## ALTERING THE LOOM

LESSON 5: CREATING SIMPLE VARIATIONS WITH LOOM ALTERATIONS

Loom alterations constitute a fool-proof way for making variations of a parent figure. As long as essential features of a loom are conserved, additional loops and/or twists almost always add complexity and richness to the final design. For the North American Net Loom (Opening A), essential features include: (1) the presence of one or more loops on each thumb, index, and little finger, and (2) the presence of transverse or "straight-across" near thumb and far little finger strings.

As in the Ten Men System, altered looms are easily created by rotating loops or by doubling them using the *Katilluik* maneuver (figures like 'Five-Pointed Star' utilize both techniques, see Murphy 1998:193-194). In my notational system, +1/2 indicates a half-turn rotation away from you whereas -1/2 indicates a half-turn rotation towards you. Likewise, +2/2 indicates a full rotation away from you whereas -2/2 indicates a full rotation towards you. 0 is used to indicate no rotation at all.

Full-turn rotations are easily accomplished by tracing out a circle with the tip of your finger, avoiding adjacent loops. Half-turn rotations are best accomplished using two transfers (a method i call "rolling"). For example, to accomplish a +1/2 rotation of the index loop, first transfer the index loop to the thumb, inserting the thumb *from below*, then retransfer this loop to the index, inserting the index *from above*. To accomplish a -1/2 rotation do the same, but reverse *from above* and *from below*. Rolling avoids the awkwardness of having to use the opposite hand to lift a loop off a finger, twist it, and reset it. Full rotations can also be accomplished by rolling (i.e., by using four transfers to combine two half-turn rotations).

For practice try the following figure: Opening A, rotate thumb loop +2/2, rotate index loop -1/2, rotate little finger loop +2/2, then make the 'Inuit Net' from the beginning, as if you had Opening A on your hands. The result is shown in fig. 8.



**Fig. 8 -** *Inuit Net variation made by twisting loom loops*

To tabulate the outcome of all possible combinations (-2/2, -1/2, 0, +1/2, +2/2) for each of the three loops of our loom, one would need three matrices (fig. 9). Note, however, that half-rotations of the thumb and little finger loops are not permitted since they alter the position of the transverse strings that eventually become frame lines of the final design. Students should therefore place an 'X' in these rows and columns.
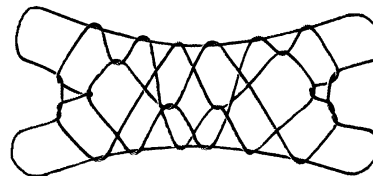
**Little Finger**

| Index \ | +2/2 | +1/2 | 0 | -1/2 | -2/2 |
|---|---|---|---|---|---|
| +2/2 | | X | | X | |
| +1/2 | | X | | X | |
| 0 | | X | | X | |
| -1/2 | | X | | X | |
| -2/2 | | X | | X | |

Thumb: 0

**Thumb**

| Little Finger \ | +2/2 | +1/2 | 0 | -1/2 | -2/2 |
|---|---|---|---|---|---|
| +2/2 | | X | | X | |
| +1/2 | X | X | X | X | X |
| 0 | | X | | X | |
| -1/2 | X | X | X | X | X |
| -2/2 | | X | | X | |

Index: 0

**Index**

| Thumb \ | +2/2 | +1/2 | 0 | -1/2 | -2/2 |
|---|---|---|---|---|---|
| +2/2 | | | | | |
| +1/2 | X | X | X | X | X |
| 0 | | | | | |
| -1/2 | X | X | X | X | X |
| -2/2 | | | | | |

Little Finger: 0

**Fig. 9 -** *Matrices for exploring the effects of loom loop twists*

*Katilluik* is an Inuit word meaning "to share or bring together" and is useful for adding richness to a design since loops are doubled. The *Double-Katilluik Three-Loop Loom* is a very important beginning position for me, and many of my favorite patterns begin with it (see 'Murphy's Mouth' on page 195). From Opening A, a *Double Katilluik Three-Loop Loom* is set up as follows:

- Insert the right thumb, from below, into the left thumb loop and withdraw the left thumb completely, leaving two loops held loosely on the right thumb; then reinsert the left thumb, from below, into the two loops on the right thumb and extend.
- Insert the right little finger, from below and from the far side, into the left little finger loop and withdraw the left little finger completely, leaving two loops held loosely on the right little finger; then reinsert the left little finger, from below and from the far side, into the two loops on the right little finger and extend (fig. 10).
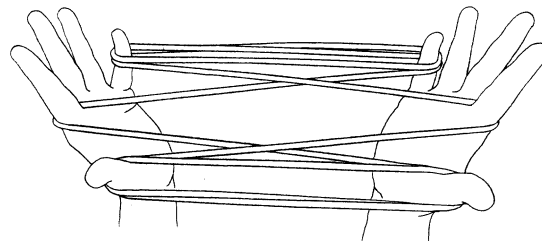


**Fig. 10 -** *Double-Katilluik Three-Loop Loom*

For practice try making the Navaho Net using a *Double-Katilluik Three-Loop Loom.* Throughout the weaving process treat each double string as if it

were a single string. The result is shown in fig. 11. In some of my more advanced creations like 'Navaho Release' and 'Murphy's Mouth' i selectively retrieve only one of the double strings during the first weave. You might wish to experiment with this modification as well.
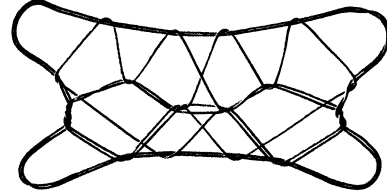
**Fig. 11 -** *Double-Katilluik Navaho Net*

There are at least two ways to double the index loops of Opening A using the *Katilluik* maneuver:

*Index Katilluik Method 1*
- Insert the left index, from below and from the far side, into the right index loop, then insert the right index, from below and from the near side, into the upper left index loop and extend (fig. 12). This creates and extra set of near and far index strings, both of which are transverse.
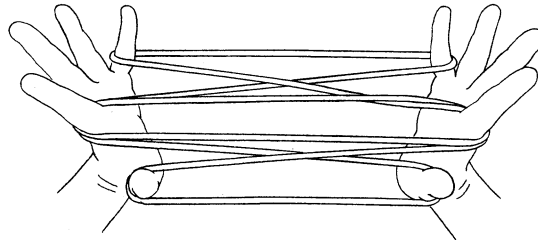
**Fig. 12 -** *Index Katilluik Loom, method 1*

*Index Katilluik Method 2*
- Transfer the thumb loop to the top of the index, then insert the left thumb, from above, into the right upper index loop and return with the right upper near index string (rotate thumb toward you and up as you retrieve the string); insert the right thumb into the left thumb loop from below and extend (fig. 13). This creates an extra set of near and far index strings which cross.
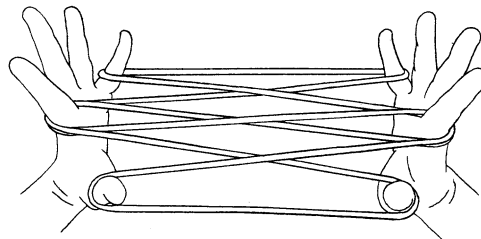
**Fig. 13 -** *Index Katilluik Loom, method 2*

