger string and return.
- Pass each middle finger toward you over both index strings and down through the upper thumb loop, then pick up the lower far thumb string and return.
- Drop both thumb loops and extend.

Second Inuit Weave (I-2)

- Pass each thumb away from you over the near index string and under all other strings, then pick up the far little finger string and return.

Shifting the Loops

- Drop the *index* loop;
- Transfer the middle finger loop to the little finger, inserting the little finger from below;
- Transfer both little finger loops to the index, maintaining their relative order;
- Transfer the thumb loop to the ring and little finger (i.e., insert the ring and little finger into the thumb loop from below, close the near thumb string to the palm, and withdraw the thumb). It really doesn’t matter which of the three lesser fingers you use here: any combination will do.

Fixing the Bottom

- Pass each thumb under both index loops and away from you through the ring-little finger loop, then pass the thumb up behind the strings and insert it, from below, into the upper index loop;
- With each thumb hook down the upper far index string and draw it down through the ring-little finger loop until the thumb is below the far little finger string, then with each thumb pick up the far little finger string and draw it through the loop on each thumb, which slips off as you return.
- Drop the ring-little finger loop and extend.

Cleaning the Top

- Transfer the thumb loop to the little finger (i.e., insert the little finger into the thumb loop from below, close the near thumb string to the palm, and withdraw the thumb). Again, you may use only the little finger, or the ring and little fingers, or the middle, ring, and little fingers here, whatever you are comfortable with.

- Transfer both index loops to the thumb, maintaining their relative order.
- Insert each index, from above, into the upper and lower thumb loops, pick up the lower near thumb string, and draw it through the upper thumb loop; then curl the tip of each index around the upper near thumb string, drawing this string away from you and up through the index loop, which slips off.
- Drop both thumb loops and extend to complete the figure.

Note: If, for practice, you started with Opening A rather than a partially completed figure, the result is simply ‘Inuit Net’ (fig. 7).

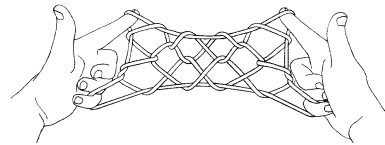


Fig. 7 - Inuit Net

4-LOOP INUIT OUT

The Loom

- Begin with a partially completed figure in a 4-loop loom configuration (i.e., the figure has a thumb loop, an index loop, a middle finger loop, and a little finger loop, and the near thumb and far little finger strings are transverse or “straight across” strings). *Note:* If you’re just practicing, begin with a simple 4-loop DNA loom.
- Combine the index and middle finger loops as follows: Transfer the index loop to the middle finger, then transfer both middle finger loops to the index, maintaining their relative order.

The Weaving Sequence

- You now have something that resembles Opening A on your hands, the index loop being doubled. Now do all the weaves of the 3-loop Inuit Out sequence (skip *The Loom*), treating the double index loop as if it were single.

Note: If, for practice, you started with a 4-loop DNA loom rather than a partially completed figure, the result is simply ‘4-loop Inuit Net’ (fig. 8).

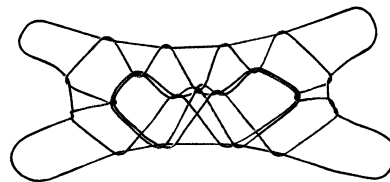


Fig. 8 - 4-loop Inuit Net

5-LOOP INUIT OUT

The Loom

- Begin with a partially completed figure in a 5-loop loom configuration (i.e., the figure has a thumb loop, an index loop, a middle finger loop, a ring finger loop, and a little finger loop, and the near thumb and far little finger strings are transverse or “straight across” strings). *Note:* If you’re just practicing, begin with a simple 5-loop DNA loom.

- Combine the index, middle, and ring finger loops as follows: Transfer the index loop to the middle finger, then transfer both middle finger loops to the ring finger, then transfer the three ring finger loops to the index, maintaining their relative order throughout.

The Weaving Sequence

- You now have something that resembles Opening A on your hands, the index loop being tripled. Now do all the weaves of the 3-loop Inuit Out sequence (skip *The Loom*), treating the triple index loop as if it were single.

Note: If, for practice, you started with a 5-loop DNA loom rather than a partially completed figure, the result is simply '5-loop Inuit Net' (fig. 9).

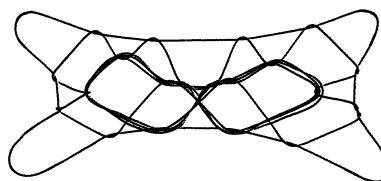


Fig. 9 - 5-loop Inuit Net

FIRST INUIT WEAVE INVERSE

I-1' (first Inuit weave inverse) is a key element in many of my iterative figures (i.e., 'Cherokee Seven Stars') and is referred to extensively in this article. For sake of completeness the method is reproduced here. If you wish to practice, begin with Opening A then proceed as follows:

First Inuit Weave Inverse (I-1')

- Pass each thumb away from you over the near index string and under the far index string, then pick up the near little finger string and return.
- With the help of the opposite hand, remove the upper thumb loop, rotate it a half turn towards you (a $-1/2$ rotation), and reset it on the thumb as an upper loop.
- Pass each middle finger toward you over both index strings and down through the upper thumb loop (this takes some practice since the upper loop is now very tight), then pick up the lower far thumb string and return.
- Drop both thumb loops and extend.

Power Lift

There are several good illustrations of this move in my first article (Murphy 1997:64-65). Here's how to apply it to a figure that ends with *Inuit Out*:

- Transfer each index loop to the thumb, inserting the thumb from below.
- Gently withdraw the little finger from its loop and reinsert it from the opposite side. The figure now lies flat between your hands.

- With each thumb pick up the near little finger string.
- Pass the index and middle fingers toward you over both strings of the upper thumb loop and pinch between them the lower near thumb string, then wrap the string around the tip of the index by rotating the pair away from you and up.
- To expand the central design, separate the indices and little fingers as far as possible and push the thumbs toward the center of the figure (two ringlets tightly encircle each thumb). As an example, see fig. 63.

Caroline Extension

The Caroline Extension, otherwise known as the ‘Pindiki’ move, is used throughout the Pacific to display finished patterns. Here’s how to apply it to a figure that ends with *Inuit Out*:

- After *Cleaning the Top* and extending the figure, pass each thumb away from you, under the index loop, and pick up the near little finger string and the far index string; Release the index loop.
- Gently release each little finger loop and reinsert the little finger from the opposite side.
- With the tip of each index pick up the lower far thumb string, but as you return press the thumb against the first joint of your index finger to keep the string you just retrieved from slipping. Extend with palms facing away from you.

VERTICAL NETS

LESSON 2: LEARNING TO WEAVE THE VERTICAL NET

The finishing moves of the Inuit Net sequence are two very unusual weaves which I call “fixing the bottom” and “cleaning the top.” In the Inuit Net sequence, these weaves are applied to a partially woven figure of considerable complexity (fig. 10). Note carefully the positions of the two transverse strings. In fig. 10, these are the upper near index string (top transverse) and the far little finger string (bottom transverse). In many string figures transverse strings become the frame strings of the final design, and for this reason their relative positions during the weaving sequence are important. In the “fixing the bottom” weave, the “bottom” transverse string is drawn through the upper index loop. In the “cleaning the top” weave the top transverse is drawn through the lower index loop (after both are transferred to the thumb!).

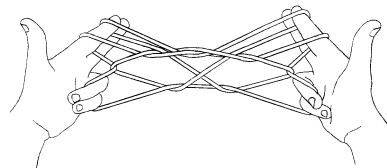


Fig. 10 - *Inuit Net intermediate stage*

What would happen if these two weaves were applied to a greatly simplified version of fig. 10? A valid string figure should result if three features are present: (1) a transverse upper near index string; (2) a transverse far little finger string; and (3) a lower index loop. The simplest string configuration with these features is shown in fig. 11.

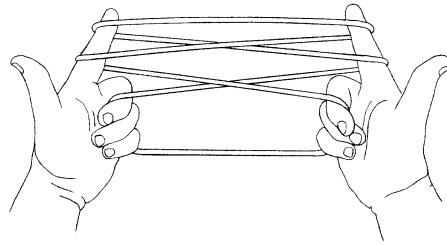


Fig. 11 - Loom with features of fig. 10

To form this simple loom, proceed as follows:

- Begin with Opening A.
- Transfer each thumb loop to the top of the index, inserting the index finger from below.
- Pass the thumb under the index loops, transfer the little finger loop to the thumb, then immediately retransfer this loop to the middle-ring-little fingers, inserting them from above and pressing their tips to the palm.

Now “fix the bottom” and “clean the top” as described on page 223. The result is shown in fig. 12. This simple design closely resembles the Navajo figure ‘Carrying Wood’ (Jayne 1962:68). Readers should note that the process of abstracting a set of weaves and applying them to a simpler (or more complex) string arrangement with similar features is a powerful design strategy, as demonstrated throughout this article.

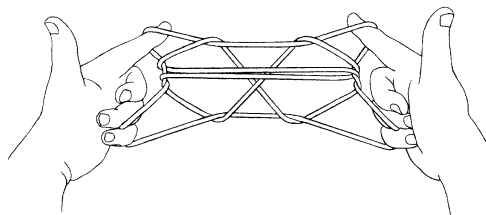


Fig. 12 - Inuit Net finishing moves applied to a simple loom

Inspired by my success with iterating the first Inuit weave, I immediately wondered whether it would be possible to iterate fixing the bottom and cleaning the top. Since there are two far index strings in fig. 11 it should be possi-

ble to fix the bottom twice (in the traditional method we skip the lower far index string, passing the thumb up behind it instead). But cleaning the top can only be done once since two loops are required for each iteration. The solution was to create a loom with more than two loops on each index. To create the extra loops, i adapted the loop-adding procedure i devised for building DNA looms. i call this loom the *Vertical Loom* since any number of loops can be stacked on the index fingers prior to weaving.