For practice try making the Inuit Net using a loom in which the index loops have been doubled using Method 2. Throughout the weaving process treat the double index loop as if it were a single loop. The result is shown in fig. 14. Again, you might want to experiment by passing



**Fig. 14 -** *Index Katilluik Inuit Net*

the thumbs down through only one of the two index loops in either the First or Second Inuit Weave.
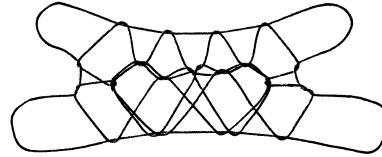
## ALTERING THE WEAVING PHASE

LESSON 6: CREATING SIMPLE VARIATIONS WITH WEAVE ALTERATIONS

*First Weave Variations*
By now my students understand how the first weaves of the Inuit, Navaho, and Klamath Nets differ. Each begins with the thumb retrieving a string, but the identity of that string (near little or far index), and the path taken by the thumb along the way (over index loop or down through it), can differ. i therefore encourage my students to explore alternative string/path combinations. There are, in fact, four different strings the thumb can retrieve (near index, far index, near little finger, far little finger) and depending on which string is selected, up to nine different pathways (i.e., when retrieving the far little finger string, the thumb can go over three strings, or under three strings, or over two and under one, etc.). For example, make the Navaho Net, but during the first weave (N-1) pass the thumb down through the index loop, under the near little finger string, and pick up the *far* lit-

tle finger string. The result is a pleasing double-walled diamond figure (fig. 15) known as 'Big Star' among the Navaho Indians (Jayne 1906:64). If you make 'Big Star' with a modified loom, you get a very pleasing figure which I have adopted as my logo. The modification creates a star with an octagonal hole in the center:
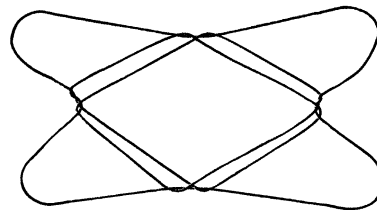


**Fig. 15 -** *Navaho 'Big Star'*

*Murphy's Logo*
•   Opening A
•   Modify the loom as follows: rotate little finger loop +2/2; rotate thumb loop +2/2
•   Alter the First Navaho Weave as follows: Pass each thumb over the near index string and under all other strings, pick up the far little finger string,

and return. With each middle finger pick up the lower far thumb string and return. Drop thumb loops and extend.

• Now finish making the Navaho Net, starting with the Second Navaho Weave (N-2). The result is 'Murphy's Logo' (fig. 16; see also fig. 49).
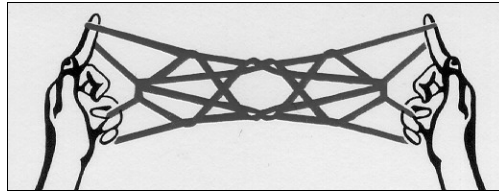


**Fig. 16 -** *Murphy's Logo*

*Second Weave Variations*

The second weave for each of the three North American Nets is the same: thumb goes down through (lower) index loop and retrieves far little finger string. Variations here are limited. If the far little finger string (a transverse string) is not retrieved, the design will collapse when extended since one of the frame lines will be missing. However the path taken by the thumb prior to retrieving the far little finger string *can* be altered. For example, make the Navaho Net, but during the second weave (N-2) pass the thumb *up through* the index loop rather than *down through* it prior to retrieving the far little finger string. The result is a pleasing design (fig. 17) known as 'A Third Owl' among the Navaho (Jayne 1906:55-56). Or, make the Navaho Net, but during the second weave pass the thumb *over* the index loop and *under* the middle and little finger loops prior to retrieving the far little finger string. The result is shown in fig. 18. This variation is used in my three-dimensional 'Navaho Release' figures (see page 193).
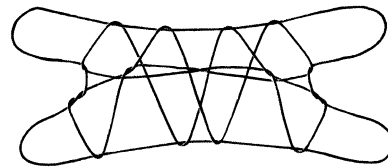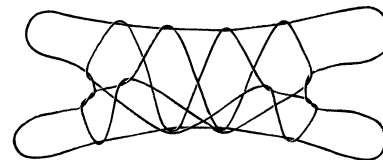


**Fig. 17 -** *Navaho 'Owl'*



**Fig. 18 -** *Navaho Net with altered second weave*

LESSON 7: REPETITIVE WEAVING AND HYBRID NETS

In addition to allowing one to examine the heart of each net, the *Continuation Move* described on page 173 serves two other purposes: it facilitates the introduction of richness by allowing repetitive weaving (as in the Ten Men

system, see Murphy 1998:165), and it facilitates switching from one net sequence to another (i.e., it allows the formation of hybrid nets)

First, let's examine its use in adding richness. Complete the first and second weave of the Inuit Net (I-1 and I-2), apply the *Continuation Move*, then make the Inuit Net from the beginning as if you had Opening A on your hands (i call this *Inuit Out*). The result is shown in fig. 19 (i particularly like the design motifs on either side of the central diamond — you'll find them in many of the complex variations i present later on). You can likewise add richness to the Navaho Net by completing the first and second weaves of the Navaho Net (N-1 and N-2), applying the *Continuation Move*, then making the Navaho Net from the beginning (fig. 20), and the same technique can be used to add richness to the Klamath Net (fig. 21). Obviously you are not limited to one repetition of the weaving sequence: Any number of continuation moves can be introduced provided your string is long enough!.
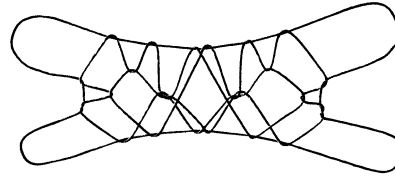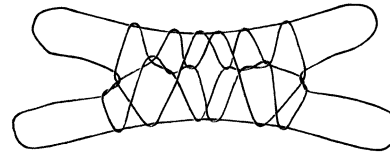


**Fig. 19 -** *I-1, I-2, CM, Inuit Out*
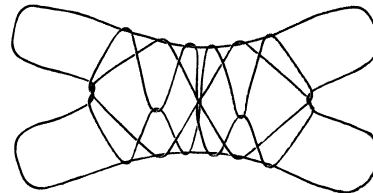


**Fig. 20 -** *N-1, N-2, CM, Navaho Out*



**Fig. 21 -** *K-1, K-2, CM, Klamath Out*

To switch from one net to another in mid-course, complete the first two weaves of any given net, apply the *Continuation Move* to obtain an Opening A-like configuration, then shift the loops around until you achieve an arrangement that allows you to *Fix the Bottom* and *Clean the Top*. Recall that for the Inuit Net, the *upper near index* and *far little finger* strings must be transverse; for the Navaho Net the *lower near thumb* and *upper far index* string must be transverse; and for the Klamath Net the *near thumb* and *far little finger* strings must be transverse. The following list should assist you. Note that for each net there are two ways to achieve the desired transverse string arrangement.

*Switching to the Navaho Net*
    *Method 1*: Apply the *Continuation Move*, transfer the little finger loop to the top of the index finger, and with each thumb pick up the upper near index string. You are now ready to *Fix the Bottom* and *Clean the Top* using the Navaho method.
    *Method 2*: Apply the *Continuation Move*, transfer the thumb loop to the top of the index (inserting the index from above), pass the thumb under the

index loops and pick up the far little finger string, drop the little finger loop, and with each thumb pick up the upper near index string. You are now ready to *Fix the Bottom* and *Clean the Top* using the Navaho method.

*Switching to the Inuit Net*
   *Method 1*: Apply the *Continuation Move*, transfer the thumb loop to the top of the index, withdraw the little finger from its loop, then reinsert the ring and little fingers into this loop from above and close them to the palm. You are now ready to *Fix the Bottom* and *Clean the Top* using the Inuit method.
   *Method 2*: Apply the *Continuation Move*, transfer the little finger loop to the top of the index, inserting the index from above, transfer the thumb loop to the ring-little fingers, inserting them from below and closing them to the palm. You are now ready to *Fix the Bottom* and *Clean the Top* using the Inuit method.

*Switching to the Klamath Net*
   *Method 1*: Transfer the little finger loop to the top of the index, inserting the index from above; transfer the thumb loop to the three lesser fingers (i.e., pass them under the index loops and insert them, from below into the thumb loop, close them over the near thumb string and withdraw the thumb), transfer the upper index loop to the thumb. You are now ready to *Fix the Bottom* and *Clean the Top* using the Klamath method.
   *Method 2*: Withdraw the little finger from its loop, then reinsert the three lesser fingers into this loop from above and close them to the palm. You are now ready to *Fix the Bottom* and *Clean the Top* using the Klamath method.

LESSON 8: SWITCHING SYSTEMS

In addition to switching from one net to another in mid-course, it's possible to switch from one *system* to another (i.e., from the Ten Men system to the North American Net system or vice-versa). Recall that in the Ten Men system, the transverse strings of the three-loop loom are the upper and lower near index strings (Murphy 1998: 163, fig. 1, step 5).

*Switching from North American Nets to a Ten Men Loom*
After completing the first two weaves of any given net and applying the *Continuation Move* to obtain a configuration that resembles Opening A, select one of the following two methods to set up the Ten Men Loom:
   *Method 1*: Transfer the little finger loop to the thumb, inserting the thumb from above (pass thumb over the index loop during the transfer); transfer the index loop to the little finger, inserting the little finger from below; transfer both thumb loops to the index fingers (simultaneously, not individually). You now have a modified Ten Men Loom.

*Method 2*: Transfer the thumb loop to the middle finger, inserting the middle finger from below (pass middle finger over the index loop during the transfer); 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; transfer the index loop to the little finger, inserting the little finger from below (pass little finger under the middle finger loop during the transfer); transfer thumb loop to the index, inserting index from below, then transfer the middle finger loop to the index, again inserting the index finger from below. You now have a modified Ten Men Loom.

*Switching from Ten Men to a North American Net Loom*
Again, there are at least two ways of doing this. After completing any number of Ten Men weaves and resetting the loom, select one of the following methods for setting up the North American Net Loom. Note that Method 1 is used in my 'Sunrise over Klamath Bridge' (see page 198).

*Method 1*: Transfer the upper index loop to the thumb, inserting the thumb from below; transfer the remaining index loop to the middle finger, inserting the middle finger from above; transfer the little finger loop to the thumb, inserting the thumb from below (pass thumb under the middle finger loop during the transfer), then retransfer this loop to the index, inserting the index from below; transfer the middle finger loop to the little finger, inserting the little finger from below. You have a modified North American Net Loom.

*Method 2*: Transfer the upper index loop to the middle finger, inserting the middle finger from above; transfer the index loop to the thumb, inserting the thumb from below; transfer the little finger loop to the thumb, inserting the thumb from below (pass thumb under the middle finger loop during the transfer), then retransfer this loop to the index, inserting the index from below; transfer the middle finger loop to the little finger, inserting the little finger from below. You now have a modified North American Net Loom.

LESSON 9: INVERSE OR RECIPROCAL WEAVES

In the Ten Men system, each of the five basic weaves (**a**, **b**, **c**, **d**, **e**) has its inverse weave (**a'**, **b'**, **c'**, **d'**, **e'**) created by 'downflipping' the string rather than picking it up from below in the normal fashion (Murphy 1998:166-167). Once a loom is established, the sequence **a**, reset loom, **a'**, reset loom (or **a'**, reset loom, **a**, reset loom) regenerates the original loom (i.e., the two weaves cancel each other). Do inverse weaves exist in the North American Net system? — Most certainly they do! From Opening A do the following:

*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 spin), and reset it on the thumb as an upper loop (fig. 22).
- 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.
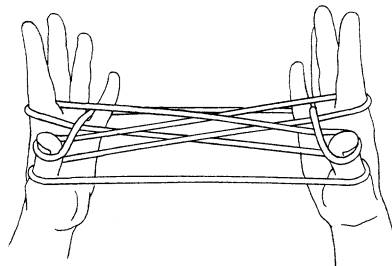- Drop both thumb loops and extend.



**Fig. 22 -** *First Inuit weave inverse, just after thumb loop rotation*

Inverses of the First Navaho Weave (N-1) and First Klamath Weave (K-1) also exist. Begin with Opening A and do the following:

*First Navaho Weave Inverse* (N-1')
- Pass each thumb away from you over the near index string and over 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 spin), and reset it on the thumb as an upper loop (fig. 23).
- Pass each middle finger toward you over both index strings and down through the upper thumb loop (again, this takes some practice since the upper loop is now very tight), then pick up the lower far thumb string and return.
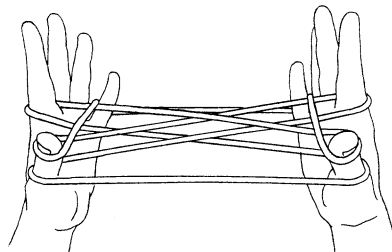- Drop both thumb loops and extend.



**Fig. 23 -** *First Navaho weave inverse, just after thumb loop rotation*

*First Klamath Weave Inverse* (K-1')
- Pass each thumb away from you *over* the near index string, pick up the far index 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 spin), and reset it on the thumb as an upper loop (fig. 24).
- Pass the tips of each index and middle finger down through the upper thumb loop and pinch between them the lower near thumb string; draw this string through the upper thumb loop and place it on the back of each index by rotating the index-middle finger pair away from you and up.
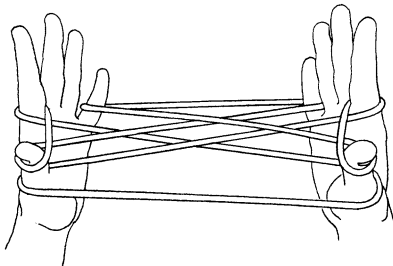- Drop both thumb loops and extend.