Although nearly square when finished, most vertical nets require a loop made from a rather long string since the loom often has three or more index loops. i use “spans” to measure string length, a span being the distance between your fingertips when your arms are fully extended in opposite directions. String made from 100% nylon is too slippery for making Vertical Nets and should be avoided (the side knots will slip, preventing a sharp extension). A thin smooth cotton string is much preferred (postal twine, for example). Here’s how to make a simple Vertical Net:

Forming the Vertical Loom (V-Loom)

- Begin with a 3-loop L-DNA loom.
- Transfer the thumb loop to the top of the index, inserting the index finger from below.
- Create another index loop as follows: Insert the left thumb, *from above*, into the upper index finger loop and return with the upper near index string (rotate the left thumb toward you and up); insert the right thumb, from below, into the left thumb loop and extend. Now transfer the thumb loop to the top of the index, inserting the index from below. Using this procedure, create as many index loops as you like. In this example the procedure is done only once.
- Pass the thumb under the index loops, transfer the little finger loop to the thumb, then immediately retransfer this loop to the middle-ring-little fingers, inserting them from above and pressing their tips to the palm. This completes the vertical loom. Since there are three loops on each index in this example, *V3-Loom* is an appropriate abbreviation (fig. 13A).

Now “fix the bottom” in an iterative fashion. i have renamed this the *First Vertical Weave*.

First Vertical Weave (V-1)

- Pass each thumb under all the index loops and away from you through the middle-ring-little finger loop;
- With each thumb hook down the lowest far index string and draw it down through the middle-ring-little finger loop until the thumb is below the far little finger string (fig. 13B), then with each thumb pick up the far little finger string and draw it through the loop on each thumb, which slips off as you return.

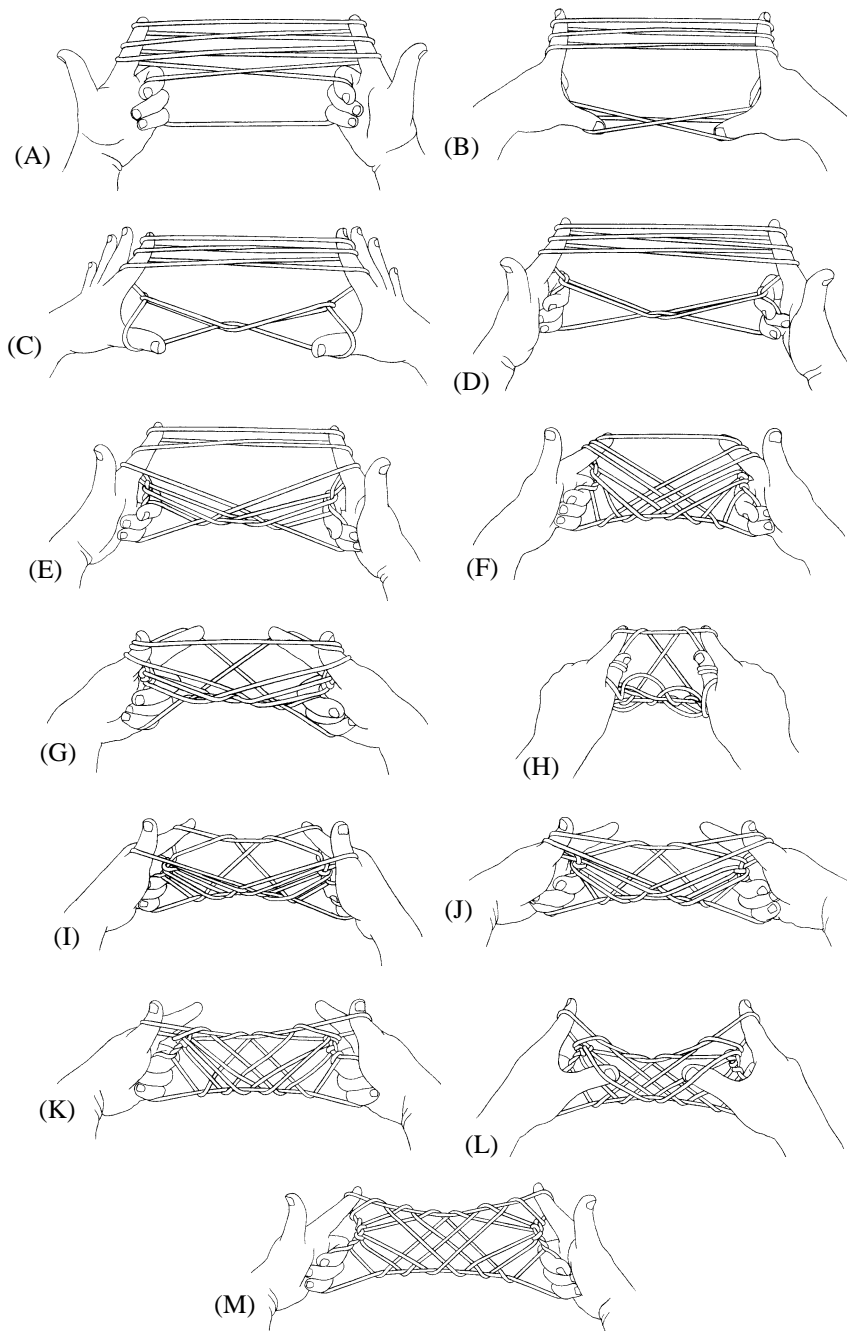


Fig. 13 - Stages in the manufacture of 'Vertical Net.'

- Drop the middle-ring-little finger loop and extend (fig. 13C).
- Transfer the thumb loop to the middle-ring-little fingers by inserting the three lesser fingers from below, closing the near thumb string to the palm, and withdrawing the thumb (fig. 13D).

Repeat the V-1 sequence until all the far index strings have been consumed. In this example, V-1 is done a total of three times (see figs. 13D, 13E, and 13F). The first iteration might feel particularly awkward, but don't fret: subsequent iterations are much easier. Now "clean the top" in an iterative fashion. I have renamed this the *Second Vertical Weave*:

Second Vertical Weave (V-2)

- Transfer all index loops to the thumb, maintaining their relative order. In this example you have an upper, a middle, and a lower thumb loop. But if you created extra loops when building your loom, these names will not make sense. For this reason we will call the top thumb loop the upper loop and the loop below it the "upper-minus-one" loop.
- Insert each index, from above, into the upper and upper-minus-one thumb loops, pick up the upper-minus-one near thumb string, and draw it through the upper thumb loop (fig. 13G); then curl the tip of each index around the upper near thumb string, drawing this string away from you and up through the index loop, which slips off (fig. 13H).
- Drop the upper and upper-minus-one thumb loops and extend (fig. 13I).
- Transfer the index loop to the top of the thumb, inserting the thumb from below (fig. 13J).

Repeat the V-2 sequence until only one thumb loop remains. In this example, V-2 is done a total of two times (see figs. 13J, and 13K).

The resulting net, although pleasing, lacks symmetry. In this example three loops encircle the bottom transverse string, but only two encircle the upper transverse string. To "repair" the figure I devised a finishing move that supplies the missing loop:

Vertical Net Finishing Move (V-finish)

- To free the thumb, retransfer the thumb loop to the index, inserting the index from below.
- On each hand examine the diagonal strings that run from the palmar "knot" to the far little finger string. Only one of these runs to the center of the far little finger string. With each thumb pick up the diagonal string that runs to the center (fig. 13L) and return with it.
- Transfer the index loop to the top of the thumb, inserting the thumb from below.

- Insert each index, from above, into the upper and lower thumb loops, pick up the lower near thumb string, and draw it through the upper thumb loop; then curl the tip of each index around the upper near thumb string, drawing this string away from you and up through the index loop, which slips off.
- Drop both thumb loops and extend (fig. 13M).

If desired, apply the Power Lift or Caroline Extension. The formula for this figure is:

V_n -Loom, $[V-1]^n$, $[V-2]^{n-1}$, V-finish, (Power Lift or Caroline Extension).

where n = the number of index loops in the initial Vertical Loom and superscripts indicate how many times the bracketed sequence is repeated before advancing to the next weave. The result of $n = 4$ is shown in fig. 14. This figure resembles the Nauruan mat seen on the

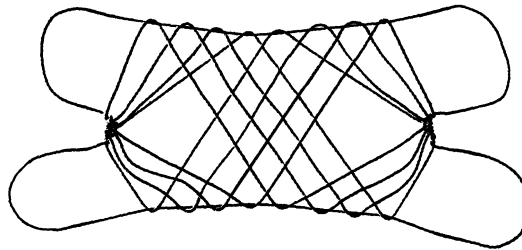


Fig. 14 - Vertical Net, V4 loom

cover of Mrs. Jayne's book (1962 reprint, Dover Publications). Note, however, that some "looseness" in the web is unavoidable since the side knots prevent full absorption of the internal slack during the extension.

LESSON 3: HYBRID VERTICAL NETS

Hybrid figures are among my favorites. Here i present two Vertical Nets that incorporate moves from my Ten Men system.

Lightning Across the Middle

This figure was invented by my friend Keith Kaplon. It starts with a Ten Men loom, which is then modified and rearranged to give a Vertical Net Loom. Two V-1 weaves follow, but the lowest far index string is skipped. The figure ends with a series of reverse V-2 weaves, which Kaplon called the "Dipsy-Doodle." Use a loop made from a string measuring $2\frac{1}{2}$ spans.

Modified V-Loom

- Ten Men Loom (Opening A; With your mouth reach over all the strings and return with the far little finger string; With your right index reach over the right mouth string, pick up the left mouth string, and return;

With your left index pick up the right mouth string and return; Release the mouth loop and the loop on each thumb and extend).

- Do an **a** weave without resetting the loom (Pass each thumb under the index loops, pick up the near little finger string, and return. With each thumb pick up the upper near index string, then Navaho the thumb loops).
- With each little finger pick up the upper far index string and return. Drop the upper index loop and extend. You now have palmar strings.
- Now do a modified Opening A: With the right index pick up the left palmar string (segment near left thumb); Pass the left index down through the upper right index loop only and pick up the right palmar (segment near right thumb). Return, but *do not wriggle* (see-saw) hands to absorb slack.
- Transfer the thumb loop to the top of the index, inserting the index finger from below.
- [Two loops hang from the upper near index string (fig. 15). Each loop is a continuation of the lower far index string. Behind these two loops hangs a single transverse string, this being a continuation of the lower near index string. Pass each thumb away from you, through the hanging loop nearest it, and pick up the single transverse string, drawing it through the hanging loop]. Now wriggle hands to absorb slack.
- With each thumb pick up the upper near index string, then Navaho the thumb loops, drop the upper index loop, and transfer the thumb loop to the top of the index, inserting the index from below.
- Pass the thumb under the index loops, transfer the double little finger loop to the thumb, then immediately retransfer this loop to the middle-ring-little fingers, inserting them from above and pressing their tips to the palm. You now have a modified *Vertical Loom*.