**Fig. 24 -** *First Klamath weave inverse, just after thumb loop rotation*

To demonstrate the inverse relationship, try the following experiment: Establish your loom (do Opening A), then complete the First Inuit Weave (I-1). You now have a loop on each index, middle finger, and little finger. To "reset the loom" transfer the middle finger loop to the thumb, inserting the thumb from below, thus generating a configuration that resembles Opening A. Now apply the inverse weave. If you now reset the loom (i.e., transfer the middle finger loop to the thumb) you should have Opening A on your hands. And because I-1 and I-1' are true inverse weaves, the sequence I-1', reset loom, I-1, reset loom also regenerates the original loom. The same thing happens with N-1 and N-1', or K-1 and K-1' performed in either order — the two weaves cancel, thus restoring Opening A.

Now practice using the inverse weaves as a means of adding richness: Make the Inuit Net but replace the first weave with its inverse (I-1'). The result is shown in fig. 25. Now try the following combination: Do Opening A, First Inuit Weave Inverse (I-1') and Second Inuit Weave (I-2); apply the *Continuation Move*, then make the Inuit Net from the beginning, as if you had Opening A on your hands. The result is shown in fig. 26. Note that by introducing the second weave and *Continuation Move* between the two reciprocal weaves, the cancellation is forestalled (in my Ten Men system universe weaves produce the same effect, see Murphy 1998:172-176).
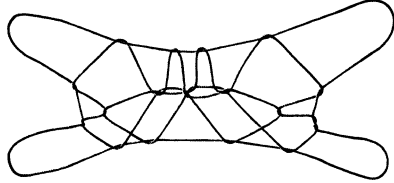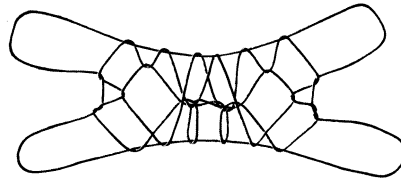
**Fig. 25 -** *Inuit Net with I-1' weave*



**Fig. 26 -** *I-1', I-2, CM, Inuit Out*

As in the Ten Men system, each weave also has its *anti-inverse* counterpart (notated using a double-prime), the only difference being the direction in which the upper thumb loop is rotated prior to resetting it on the thumb (i.e., +1/2 rather than -1/2). As a design tool an anti-inverse weave is useful for introducing a running half-hitch into the figure. As an example, make the Navaho Net but replace the first weave (N-1) with its anti-inverse (N-1"). The result is shown in fig. 27.
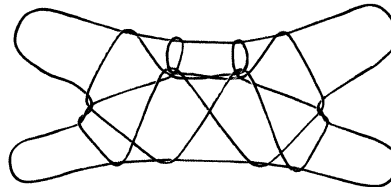


**Fig. 27 -** *Navaho Net with N-1" weave*

LESSON 10: ROLLING A FIGURE

Rolling is a technique for "turning over" a loom or a partially completed figure so that the underside can be manipulated. A crude way to "turn over" Opening A would be to lay the figure on your lap, fingers pointing down, release all loops, then reinsert the fingers from below (i.e., insert the thumb into the former little finger loop, the index into the former index loop — but from the opposite side — and the little finger into the former thumb loop). This achieves a +1/2 rotation of the entire figure (assuming that the axis of rotation is a line connecting the knuckle of each index finger). A much more elegant way of doing this is as follows:

- Transfer the thumb loop to the middle finger, inserting the middle finger from above (this introduces a +1/2 spin).
- 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 spin).
- 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 spin). The entire figure has now been rotated a half turn away from you.
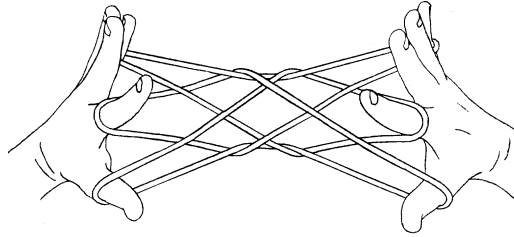
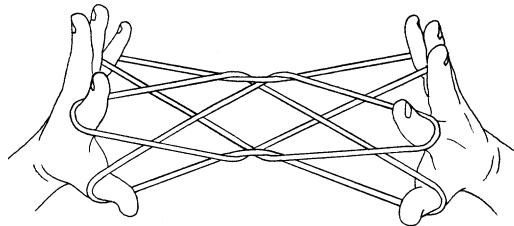**Fig. 28 -** *I-1, I-2, CM, before rolling*



**Fig. 29 -** *I-1, I-2, CM, after rolling*

Weaving the Inuit Net from a rolled version of Opening A is not very excit-ing — two string crossings in the center of the final pattern will differ. But when applied to a partially woven version of the Inuit Net (one that resem-bles Opening A), the effect is quite dramatic. For practice try the following: Do Opening A, the First and Second Inuit Weaves, and the *Continuation Move* (you now have something that resembles Opening A, fig. 28); next, *roll the entire figure* as described above so that the underside is now facing upward (fig. 29), then make the Inuit Net from the beginning, as if you had Opening A on your hands. The result is shown in fig. 30. Rolling is an important technique to master — i use it extensively in some of my higher order creations (see 'Inuit Bridge' on page 190).
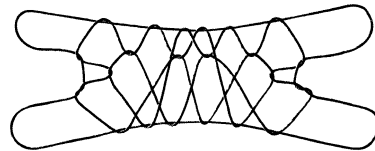


**Fig. 30 -** *I-1, I-2, CM, roll, Inuit Out*

LESSON 11: THE ITERATION MOVE (IM)

The *Iteration Move* is hybrid move — a cross between the *Continuation Move* and *Rolling*. Like rolling, it inverts a partially completed figure so that the underside can be manipulated. But unlike rolling, the partially completed figure need not resemble Opening A. In fact, it is best applied just after com-pleting the first weave of a North American Net:

*Iteration Move* (performed just after I-1, N-1, or K-1 or their primes)

- Pass each thumb away from you under all the strings, pick up the far little finger string, and return; drop the little finger loop (this transfers the little finger loop to the thumb and introduces a +1/2 spin).
- Transfer the middle finger loop (or upper index loop if you started with K-1) to the thumb (over the index loop), inserting the thumb from below, then retransfer this loop to the little finger, inserting the little finger from above (this move shifts the middle finger loop to the little finger while simultaneously introducing a +1/2 spin).
- 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 spin). The entire figure has now been rotated a half turn away from you.

As an exercise try the following: Do Opening A, followed by the first weave of the Klamath Net (K-1), and apply the *Iteration Move.* Now make the Klamath Net from the beginning, as if you had Opening A on your hands. The result is shown in fig. 31. The *Iteration Move* is used extensively in a figure i call 'Cherokee Seven Stars' (see page 192).
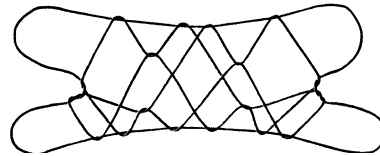


**Fig. 31 -** *K-1, IM, Klamath Out*

## ALTERING THE FINISHING PHASE

LESSON 12: NAVAHO NET VARIATIONS IN JAYNE'S BOOK

i haven't experimented much with altering the *Finishing Phase* ('Fixing the Bottom' and 'Cleaning the Top'). My 'Navaho Release' series of figures (page 193) is a preliminary attempt at doing so. However, there are many examples in Jayne's book of Navaho Nets in which the *Finishing Phase* has been altered. Examples include 'Seven Stars' (Jayne 1962:56-58), 'Two Horned Star' (Jayne 1962:58-60), and 'Two Coyotes' (Jayne 1962:60-63), a figure which also employs a modified Second Navaho Weave (N-2). Of the remaining Navaho Net variations in her book, 'An Owl' (Jayne 1962: 53-54) and 'A Second Owl' (Jayne 1962:54-55) both employ altered looms. An altered Second Navaho Weave (N-2) is used in 'A Third Owl' (Jayne 1962:55-56). In 'Big Star' (Jayne 1962:64), the First Navaho Weave (N-1) is altered, and in 'North Star' (Jayne 1962:65), part 1 of the First Navaho Weave is omitted. In the last variation, 'Carrying Wood' (Jayne 1962:66-69), the First and Second Navaho Weaves (N-1 and N-2) are omitted.

## ALTERING THE EXTENSION PHASE

LESSON 13: MASTERING THE POWER LIFT AND OTHER EXTENSIONS

Most two-weave patterns of the North American Net family are easy to extend. However, many higher order patterns in which the two-weave sequence has been iterated a number of times, will tend to collapse in the center. To help open up the design and reveal its inner complexity i encourage my students to use a long thin string combined with one of three alternative endings: the *Power Lift*, the *Two Diamonds Ending*, or the *Caroline Extension*.

*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 North American Net figure:

- 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 lays 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). See fig. 32.
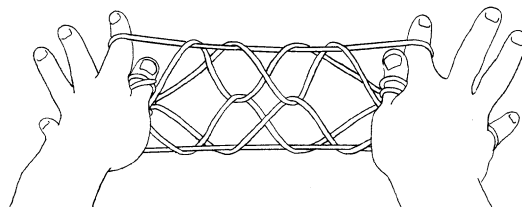


**Fig. 32 -** *The Power Lift applied to the Klamath Net*

*Two Diamonds Ending*
- After *Cleaning the Top* and extending the figure, straighten each little finger and bring it towards you, under the index loop. Transfer the little finger loop to the thumb, inserting the thumb from below.
- Transfer the index loop to the little finger, inserting the little finger *from above* (this inverts the loop).

- Transfer the thumb loop to the index finger, inserting the index finger from below. The figure now lays flat between your hands.
- Now do movements three, four, five, and six of Jayne's 'Osage Two Diamonds' (1962:28-30). These steps are also illustrated in my first article (Murphy 1997:58, fig. 1, illustrations D through L). The extension is on thumbs and indices, with palms facing away from you (fig. 33).
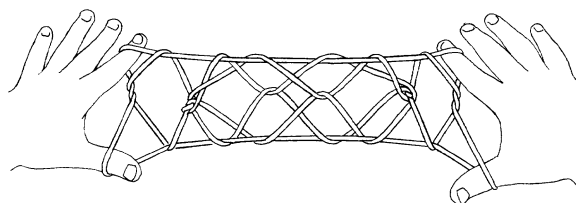


**Fig. 33 -** *The Two Diamonds Ending applied to the Klamath Net*

*Caroline Extension*
- 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 loops.
- Gently release each little finger loop and reinsert the little finger from the opposite side.
- With the tip of each index pick up the 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 (fig. 34).
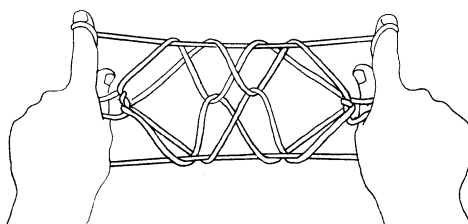


**Fig. 34 -** *The Caroline Extension applied to the Klamath Net*

*Two Diamonds Ending* plus *Power Lift*:
- After completing the *Two Diamonds Ending*, transfer the thumb loop to the little finger by passing each little finger under the index loop, picking up the near thumb string, and releasing the thumb loop.
- Transfer the index loop to the thumb, inserting the thumb from below. The figure now lays flat between your hands.
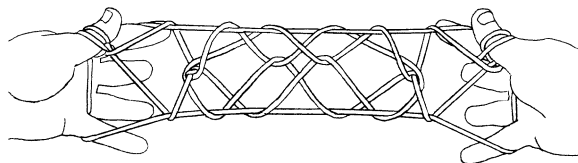- Finish by doing the last three moves of the *Power Lift* (fig. 35).

**Fig. 35 -** *The Two Diamonds Ending plus Power Lift applied to the Klamath Net*

## ADVANCED NORTH AMERICAN NET VARIATIONS

The following advanced figures are not difficult once you have mastered the basic figures and the weaving techniques outlined in Lessons 1 through 13. Since many of the weaving sequences are quite long and repetitive, the most difficult aspect of making these figures is keeping track of where you are in the sequence. To overcome this difficulty i teach my students how to condense a long sequence into a concise mathematical formula using abbreviations that are meaningful to them. This also teaches them how to think in abstract terms. Examples are provided below.

   All of these figures require a loop made from a two- or three-span string (a span being the distance between your fingertips when your arms are fully extended in opposite directions). You will need to use the *Power Lift* or the *Caroline Extension* to effectively display the finished design. One figure ('Murphy's Mouth') requires the *Two-Diamond Ending* followed by the *Power Lift*. Also essential is a string capable of generating some friction (100% nylon is too slippery). Cotton in all its guises is a favorite.

   The term *Inuit Out* means "make the Inuit Net from the beginning, as if you had Opening A on your hands." *Navaho Out* and *Klamath Out* are similarly defined. The illustrations show how the figure looks when pinned to a board (i.e., the finger loops have been untwisted to facilitate mounting).

*Inuit Bridge* (fig. 36)
This figure features a gently curving arch embedded in a mesh-like array of diamonds, hence the name. The sequence for this figure is:

- Opening A
- First and Second Inuit Weaves
- Continuation Move
- Roll the figure
- First and Second Inuit Weaves
- Continuation Move
- Roll the figure
- First and Second Inuit Weaves
- Continuation Move

- Roll the figure
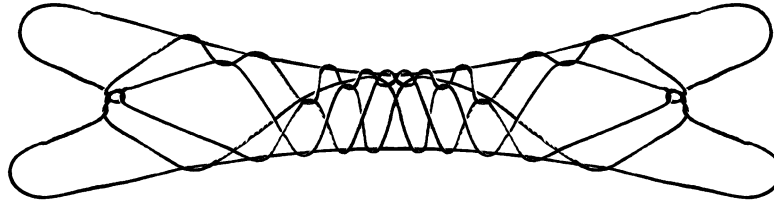- Inuit Out
- Power Lift or Caroline Extension



**Fig. 36 -** *Inuit Bridge*

As written, the instructions are hard to follow — you will probably lose your place if you try to read and weave at the same time. But when the sequence is expressed as a formula or equation, the figure is much easier to make. The formula for this figure, when written out in full, is:

Opening A, I-1, I-2, CM, Roll, I-1, I-2, CM, Roll, I-1, I-2, CM, Roll, Inuit Out, Power Lift or Caroline Extension

If we now place the repetitive sequence in brackets, and use a superscript number to indicate how many times to repeat it, the formula becomes:

Opening A, $[\text{I-1, I-2, CM, Roll}]^3$, Inuit Out, Power Lift or Caroline Extension

Try making the figure from the formula and you will no doubt succeed much more rapidly! A matrix for creating 'Bridge' variations is presented in the Appendix.