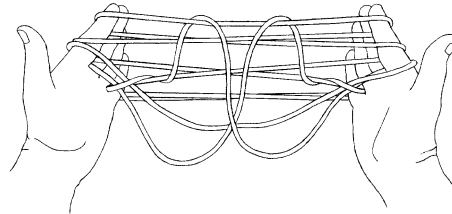


Fig. 15 - Intermediate stage of Lightning Across the Middle

Modified V-1 Weave

- Pass each thumb under all the index loops and away from you through the double middle-ring-little finger loop;
- Pass each thumb up behind the strings and insert it, from below, into the middle index loop. With each thumb hook down the middle far index string and draw it down through the double middle-ring-little finger loop until the thumb is below the double far little finger string, then with each

thumb pick up the double far little finger string and draw it through the loop on each thumb, which slips off as you return.

- Drop the double middle-ring-little finger loop and extend.
- Transfer the double thumb loop to the middle-ring-little fingers by inserting the three lesser fingers from below, closing the double near thumb string to the palm, and withdrawing the thumb.
- Pass each thumb under all the index loops and away from you through the double middle-ring-little finger loop.
- Pass each thumb up behind the strings and insert it, from below, into the upper index loop. With each thumb hook down the upper far index string and draw it down through the double middle-ring-little finger loop until the thumb is below the double far little finger string, then with each thumb pick up the double far little finger string and draw it through the loop on each thumb, which slips off as you return.
- Drop the double middle-ring-little finger loop and extend.
- Transfer the double thumb loop to the middle-ring-little fingers by inserting the three lesser fingers from below, closing the double near thumb string to the palm, and withdrawing the thumb.

Modified V-2 Weave (Dipsy Doodle)

- Transfer all index loops to the thumb, maintaining their relative order.
- In the Dipsy Doodle sequence, the near thumb strings are woven from bottom to top without releasing any loops from the thumb until all three strings have been woven: First, insert each index and middle finger, from above, into all three thumb loops, pass their tips in front of the lowest near thumb string, then pinch the middle near thumb string between them (index above, middle finger below) and draw this string up through the thumb loops *without* rotating their tips away from you and up. You now have a loop on each middle finger (fig. 16).
- Next, insert each index, from below, into the middle finger loop and pinch between their tips the remaining near thumb string. Draw this string away from you, through the index-middle finger loop, by rotating their tips away from you and up, catching the retrieved string on the back of the index. Release all three thumb loops and extend (fig. 17). If desired, apply the Power Lift or Caroline Extension. A shorthand method for this figure is:

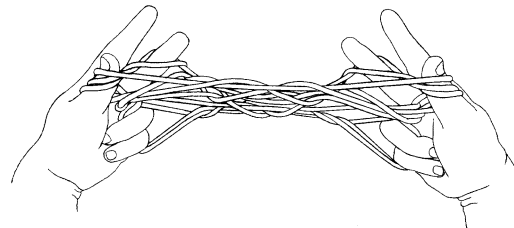
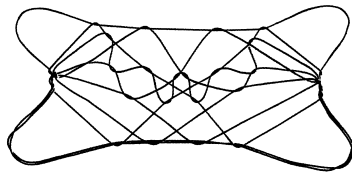


Fig. 16 - Dipsy Doodle move, half-way point

Ten Men Loom, **a** without resetting loom, transfer upper index loop to little finger, index picks up opposite palmar string (near thumb) as in opening A, lift thumb loop to top of index, thumb through hanging loop gets hanging transverse, wriggle, thumb picks up upper near index string, Navaho thumbs, drop upper index loop, transfer thumb loop to index, three lesser fingers take little finger loop from behind, [V-1, skipping lowest far index string]², [reverse V-2, done dipsy doodle style]² (Power Lift or Caroline Extension).

Fig. 17 - James Murphy with *Lightning Across the Middle*

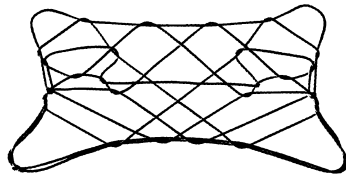


Thunder Across the Middle

This figure, also invented by Keith Kaplon, is a less complex version of *Lightning Across the Middle*. Since thunder often follows lightning the name *Thunder Across the Middle* seems appropriate. To make it, simply omit the instructions in [brackets]. See fig. 18. Use a loop made from a string measuring 2 spans. A shorthand method for this figure is:

Ten Men Loom, **a** without resetting loom, transfer upper index loop to little finger, index picks up opposite palmar string (near thumb) as in opening A, lift thumb loop to top of index, wriggle, thumb picks up upper near index string, Navaho thumbs, drop upper index loop, transfer thumb loop to index, three lesser fingers take little finger loop from behind, [V-1, skipping lowest far index string]², [reverse V-2, done dipsy doodle style]² (Power Lift or Caroline Extension).

**Fig. 18 - James Murphy with
*Thunder Across the Middle***



As humans our five fingers limit the number of loops we can manipulate while weaving string figures. Nauruans, who routinely employed 5-loop looms to create their most intricate designs, showed us that “more” is often “better” when weaving string figures. Vertical looms allow us to easily manipulate *more than* five loops. In fact, the number of loops is limited only by the length of your string and the length of your index finger.

LOOP PASSAGES (BRAIDING)

LESSON 4: REPRODUCING A WEAVE ARTIFICIALLY

Despite their apparent complexity the procedures for making most string figures are essentially the same: loops derived from an initial loom are drawn through each other until a pleasing design results. During this procedure loops are often twisted, exchanged, dropped, or created anew from portions of existing loops. Understanding the consequences of each manipulation allows one to skilfully alter the weaving sequence. The entire Vertical Net family of figures arose from a careful analysis of the positions of the two transverse strings in the final weaving stages of the Inuit Net.

In theory it should be possible to mimic many simple weaving sequences artificially using a series of *loop passage* or *braiding* maneuvers. During a loop passage maneuver a loop is temporarily removed from a finger (often by the opposite hand), passed up (or down) through another loop, then reset on

its original finger. As an experiment start with Opening A, do the first Inuit weave (I-1, see page 223), then reset the loom (transfer the middle finger loop to the thumb, inserting the thumb from below) so that the configuration of the strings can be more clearly seen. The result is shown in fig. 19. Note that the following series of loop passages accomplishes the same thing:

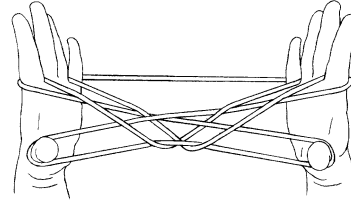


Fig. 19 - First Inuit Weave*

First Inuit Weave (manual loop passage method)

- Pass your right thumb and index finger down through the left index loop; grasp the segment of string that crosses the back of the left little finger (fig. 20A); lift the left little finger loop off the left little finger, draw it *up* through the left index loop (fig. 20B), then return the loop, without twisting it, to the left little finger (fig. 20C). Repeat on the opposite hand.

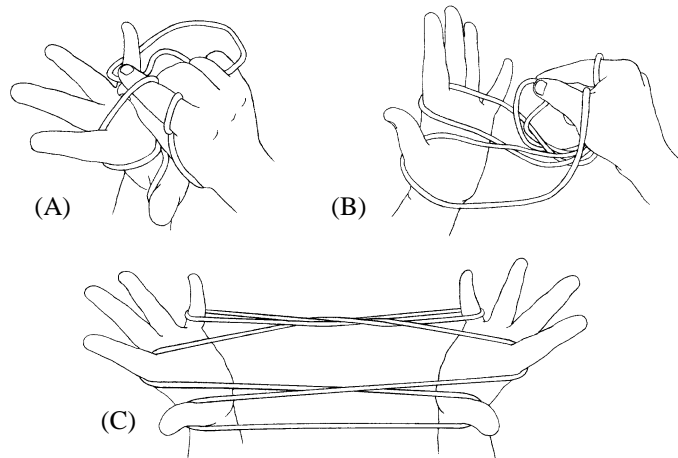


Fig. 20 - Stages of a manual loop passage

- Pass your right thumb and index finger down through the left little finger loop, then toward you over the left index loop; grasp the segment of string that crosses the back of the left thumb; lift the left thumb loop off the left thumb, draw it *up* through the left little finger loop, then pass it toward you over the left index loop and return the loop, without twisting it, to the left thumb. Repeat on the opposite hand.
- With your right thumb and index grasp the segment of string that crosses the back of the left little finger, lift the left little finger loop off the left little finger, pass the loop *down* through the left index loop, then return

the loop, without twisting it, to the left little finger. Repeat on the opposite hand. The result should be identical to fig. 19.

A shorthand notation for this sequence is:

Little finger loop *up* through index loop and return
 Thumb loop over index loop, *up* through little finger loop and return
 Little finger loop *down* through index loop and return

The inverse of the first Inuit weave can be studied in a similar fashion. As an experiment start with Opening A, do the first Inuit weave inverse (I-1', see page 225), then reset the loom (transfer the middle finger loop to the thumb, inserting the thumb from below) so that the configuration of the strings can be more clearly seen. The result is shown in fig. 21. Note that the following series of loop passages accomplishes the same thing:

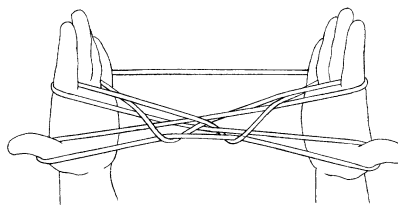


Fig. 21 - First Inuit Weave Inverse*

First Inuit Weave Inverse (manual loop passage method)

- Pass your right thumb and index finger down through the left index loop; grasp the segment of string that crosses the back of the left little finger; lift the left little finger loop off the left little finger, draw it *up* through the left index loop, then return the loop, without twisting it, to the left little finger. Repeat on the opposite hand.
- With your right thumb and index finger grasp the segment of string that crosses the back of the left thumb and lift the left thumb loop off the left thumb; pass the loop you are holding over the left index loop, *down* through the left little finger loop, then toward you over the left index loop; return the loop, without twisting it, to the left thumb. Repeat on the opposite hand.
- With your right thumb and index grasp the segment of string that crosses the back of the left little finger, lift the left little finger loop off the left

**It's important to note that simple loop transfers do not change the core or "heart" of a partially completed string figure: the internal relationships of the various loops remains the same, (loop x passes through loop y, which passes through loop z, etc.) regardless of which fingers support the loops. It therefore seems appropriate to retain the names "First Inuit Weave" and "First Inuit Weave Inverse" for the string arrangements shown in figs. 19 and 21, respectively, even though the middle finger loop has been transferred to the thumb in each case. This convention will be applied throughout the remainder of this article.*

little finger, pass the loop *down* through the left index loop, then return the loop, without twisting it, to the left little finger. Repeat on the opposite hand. The result should be identical to fig. 21.

A shorthand notation for this sequence is:

Little finger loop *up* through index loop and return
 Thumb loop over index loop, *down* through little finger loop and return
 Little finger loop *down* through index loop and return

This analysis suggests that the only difference between the first Inuit weave and its inverse is the direction in which the thumb loop passes through the little finger loop.

Since each hand must work sequentially, manual loop passages represent a rather awkward and inefficient method for creating string figures. But loop passages need not be awkward. By carefully shifting loops it is possible to accomplish loop passages with both hands acting in unison. To practice this refined technique, begin with Opening A and proceed as follows:

First Inuit Weave (refined loop passage method)

- Pass each thumb under the index loop; transfer the little finger loop to the top of the thumb, then pass the thumb, with its loops, up through the index loop; transfer the upper thumb loop to the little finger and return the thumb to its original position.
- Pass the thumb, carrying its loop near the top of the thumb, over the index loop, then up through the little finger loop; transfer the thumb loop to the top of the little finger and return the thumb to its original position; pass the thumb over the index loop, transfer the upper little finger loop to the thumb, and return the thumb to its original position.
- Pass the thumb over the index loop, transfer the little finger loop to the thumb, then retransfer this loop to the top of the index finger and return the thumb to its original position; now pass the thumb up through both index loops, transfer the upper index loop to the top of the thumb, carry this loop down through the lower index loop, and transfer it to the little finger; return thumb to its original position. The result is shown in fig. 19.

The loop passages that accomplish the first Inuit weave inverse can likewise be done using refined loop passages. Start with Opening A, then do the following:

First Inuit Weave Inverse (refined loop passage method)

- Pass each thumb under the index loop; transfer the little finger loop to

the top of the thumb, then pass the thumb, with its loops, up through the index loop; transfer the upper thumb loop to the little finger and return the thumb to its original position.

- Pass the little finger over the index loop, then transfer the thumb loop to the top of the little finger and return; pass the thumb over the index loop, then up through the little finger loops; transfer the upper little finger loop to the thumb, carry this loop down through the lower little finger loop, and return the thumb to its original position.
- Pass the thumb over the index loop, transfer the little finger loop to the thumb, then retransfer this loop to the top of the index finger and return the thumb to its original position; now pass the thumb up through both index loops, transfer the upper index loop to the top of the thumb, carry this loop down through the lower index loop, and transfer it to the little finger; return thumb to its original position. The result is shown in fig. 21.

With practice, one can learn to do almost any loop passage sequence using transfers. When a long series of transfers is done rapidly and smoothly, the motions are mesmerizing to watch (the hands will appear to “dance”).

LESSON 5: SIMPLE BRAIDED THREE-LOOP FIGURES

To introduce my students to the world of loop passages (braiding) and the mathematics associated with it, i devised a simple weaving sequence to serve as a test pattern. The sequence features two braiding maneuvers. A loop made from a 2-span string should suffice since each begins with a 3-loop loom (Opening A). The general formula is:

opening A
 braid, braid
 rotate index loop $+2/2$
 inuit out
 power lift or caroline extension

where braid = w, x, y, or z

w, x, y, and z are braiding sequences defined as follows:

w braiding sequence
 rotate index loop $+1/2$
 thumb loop *up* through index loop and return
 little finger loop *up* through index loop and return

x braiding sequence

rotate index loop $+1/2$
 thumb loop *up* through index loop and return
 little finger loop *down* through index loop and return

y braiding sequence

rotate index loop $-1/2$
 thumb loop *down* through index loop and return
 little finger loop *up* through index loop and return

z braiding sequence

rotate index loop $-1/2$
 thumb loop *down* through index loop and return
 little finger loop *down* through index loop and return

In order to explore all possible combinations you would need a 4-by-4 matrix (a table with 16 squares). But for now, just try making the figure whose braiding sequence is w z (fig. 22).

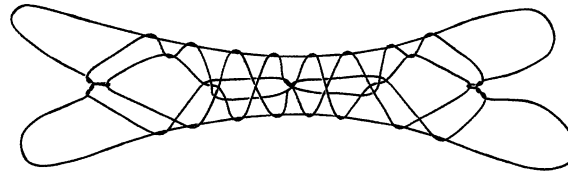


Fig. 22 - Loop passage test pattern (braiding sequence = w z)

The formula is:

opening A
 w, z
 rotate index loop $+2/2$
 inuit out
 power lift or caroline extension

To help you get started, the entire weaving sequence is spelled out below. Refined loop passages are used here, but manual loop passages work just as well. Use whichever method suits you.

Form the Loom

- Begin with Opening A.

First Braiding Sequence (w)

- Roll the index loop $+1/2$ as follows: transfer the index loop to the thumb,

inserting the thumb from below; then retransfer this loop to the index, inserting the index from above.

- Pass the thumb, carrying its loop near the top of the thumb, up through the index finger loop; transfer the thumb loop to the top of the index and return the thumb to its original position; transfer the upper index loop to the thumb, inserting the thumb from below.
- Pass each thumb under the index loop; transfer the little finger loop to the top of the thumb, then pass the thumb, with its loops, up through the index loop; transfer the upper thumb loop to the little finger and return the thumb to its original position.

Second Braiding Sequence (z)

- Roll the index loop $-1/2$ as follows: transfer the index loop to the thumb, inserting the thumb from above; then retransfer this loop to the index, inserting the index from below.
- Transfer the thumb loop to the top of the index, inserting the index from below; pass the thumb up through both index loops, transfer the upper index loop to the thumb and carry this loop down through the lower index loop, returning the thumb to its original position.
- Pass the thumb over the index loop, transfer the little finger loop to the thumb, then retransfer this loop to the top of the index finger and return the thumb to its original position; now pass the thumb up through both index loops, transfer the upper index loop to the top of the thumb, carry this loop down through the lower index loop, and transfer it to the little finger; return thumb to its original position.

Finishing Moves

- Roll the index loop $+2/2$ as follows: transfer the index loop to the thumb, inserting the thumb from below; then retransfer this loop to the index, inserting the index from above; again transfer the index loop to the thumb, inserting the thumb from below; then retransfer this loop to the index, inserting the index from above.
- Inuit Out (make the Inuit Net from the beginning, as if you had Opening A on your hands, see page 222).
- Power lift or Caroline Extension (fig. 22).

You may also wish to experiment with introducing a full index loop rotation rather than a half rotation at the beginning of the four braiding sequences, thus defining four new weaves (w^* , x^* , y^* , and z^*):

w^* braiding sequence

rotate index loop $+2/2$

thumb loop *up* through index loop and return

little finger loop *up* through index loop and return

x^* braiding sequence

rotate index loop $+2/2$
thumb loop *up* through index loop and return
little finger loop *down* through index loop and return

y^* braiding sequence

rotate index loop $-2/2$
thumb loop *down* through index loop and return
little finger loop *up* through index loop and return

z^* braiding sequence

rotate index loop $-2/2$
thumb loop *down* through index loop and return
little finger loop *down* through index loop and return

This simple modification converts the string crossing between each diamond to a wrap. For example, try making the figure whose braiding sequence is $x^* y^*$ (fig. 23). Its center has an unusual symmetry.

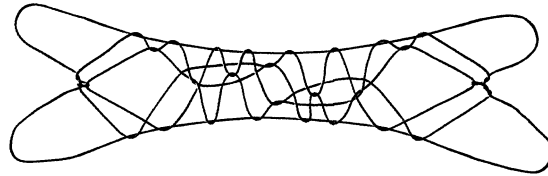


Fig. 23 - Loop passage test pattern (braiding sequence = $x^* y^*$)

The formula is:

opening A
 x^*, y^*
rotate index loop $+2/2$
inuit out
power lift or caroline extension

The entire weaving sequence is spelled out below:

Form the Loom

- Begin with Opening A.

First Braiding Sequence (x^)*

- Roll the index loop $+2/2$ as follows: transfer the index loop to the thumb, inserting the thumb from below; then retransfer this loop to the index, inserting the index from above; again transfer the index loop to the

thumb, inserting the thumb from below; then retransfer this loop to the index, inserting the index from above.

- Pass the thumb, carrying its loop near the top of the thumb, up through the index finger loop; transfer the thumb loop to the top of the index and return the thumb to its original position; transfer the upper index loop to the thumb, inserting the thumb from below.
- Pass the thumb over the index loop, transfer the little finger loop to the thumb, then retransfer this loop to the top of the index finger and return the thumb to its original position; now pass the thumb up through both index loops, transfer the upper index loop to the top of the thumb, carry this loop down through the lower index loop, and transfer it to the little finger; return thumb to its original position.

Second Braiding Sequence (y)*

- Roll the index loop $-2/2$ as follows: transfer the index loop to the thumb, inserting the thumb from above; then retransfer this loop to the index, inserting the index from below; again transfer the index loop to the thumb, inserting the thumb from above; then retransfer this loop to the index, inserting the index from below.
- Transfer the thumb loop to the top of the index, inserting the index from below; pass the thumb up through both index loops, transfer the upper index loop to the thumb and carry this loop down through the lower index loop, returning the thumb to its original position.
- Pass each thumb under the index loop; transfer the little finger loop to the top of the thumb, then pass the thumb, with its loops, up through the index loop; transfer the upper thumb loop to the little finger and return the thumb to its original position.