*Inuit Bowl* (fig. 37)
This is merely an inverted form of the *Inuit Bridge*, made by inserting an extra roll between the *Inuit Out* and *Power Lift* moves.
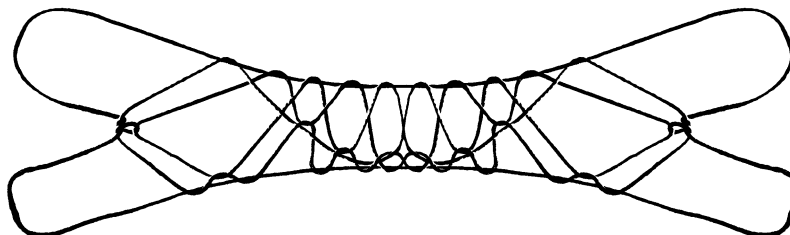


**Fig. 37 -** *Inuit Bowl*

*Inuit Diamonds* (fig. 38)

This is a simple variation of *Inuit Bridge*, the only difference being the addition of an index loop rotation at the end of the repeating unit (full turn away from you). Since rolling the figure requires a +1/2 rotation of the index loop, the extra +2/2 rotation results in a +3/2 rotation of the index loop between repetitive units. The formula for this figure is:

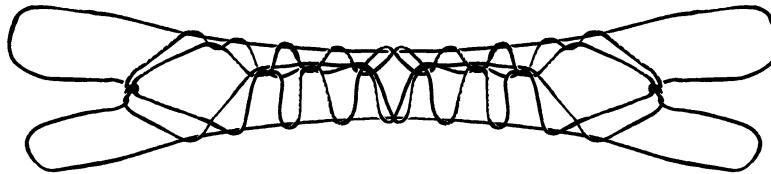Opening A, [I-1, I-2, CM, Roll, rotate index loop +2/2]$^3$, Inuit Out, Power Lift or Caroline Extension.



**Fig. 38 -** *Inuit Diamonds*

*Cherokee Seven Stars* (fig. 39)

In my Ten Men system i prevented reciprocal weaves (**a a'**) from cancelling by inserting a Universe move between them (**a Aa'**). In the North American Net system you can frustrate the reciprocal weave relationship by rotating the figure on your hands between the first weave (I-1, for example) and its inverse (I-1'). This procedural idea leads to some very interesting designs, one of which i call 'Cherokee Seven Stars' (since i am half Cherokee!).

After one repetition of the sequence a star with an octagonal hole is formed in the center of the design. Each subsequent repetition adds two stars with hexagonal centers. So to form seven stars you need to do the repetitive sequence four times. i stop at seven for symbolic reasons: among the Cherokee, it is customary to consider the welfare of the next seven generations in all the decisions we make. The formula for this figure is:

Opening A, [I-1, IM, I-1', IM, rotate index loop +2/2]$^4$, Inuit Out, Power Lift or Caroline Extension.
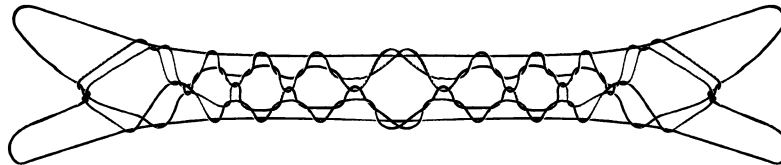


**Fig. 39 -** *Cherokee Seven Stars*

Again, be aware that the *Iteration Move* (IM) ends with a +1/2 rotation of the index loop. When combined with the +2/2 rotation that follows, the net effect is a +3/2 rotation of the index loop between the repetitive units. A matrix for creating 'Cherokee Star' variations is presented in the Appendix.

ALTERED LOOM VARIATIONS

The following series of figures is a sample of what you can do with looms that have been modified using the *Katilluik* maneuver as a means of doubling selected loops. Since the doubled loop has a transverse string *and* a non-transverse string on the near (or far) side, it is interesting to see what happens when only one of the two strings is selected for weaving.

*Navaho Release* (fig. 40)
One of my students discovered this figure by accident when a loop slipped off his index finger. I call it a "release" because the center dissolves during the final extension.
- Opening A
- Katilliuk the thumb loops, then Katilluik the little finger loops to form the Double Katilluik Three-Loop Loom.
- First Navaho Weave (N-1), picking up only the *non-transverse* near little finger string in part 1 of the weave (in part 2 pick up *both* far thumb strings).
- Do an altered Second Navaho Weave: Pass each thumb away from you over the near index string *and the far index string* and under all other strings, then pick up the (double) far little finger string and return.
- Continuation Move
- First Navaho Weave (N-1), picking up only the *non-transverse* near little finger string in part 1 of the weave (in part 2 pick up *both* far thumb strings).
- Do an altered Second Navaho Weave: Pass each thumb away from you over the near index string *and the far index string* and under all other strings, then pick up the (double) far little finger string and return.
- Drop the index loop, then insert the index, from below, into the double middle finger loop and separate the two fingers as far as possible to extend the figure in three dimensions (you don't need a Power Lift or Caroline Extension to display this figure). The formula for this figure is:

Opening A, Katilluik thumb and little, [N-1 (non-tv only), N-2 (over near and far index), CM][1], N-1 (non-tv only), N-2 (over near and far index), drop index, widen middle finger loop with index.

**Fig. 40 -** *Navaho Release*

*Navaho Cage* (fig. 41)

Same as *Navaho Release*, but start with a 'Left DNA Opening' (Murphy 1998:196) rather than Opening A. In the final extension, when you drop the index loop, the center will "catch" rather than dissolve, and produce a nice three-dimensional figure with four frame lines. The formula for this figure is:

Left DNA Opening, Katilluik thumb and little, [N-1 (non-tv only), N-2 (over near and far index), CM][1], N-1 (non-tv only), N-2 (over near and far index), drop index, widen middle finger loop with index.
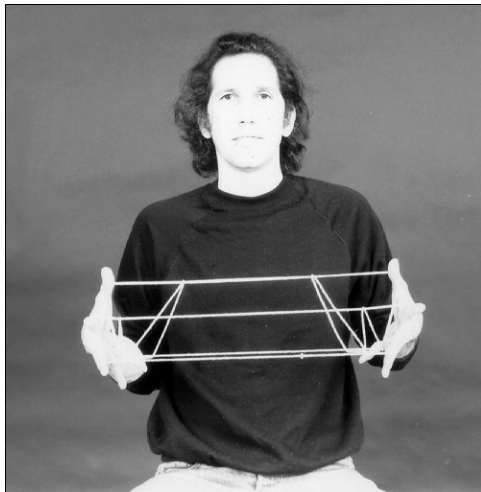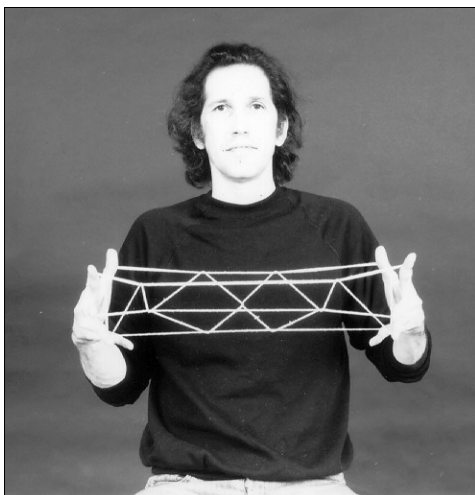


**Fig. 41 -** *Left DNA Navaho Cage*

*Murphy's Mouth* (fig. 42).

This figure is my daughter's favorite, largely because it is animated. It is a hybrid figure that combines elements of the 'Navaho Release' figure and 'Cherokee Seven Stars.' Two anti-inverse Navaho weaves are used as finishing moves to introduce half-hitches into the design. The half-hitches act as pulleys that allow the mouth to open and close.

- Opening A
- Katilliuk the thumb loops, then Katilluik the little finger loops to form the Double Katilluik Three-Loop Loom.
- First Inuit Weave (I-1), picking up only the *non-transverse* near little finger string in part 1 of the weave (in part 2 pick up *both* far thumb strings).
- Iteration Move
- First Inuit Weave Inverse (I-1'), picking up only the *non-transverse* near little finger string in part 1 of the weave (in part 2 pick up *both* far thumb strings).
- Iteration Move
- First Inuit Weave (I-1), picking up only the *non-transverse* near little finger string in part 1 of the weave (in part 2 pick up *both* far thumb strings).
- Iteration Move
- First Inuit Weave Inverse (I-1'), picking up only the *non-transverse* near little finger string in part 1 of the weave (in part 2 pick up *both* far thumb strings).
- Iteration Move
- First Navaho Weave Anti-Inverse (N-1"), picking up only the *non-transverse* near little finger string in part 1 of the weave (in part 2 pick up *both* far thumb strings).
- Do an altered Second Navaho Weave: Pass each thumb away from you over the near index string *and the far index string* and under all other strings, then pick up the (double) far little finger string and return.
- Continuation Move
- First Navaho Weave Anti-Inverse, picking up only the *non-transverse* near little finger string in part 1 of the weave (in part 2 pick up *both* far thumb strings).
- Do an altered Second Navaho Weave: Pass each thumb away from you over the near index string *and the far index string* and under all other strings, then pick up the (double) far little finger string and return.
- Drop the index loop, then insert the index, from below, into the double middle finger loop and separate the two fingers as far as possible to extend the figure in three dimensions.
- Drop thumb loop.
- Withdraw the middle finger from the loop surrounding the index and middle finger. You now have a loop on each index and each little finger.

- Now do movements three, four, five, and six of Jayne's 'Osage Two Diamonds' (1962:28-30). These steps are also illustrated in my first article (Murphy 1997:58, fig. 1, illustrations D through L). The extension is on thumbs and indices, with palms facing away from you (fig. 42).
- After completing the *Two Diamonds Ending*, transfer the thumb loop to the little finger by passing each little finger under the index loop, picking up the near thumb string, and releasing the thumb loop.
- Transfer the index loop to the thumb, inserting the thumb from below. The figure now lays flat between your hands.
- Now proceed with the *Power Lift*: 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, lifting the string over the upper thumb loop as you straighten the index and middle fingers.
- This completes 'Murphy's Mouth.' In the center you should have a "hole" with a row of diamonds above and below. The diamonds represent teeth. To expand and contract the central design (i.e., to see the mouth "chew"), repeatedly separate the indices and little fingers as far as possible while pushing the thumbs toward the center of the figure (two ringlets tightly encircle each thumb). The formula for this figure is:

Opening A, Katilluik thumb and little, [I-1 (non-tv only), IM, I-1' (non-tv only), IM]$^2$, N-1" (non-tv only), N-2 (over near and far index), CM, N-1" (non-tv only), N-2 (over near and far index), drop index, widen middle finger loop with index to create 3D figure, drop thumb, withdraw middle finger, Two Diamonds Ending, Power Lift.
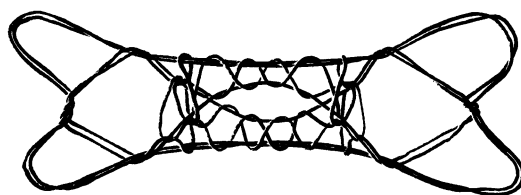


**Fig. 42 -** *Murphy's Mouth*

HYBRID OR CROSS-SYSTEM VARIATIONS

The following are hybrid figures that begin in the Ten Men system and end in the North American Net system.

*Double-Arch Bridge* (fig. 43)

This figure combines the basic Ten Men figure with the Inuit Bridge.

- Ten Men Loom
- In the Ten Men System, do the following two weaves: **a a**
- Switch to the North American Net System using Method 1 (see page 182).
- Roll the figure
- Now make the *Inuit Bridge* (*Bridge*, not *Net*!) from the beginning, as if you had Opening A on your hands. The formula for this figure is:

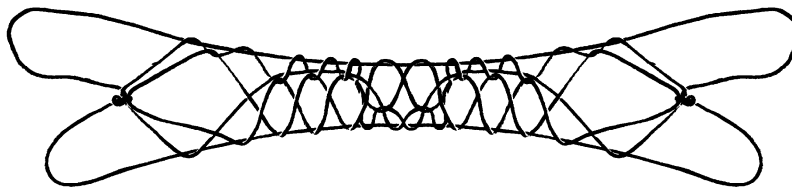    Opening A, Ten Men Loom, **a a**, switch to Net System, Roll, Inuit Bridge Out.



**Fig. 43 -** *Double Arch Bridge*

*Klamath Bridge* (fig. 44)

This figure starts with an altered Ten Men Loom and ends with a Klamath Net. Three simple Ten Men weaves are incorporated.

- Ten Men Loom
- Katilluik the upper and the lower index loops (Murphy 1998:178) to give a Double Katilluik Ten Men Loom.
- In the Ten Men System, do the following three weaves: **a a c**
- Switch to the North American Net System using Method 1 (see page 182).
- Now make the Klamath Net from the beginning, as if you had Opening A on your hands. (Interesting fact: as you complete the first Klamath weave, you should notice a "release" or "reduction of complexity" in the figure that was created by doing the **c** weave). The formula for this figure is:
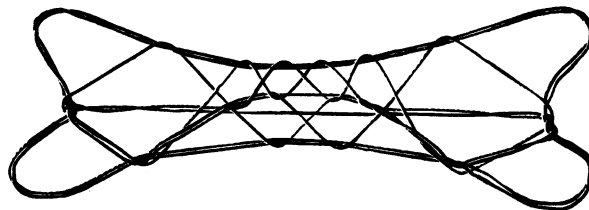


**Fig. 44 -** *Klamath Bridge*

Opening A, Double Katilluik Ten Men Loom, **a a c**, switch to Net System, Klamath Out.