Finishing Moves

- Roll the index loop $+2/2$ as follows: transfer the index loop to the thumb, inserting the thumb from below; then retransfer this loop to the index, inserting the index from above; again transfer the index loop to the thumb, inserting the thumb from below; then retransfer this loop to the index, inserting the index from above.
- Inuit Out (make the Inuit Net from the beginning, as if you had Opening A on your hands, see page 222).
- Power Lift or Caroline Extension (fig. 23).

To add complexity to the center, try exchanging the index loops just after completing Opening A (exchange means: transfer the right index loop to the top of the left index, inserting the left index from above; insert the right index from above and from the near side, into the lower left index loop, then lift this loop over the left upper index loop and off the left index, returning the

right index to its original position). For example, try the following:

- opening A
- exchange index loops
- y, y
- rotate index loop +2/2
- inuit out
- power lift or caroline extension

The index loop exchange creates a hole in the center of the design (fig. 24). Also note that the left half is not a true reflection of the right half.

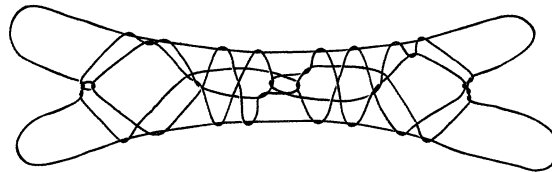


Fig. 24 - Loop passage test pattern (braiding sequence = exchange, y y)

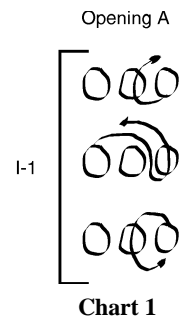
LESSON 6: A CIRCLE NOTATION FOR RECORDING LOOP PASSAGES

So far we have recorded loop passages using written formulas. The formula for the first Inuit weave is:

- Little finger loop *up* through index loop and return
- Thumb loop over index loop, *up* through little finger loop and return
- Little finger loop *down* through index loop and return

Several years ago i devised a symbolic notation for recording the same information. Rows of circles represent loops, hence the name *circle notation*. Three circles in a row represent the three loops of Opening A or a 3-loop DNA loom, as specified. Arrows indicate the direction of various loop passages. Fractions placed below circles indicate the extent and direction of loop rotations (+1/2 = half turn away; -1/2 = half turn toward; +2/2 = full turn away; -2/2 = full turn toward). Brackets are grouping symbols.

The first Inuit weave, rendered in circle notation, is shown in chart 1. By convention, the circle on the left in each row always represents the loop nearest you, in this case, the thumb loop. Here, the middle circle represents the index loop, and the circle on the right the little finger loop. The first line specifies which loom to use; in this case,



Opening A. The arrow in the first row of three circles tells the reader to pass the little finger loop up through the index loop and return it to the little finger. The exact method for doing this (manual versus refined method) is not specified (the reader is free to choose). The arrow in the second row of circles tells the reader to pass the thumb loop over the index loop, pass it up through the little finger loop, and return it to the thumb. The arrow in the last row of circles tells the reader to pass the little finger loop down through the index loop and return it to the little finger.

Opening A

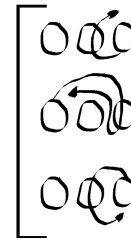


Chart 2

The first Inuit weave inverse (I-1'), rendered in circle notation, is shown in chart 2. Note that the only difference between chart 1 and chart 2 is the direction of the arrow in the second row of circles: In chart 1, the thumb loop passes *up* through the little finger loop, but in chart 2 the thumb loop passes *down* through the little finger loop.

Circle Notation for Cherokee Seven Stars

In last year's bulletin I introduced an iterative figure called 'Cherokee Seven Stars' (Murphy 1999:192). An illustration of it is reproduced in fig. 2. In this figure the first Inuit weave and its inverse are done four times. The inverse relationship is frustrated by rolling the entire figure after each weave. This complex figure is easily formed using loop passages, and the entire procedure is concisely summarized using my circle notation (chart 3):

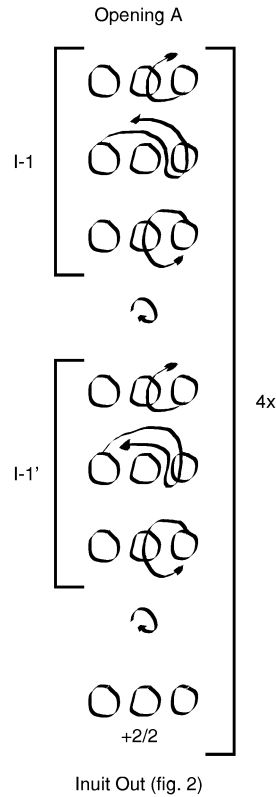
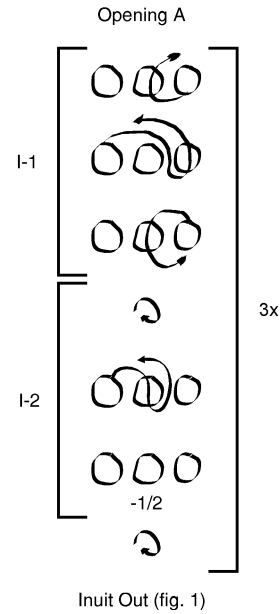
A line-by-line translation might read:

- Line 1:* Begin with Opening A
- Line 2:* Little finger loop up through index loop and return.
- Line 3:* Thumb loop over index loop, up through little finger loop and return.
- Line 4:* Little finger loop down through index loop and return.

The bracket labeled I-1 is merely a grouping symbol to emphasize that lines 2-4 represent the first Inuit weave.

Line 5: Roll the entire figure (see page 221 for a description of how to roll a 3-loop figure). The circular arrow on line 5 always means "roll the entire figure +1/2 so that the underside can be manipulated."

- Line 6:* Little finger loop up through index loop and return.
- Line 7:* Thumb loop over index loop, down through little finger loop and return.
- Line 8:* Little finger loop down through index loop and return.

**Chart 3****Chart 4**

The bracket labeled I-1' is merely a grouping symbol to emphasize that lines 6-8 represent the first Inuit weave inverse.

Line 9: Roll the entire figure (again, see page 221).

Line 10: Rotate index loop $+2/2$ (i do two consecutive $+1/2$ rolls. Recall that a $+1/2$ roll is achieved by transferring the index loop to thumb, inserting thumb from below, then retransferring the loop to index, inserting the index from above).

Important: The large bracket labeled 4x indicates that the entire bracketed weaving sequence must be done four times before advancing to Line 11.

Line 11: Inuit Out (make the Inuit Net from the beginning, as if you had Opening A on your hands). Extend using the Power Lift or Caroline Extension. Since the method of extension is not specified in the chart, the reader is free to choose.

Circle Notation for Inuit Bridge

In last year's bulletin i also introduced an iterative figure called 'Inuit Bridge' (Murphy 1999:190-191). An illustration of it is reproduced in fig. 1. In this figure the first and second Inuit weaves are done three or more times and the figure is rolled after each pair of weaves. This figure can also be made using loop passages, as illustrated in chart 4:

A line-by-line translation might read:

Line 1: Begin with Opening A.

Line 2: Little finger loop up through index loop and return.

Line 3: Thumb loop over index loop, up through little finger loop and return.

Line 4: Little finger loop down through index loop and return.

The bracket labeled I-1 is merely a grouping symbol to emphasize that lines 2-4 represent the first Inuit weave.

Line 5: Roll the entire figure (see page 221).

Line 6: Thumb loop down through index loop, then up between index and little finger loop, over index loop, and return.

Line 7: Rotate index loop $-1/2$.

The bracket labeled I-2 is merely a grouping symbol to emphasize that lines 5-7 represent the second Inuit weave.

Line 8: Roll the entire figure (see page 221).

The large bracket labeled 3x indicates that the entire bracketed weaving sequence must be done three times before advancing to Line 9.

Line 9: Inuit Out (make the Inuit Net from the beginning, as if you had Opening A on your hands). Extend using the Power Lift or Caroline Extension.

LESSON 7: THE 4-LOOP TENNIS NET

'Tennis Net' (fig. 25) is my attempt to form a mesh-like figure using a 4-loop loom. Except for the finishing moves, loop passages are used throughout. The inspiration for this figure is an iterative 3-loop Tikopian figure which i learned to make many years ago ('Flock of Kingfishers' in Firth and Maude 1970:50-51). A modified Caroline Extension is required to display the Tikopian figure (three loops are held instead of two). Unfortunately a hand injury prevents me from executing the Caroline Extension, so when i make

the Tikopian Net i finish with Inuit Out followed by the Power Lift. And for the first Tikopian weave i substitute the first Inuit weave to alter the design somewhat (see title page illustration, ‘Murphy’s Mesh’). Furthermore, my method for “resetting the loom” between iterations differs from the traditional Tikopian method. Readers interested in learning how i make this figure are referred to the Appendix.

Tennis Net (fig. 25) resembles the Tikopian Net, but the web is more complex since the figure begins with four loops instead of three.

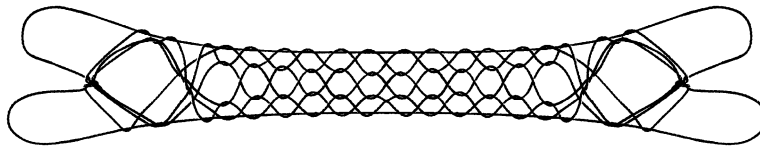


Fig. 25 - 4-loop Tennis Net

Although not illustrated here, Tennis Net is particularly impressive when woven with an octagonal loop (an eight segment loop with 45° arcs that alternate in color, arranged on the hands so that the string changes color as it winds around each finger, see fig. 26).

Tennis nets are hardy beasts that almost always extend well. In this respect they differ from many 4- and 5-loop Nauruan figures, which i like to think of as delicate hot house flowers that must be artificially nurtured to achieve their full beauty (i.e., the strings of the final design must be arranged).

A loop made from a $3\frac{1}{2}$ -span cotton string is again recommended for making all 4-loop tennis nets. The algorithm for the prototypical 4-loop Tennis Net, rendered in circle notation, is given in chart 5. A line-by-line translation might read:

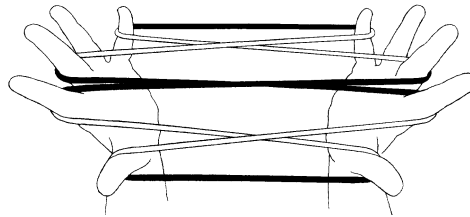


Fig. 26 - 4-loop L-DNA loom made with a two-color octagonal loop

Line 1: 4-loop L-DNA loom.

Line 2: Index loop up through thumb loop and return; middle finger loop up through little finger loop and return. (The order in which these are done does not matter).

Line 3: Rotate thumb loop $+2/2$; rotate little finger loop $-2/2$.

Line 4: Thumb loop up through index loop and return; little finger loop up through middle finger loop and return.

Line 5: Index loop up through middle finger loop and return.

Line 6: Middle finger loop up through index loop and return.

The bracket labeled 3x indicates that the entire bracketed weaving sequence must be done three times before advancing to Line 7.

Line 7: Thumb loop up through index loop and return; little finger loop up through middle finger loop and return.

Line 8: Rotate index loop +2/2; rotate middle finger loop +2/2.

Line 9: 4-loop Inuit Out (see page 222), followed by the Power Lift or Caroline Extension.

There are, in fact, numerous finishing moves that one can apply between the iterative sequence and the Inuit Out ending. In the example given above, two finishing moves are applied (lines 7 and 8). Note that one can easily omit one or both of them and still generate a pleasing design.

Since mastering this figure is essential, the complete weaving sequence using refined loop passages is spelled out below. Use a loop made from a 3½-span cotton string. During loop transfers, insert the specified finger *from below* unless instructed otherwise, and keep the transferred loop near the top of the finger to facilitate the loop passage maneuvers. Also, pass transferred loops *over* all intervening loops unless instructed otherwise. If refined loop passages prove too difficult, revert to the manual method using chart 5 as a guide.

Form the Loom

- Begin with a 4-loop L-DNA loom.

Weaving sequence

- Transfer each thumb loop to the top of the middle finger; transfer each index loop to the top of the thumb; pass each thumb, with its loop, up through the upper middle finger loop, then transfer the thumb loop to the index but do not withdraw the thumb from the upper middle finger loop; once the transfer is complete, release the upper middle finger loop onto the thumb and return the thumb to its original position, carrying the new thumb loop toward you under the index loop.
- Transfer the middle finger loop to the top of the thumb; pass each thumb, with its loops, up through the little finger loop, then transfer the upper thumb loop to the middle finger and return the thumb to its original position.

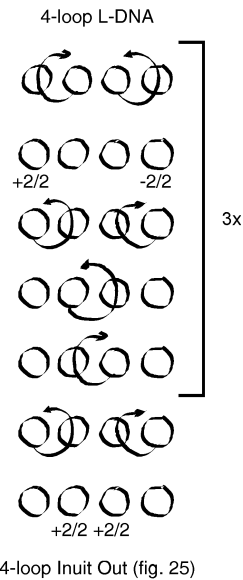


Chart 5

- Roll the thumb loop $+2/2$ as follows: transfer the thumb loop to the middle finger, inserting the middle finger from above; then retransfer this loop to the thumb, inserting the thumb from below; again transfer the thumb loop to the middle finger, inserting the middle finger from above; then retransfer this loop to the thumb, inserting the thumb from below.
- Roll the little finger loop $-2/2$ as follows: transfer the little finger loop to the thumb, then transfer the upper thumb loop to the middle finger; transfer the upper middle finger loop to the thumb, inserting the thumb from above; then retransfer this loop to the top of the middle finger, inserting the middle finger from below; again transfer the upper middle finger loop to the thumb, inserting the thumb from above; then retransfer this loop to the little finger, inserting the little finger from below.
- Pass each thumb, with its loop, up through the index loop; transfer the thumb loop to the top of the index and return the thumb to its original position; now transfer the upper index loop to the thumb.
- Pass each thumb under the index and middle finger loops, then transfer the little finger loop to the top of the thumb; without returning pass the thumb, with its loops, up through the middle finger loop; transfer the upper thumb loop to the little finger and return the thumb to its original position.
- Transfer the index loop to the top of the thumb; pass each thumb, with its loops, up through the middle finger loop; transfer the upper thumb loop to the index finger and return the thumb to its original position.
- Transfer the middle finger loop to the top of the thumb; pass each thumb, with its loops, up through the index loop; transfer the upper thumb loop to the middle finger and return the thumb to its original position.

Now repeat the entire weaving sequence two more times.

Finishing Moves

- Pass each thumb, with its loop, up through the index loop; transfer the thumb loop to the top of the index and return the thumb to its original position; now transfer the upper index loop to the thumb.
- Pass each thumb, with its loop, away from you under the index and middle finger loops, then transfer the little finger loop to the top of the thumb but do not return; pass each thumb, with its loops, up through the middle finger loop, then transfer the upper thumb loop to the little finger; withdraw the thumb from the middle finger loop and return the thumb to its original position.
- Roll the index loop $+2/2$ as follows: transfer the index loop to the thumb, inserting the thumb from below; then retransfer this loop to the index, inserting the index from above; again transfer the index loop to the thumb, inserting the thumb from below; then retransfer this loop to the index, inserting the index from above.

- Roll the middle finger loop $+2/2$ as follows: transfer the middle finger loop to the thumb, inserting the thumb from below; then retransfer this loop to the middle finger, inserting the middle finger from above; again transfer the middle finger loop to the thumb, inserting the thumb from below; then retransfer this loop to the middle finger, inserting the middle finger from above.

Complete the figure with the 4-loop Inuit Out procedure (page 224) followed by the Power Lift or Caroline Extension. See fig. 25.

LESSON 8: 4-LOOP TENNIS NET VARIATIONS

When illustrated using circle notation, it's easy to grasp the underlying symmetry of the prototypical 4-loop tennis net. In Line 2 of chart 5, the passage of the index loop up through the thumb loop is counterbalanced by a symmetrical passage of the middle finger loop up through the little finger loop. In Line 3, the $+2/2$ rotation of the thumb loop is counterbalanced by a $-2/2$ rotation of the little finger loop. The symmetry in the chart is reflected in the woven design. Many beautiful variations of the prototypical 4-loop Tennis Net can be designed on paper, long before they are formed on the hands, by simply altering its circle notation chart. Below are a few examples.

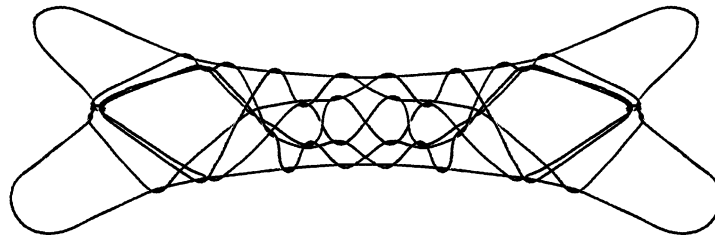


Fig. 27 - 4-loop Tennis Net, Variation 1 (chart 6)

Variation 1 (fig. 27, chart 6, page 254) is a greatly simplified version of the prototypical 4-loop tennis net (fig. 25, chart 5). When chart 6 is compared to chart 5, one immediately sees that all loop rotations have been omitted and the weaving sequence is done only once (use a loop made from a $2\frac{1}{2}$ -span string for this simple net).

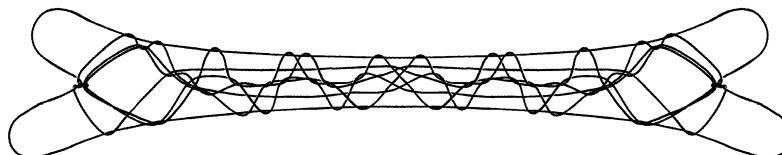


Fig. 28 - 4-loop Tennis Net, Variation 2 (chart 7)

In Variation 2 (fig. 28, chart 7), all loops are rotated a half turn at the beginning of each iteration and the entire figure is rolled at the end of each iteration. Note that the number of iterations performed *must* be a multiple of two because of the half rotations introduced into the thumb and little finger loops at the beginning of each set. If an odd number of iterations is performed, the transverse frame lines of the final design will not be properly positioned.

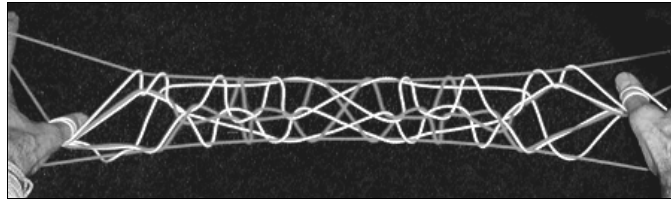


Fig. 29 - 4-loop Tennis Net, Variation 3 (chart 8)

Variation 3 (fig. 29, chart 8) is the same as variation 2 except that the figure is not rolled until the beginning of the fourth iteration. Because of this the internal transverse strings loop around the frame lines once. This effect is particularly striking when the figure is woven with an octagonal two-color loop, as in fig. 29.

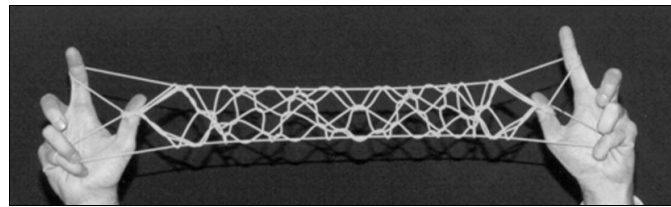


Fig. 30 - 4-loop Tennis Net, Variation 4 (chart 9)

The algorithm for Variation 4 (figs. 30 and 31, chart 9) is remarkably simple: each loop is passed *up* through the adjacent loop, starting with the thumb loop. The figure is then rolled and the procedure repeated, but this time each loop is passed *down* through an adjacent loop. This creates small “towers” or “pagodas” within the mesh.

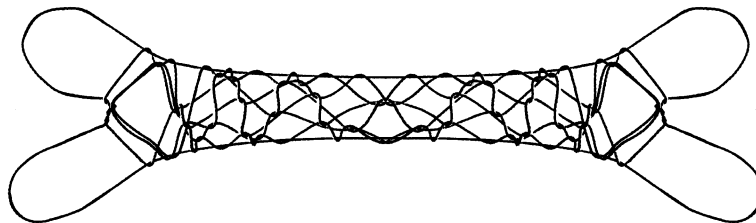


Fig. 31 - 4-loop Tennis Net, Variation 4 (chart 9)

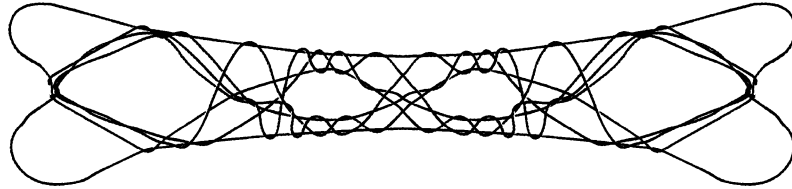


Fig. 32 - 4-loop Tennis Net, Variation 5 (chart 10)

In Variation 5 (fig. 32, chart 10) a single loop passage is repeated over and over. Between each loop passage the figure is either rolled or internal loops are rotated a half turn. The final design resembles a Ten Men variation called ‘Jaguar’ which is described in Part 2 of this series (Murphy 1998:193).

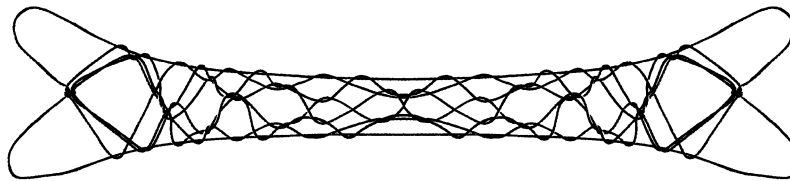
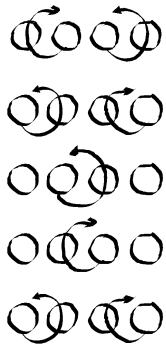


Fig. 33 - 4-loop Tennis Net, Variation 6 (chart 11)

In Variation 6 (fig. 33, chart 11), loop rotations precede the prototypical 4-loop Tennis Net algorithm (the bracketed sequence in chart 5). However, the direction and degree of twisting varies with each iteration. At the beginning of the first iteration, the index loop is rotated $+2/2$ and the middle finger loop is rotated $-2/2$; at the beginning of the second iteration the index loop is rotated $-3/2$ (one and a half turns toward you) and the middle finger loop is rotated $+3/2$ (one and a half turns away from you); at the beginning of the third iteration the index loop is rotated $+3/2$ and the middle finger loop is rotated $-3/2$. The last iteration is followed immediately by 4-loop Inuit Out.

Don’t be afraid to design some variations of your own. The six examples given above merely illustrate how loop passages and loop rotations can be shuffled, regrouped, and iterated to create hundreds of interesting designs. Very few moves are forbidden: a design of some sort will emerge as long as the near thumb and far little finger strings are transverse before applying the 4-loop Inuit Out ending. And don’t be discouraged by the fact that these figures fail to dissolve when the centers of the transverse strings are pulled in opposite directions. This minor flaw occurs because of the way the loops are “braided” during the loop passage maneuvers. The fastest way to undo a 4-loop Tennis Net is to lay the figure on your lap and patiently unbraided the loops by starting at the ends and working your way towards the center of the design.

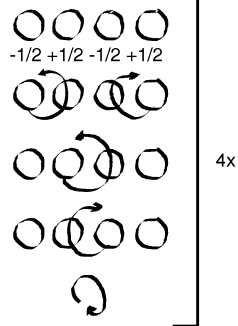
4-loop L-DNA



4-loop Inuit Out (fig. 27)

Chart 6

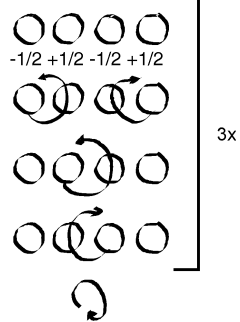
4-loop L-DNA



4-loop Inuit Out (fig. 28)

Chart 7

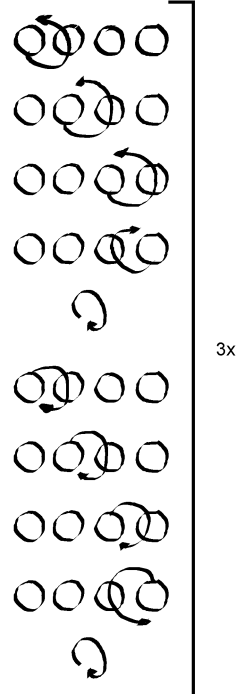
4-loop L-DNA



4-loop Inuit Out (fig. 29)

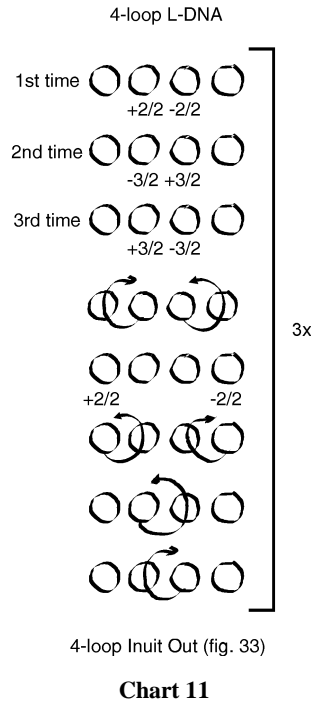
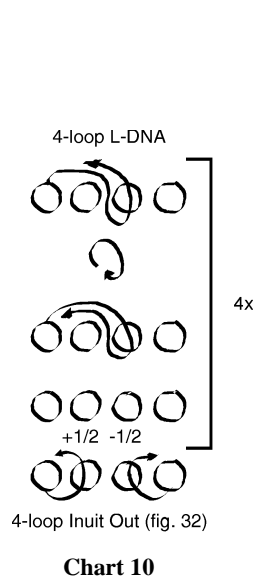
Chart 8

4-loop L-DNA



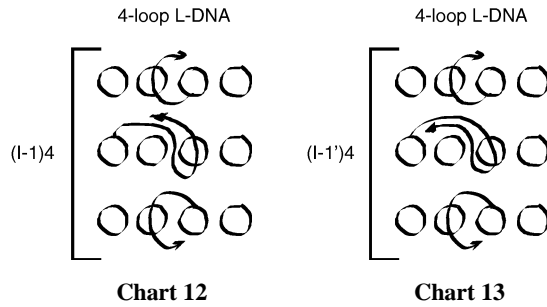
4-loop Inuit Out (figs. 30, 31)

Chart 9



LESSON 9: CHEROKEE SEVEN STARS IN A 4-LOOP ENVIRONMENT

Normally the first Inuit weave or its inverse is applied to Opening A or some other 3-loop configuration. But what would happen if you started with a 4-loop opening? Using circle notation, it's easy to envision a classic 3-loop weave transplanted into a 4-loop environment. To do this one simply adds an extra circle to the end of each row in the corresponding chart.



When the charts for the first Inuit weave and its inverse are emended in this way, two new weaves emerge: (I-1)4 and (I-1')4 (the "4" suggests a 4-loop environment). See charts 12 and 13. When these weaves are spliced into the chart for 'Cherokee Seven Stars' (chart 3), a beautiful new figure results (fig. 34, chart 14). The center star splits, and two internal transverse strings now pass through each of the eight stars.

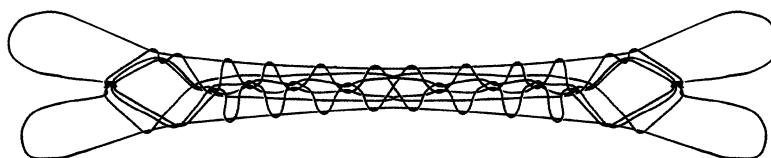


Fig. 34 - Cherokee Seven Stars in a 4-loop environment (chart 14)

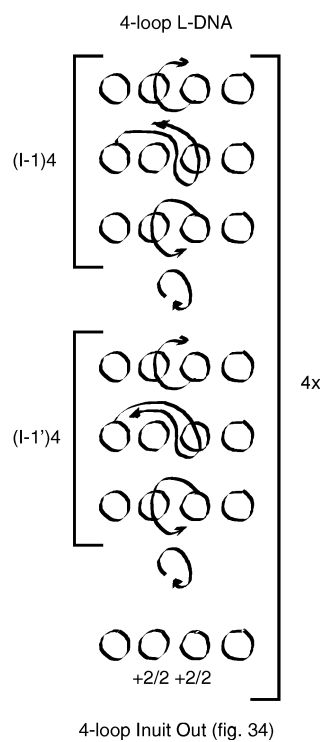
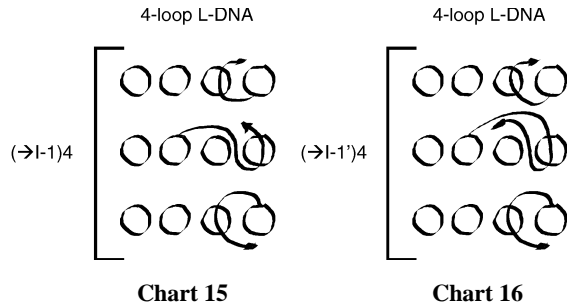


Chart 14

The extra circle can also be added to the beginning of each row. This shifts the action from the thumb, index, and middle finger loops to the index, middle, and little finger loops. Thus, two more weaves emerge: $(\rightarrow I-1)4$ and $(\rightarrow I-1')4$. See charts 15 and 16. The arrow indicates that the weave is shifted one loop toward the little finger in the corresponding circle notation chart. An attractive design results (fig. 35) from the following sequence in which normal $(I-1)4$ and $(I-1')4$ weaves are combined with their shifted counterparts:



4-loop L-DNA loom, $[(I-1)4, (\rightarrow I-1)4, \text{roll}, (I-1')4, (\rightarrow I-1')4, \text{roll}]^3$, rotate index loop $+2/2$, rotate middle finger loop $+2/2$, 4-loop Inuit Out, Power Lift or Caroline Extension (fig. 35).

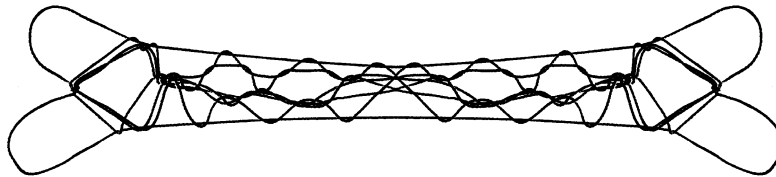


Fig. 35 - 4-loop Cherokee Seven Stars variation featuring shifted weaves

Although not illustrated here many related variations exist, some of which are listed below. For sake of brevity only the iterative portion is given:

Variation 1: $[(I-1)4, \text{roll}, (\rightarrow I-1')4, \text{roll}, (\rightarrow I-1)4, \text{roll}, (I-1')4, \text{roll}]^3$

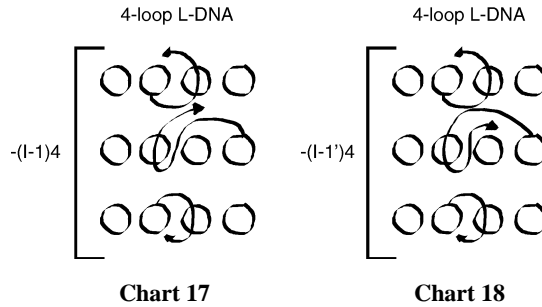
Variation 2: $[(I-1)4, (\rightarrow I-1')4, \text{roll}, (\rightarrow I-1)4, (I-1')4, \text{roll}]^3$

Variation 3: $[(\rightarrow I-1)4, (I-1)4, \text{roll}, (\rightarrow I-1')4, (I-1')4, \text{roll}]^3$

Variation 4: $[(I-1)4, \text{roll}, (I-1)4, \text{roll}, (\rightarrow I-1)4, \text{roll}, (\rightarrow I-1)4, \text{roll}]^3$

Variation 5: $[(I-1')4, \text{roll}, (I-1')4, \text{roll}, (\rightarrow I-1')4, \text{roll}, (\rightarrow I-1')4, \text{roll}]^3$

If the circle notation charts for the (I-1)4 and (I-1')4 weaves are viewed in a mirror, two more weaves emerge: -(I-1)4 and -(I-1')4 (see charts 17 and 18). Because of their mirror image relationship to the parent weaves, I call these “negative” weaves. Two figures of particular interest emerge from our definition of negative weaves (variation 6 and variation 7):



Variation 6: 4-loop L-DNA loom, [(I-1)4, roll, (I-1')4, roll, -(I-1)4, roll, -(I-1')4, roll, rotate index loop +2/2, rotate middle finger loop +2/2]², 4-loop Inuit Out, Power Lift or Caroline Extension (fig. 36).

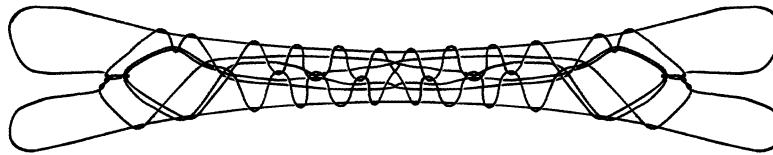


Fig. 36 - 4-loop Cherokee Seven Stars, variation 6

Variation 7: 4-loop L-DNA loom, [(I-1)4, roll, (I-1')4, roll, rotate index loop +2/2, rotate middle finger loop +2/2, -(I-1)4, roll, -(I-1')4, roll, rotate index loop +2/2, rotate middle finger loop +2/2]², 4-loop Inuit Out, Power Lift or Caroline Extension (fig. 37).

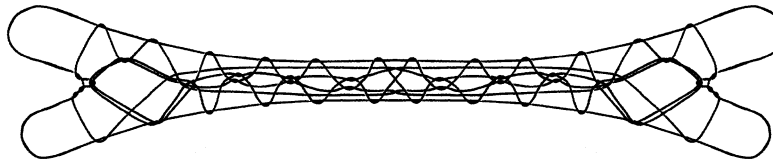


Fig. 37 - 4-loop Cherokee Seven Stars, variation 7

The differences between these figures are most striking when each is woven with a two-color octagonal loop. The two colors highlight differences in the way the innermost transverse strings duck in and out of the wraps that form the junctions between diamonds. A close-up of the junctions is shown in fig.

38. Ducking occurs whenever the index and middle finger loops are rotated between pairs of weaves. If omitted, the transverse strings fail to duck through the wrap that separates diamonds.

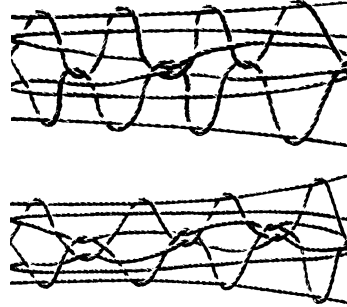


Fig. 38 - *Diamond junction differences between variation 6 (top) and variation 7 (bottom)*

Weaves can be done twice before switching to a related weave (fig. 39, chart 19). These types of weaving sequences, when transplanted back into a 3-loop environment, are also quite interesting (fig. 40, chart 20).

One can also experiment with skipping a rolling maneuver between pairs of iterations (fig. 41, chart 21).

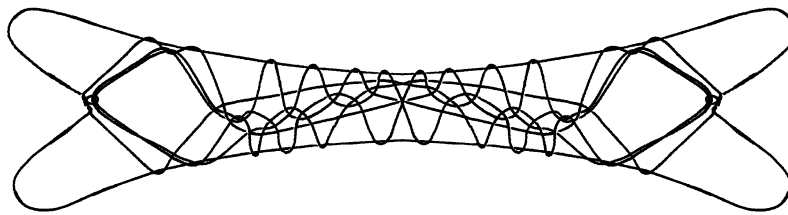


Fig. 39 - *4-loop Cherokee Seven Stars with duplicated weaves*

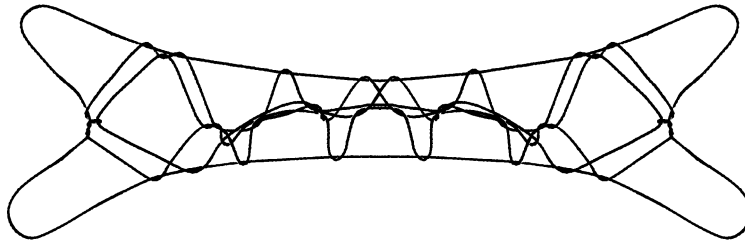


Fig. 40 - *3-loop Cherokee Seven Stars with duplicated weaves*

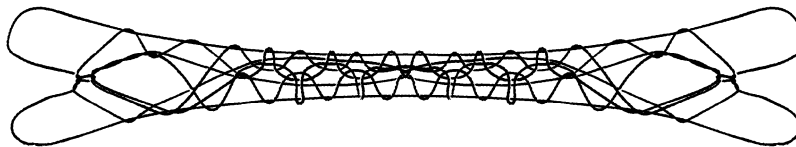
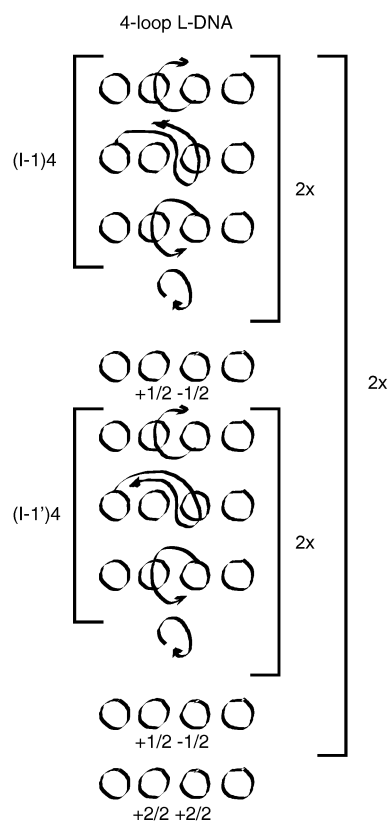
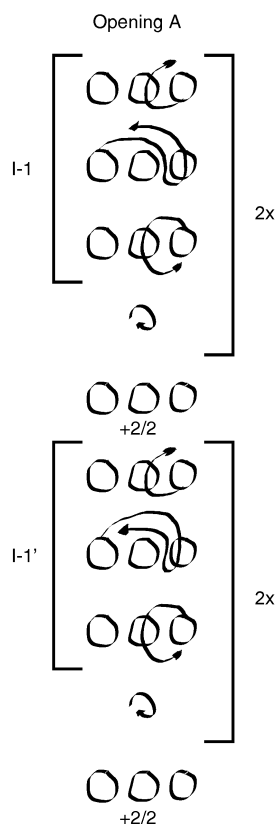


Fig. 41 - *4-loop Cherokee Seven Stars variation with every other roll omitted*



4-loop Inuit Out (fig. 39)

Chart 19



Inuit Out (fig. 40)

Chart 20

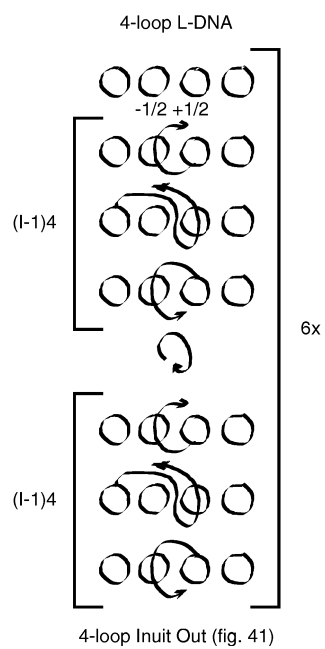


Chart 21

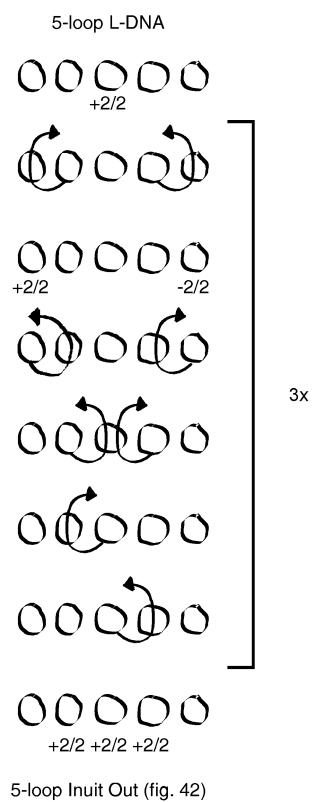


Chart 22