*Sunrise over Klamath Bridge* (fig. 45)
Same as *Klamath Bridge*, but with additional modifications made to the loom so that a small upright loop hovers above the finished pattern. A string capable of generating some friction is essential:

- Ten Men Loom
- Katilluik the upper and the lower index loops (Murphy 1998:178) to give a Double Katilluik Ten Men Loom.
- Continue to alter your Ten Men Loom as follows: Do an **opening 6** weave (Murphy 1998:179), downflipping only the *non-transverse* far lower index string. Recall that the **opening 6** move is like doing a **b'** weave on the lower index loop rather than the little finger loop.
- As a final loom alteration, do an **opening 3** weave (Murphy 1998:179), picking up the *transverse* far lower index string only (recall that an **opening 3** move is like doing a **b** weave on the lower index loop rather than the little finger loop). Also, when retrieving the transverse string, make sure each thumb passes *over* the non-transverse far lower index string (i.e., the single string that wraps around the double upper index loop). This ensures a dramatic "sunrise."
- Now you are ready to weave. Do the **a a c** weaving sequence, as in *Klamath Bridge*.
- Switch to the North American Net system using Method 1 (see page 182).
- Now make the Klamath Net from the beginning, as if you had Opening A on your hands. As you extend the figure waggle the hands: a small upright loop representing the sun should appear just above the upper frame line of the figure. The formula for this figure is:

Opening A, Double Katilluik Ten Men Loom, **opening 6** (non-tv only), **opening 3** (tv only, over non-tv), **a a c**, switch to Net System, Klamath Out, waggle.
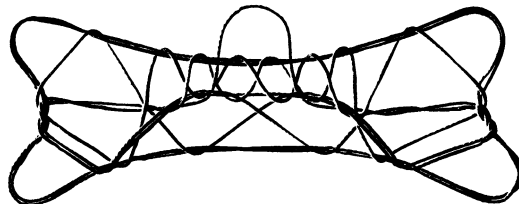


**Fig. 45 -** *Sunrise over Klamath Bridge*

## WEAVING WITH A TWO-COLOR LOOP

Recently i've introduced my students to the concept of weaving with a two-color loop (see Murphy 1997:69-73). Since the basic North American Net loom has three loops, you need a "hexagonal" two-color loop (i.e., a six-segment loop with 60º arcs that alternate in color, see fig. 46). You can make such a loop by purchasing two different colors of nylon string, cutting six segments of equal length (three of each color), and fusing the segments using a candle flame.



**Fig. 46 -** *Hexagonal loop*



**Fig. 47 -** *Opening A with two-color loop*

Once made, form the loom (Opening A) and arrange it so that the string changes color as it winds around each finger (fig. 47). Then weave the Inuit Net or a variation of it. The result is quite surprising! The colors segregate so that the upper half of the design is one color and the lower half is another color (fig. 48). Also try arranging the loom so that the color changes occur midway between the hands. Can you guess what happens to the final design?



**Fig. 48 -** *Inuit Net woven with a hexagonal two-color loop*

One final note: if you're making a Net figure that starts with a loom in which the index loops have been Katilluiked, you'll need an octagon loop (i.e., an eight-segment loop with alternating 45º arcs). For figures beginning with a Double-Katilluik Loom (thumb and little finger loops doubled), you'll need a decagon loop (i.e., a ten-segment loop with alternating 36º arcs).

## DISCUSSION AND SUMMARY

There seems to me to be several interlocking problems which overwhelm American students in their confrontation with mathematics. I am speaking of the problem students, of course. These might fall into the following categories:

1. Fear of complexity and a consequent blockage of *any* instruction.
2. A firm rooted idea that math doesn't pertain to anything which the student is interested in — that math is a thing in itself and thus of little interest.

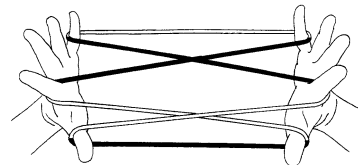3. A boredom with the seeming arbitrary nature of the problems presented in class and assigned as homework.
4. A very real and debilitating fear of being wrong, especially on tests.
5. The abysmally written texts (with rare exception).
6. The unfortunate disuniformity of the approach of disparate teachers and their quite striking differences of conceptualization of the math process. A corollary would be the incredible range of strategies employed by the students within a single class to ideate math processes and the insensitivity to this fact by many math teachers. All teachers need to remind themselves to rethink how things appeared to them before they learned them.
7. The very nature of the caste system implied by class nomenclature (honors versus regular versus remedial).
8. The inadequacy of the diagnosis of students who are at risk within a time frame which would permit meaningful intervention. Oftentimes a history of failure and an attitudinal fixing of negative self-worth occurs before problem students can be identified.
9. The inadequacy of the tutoring program for students who self-identify as needing help.
10. The tragic decline in the adequacy of mathematical preparation of our students from the lower grades. This is almost criminal in nature. Not only are almost all of our students much less able to cope with the level of work supposedly acceptable in a high school, but there is an indifference on the part of the feeder schools to even help us in sorting out the levels of inadequacy we are inheriting.

All of the above is a rather long-winded way of introducing my argument for restructuring some of the mathematics instruction we inflict upon ourselves and our students. i feel we should experiment with intervention at the beginning of the math experience we offer, especially to our at-risk population. The following points should be kept in mind as emphases:

a. There should be repetitive exercises of manual manipulation in an open-ended system of competence; i.e., one is not graded on getting the right answer, but rather, one is graded on developing unique abilities within a complex matrix of possibilities.
b. Peer interaction is encouraged.
c. There should be an ongoing discussion of the relevance of success caused by continuous effort, interest, building on success, and accepting errors as necessary steps in the learning process.
d. An effort to relate these concerns to other intellectual and artistic pursuits.

In my opinion, string figures are capable of integrating all of the above. The

first lesson i learned from my students when i started teaching string figures as math was that students will readily invent their own string figures, and will readily teach them to others if given the opportunity — an act which instantly builds confidence and topples learning barriers. That i had planned on and encouraged by the way i structured the course i teach, but what i had not anticipated, and which still surprises me is when one of them will come up with an entirely new framework of doing string figures. They figure out, or stumble upon, or have a vision which results in a new way of doing string figures. And then almost immediately everyone else in the class, including myself, learns this new method and it becomes part of the growing expertise we string figurers share with each other.

Students who have attended my class in string figures were given only one rule: they had to do string figures throughout each and every class session. They didn't have to master any body of knowledge or list of particular figures to be graded on. They merely had to learn a few basic figures, then learn to alter them in a systematic fashion. And all (!) my students learned how to make them, and all (!) were surprised at how easy it became for them, at how it made them feel, and at how it made them think in different ways. They began to open themselves up to the information they were experiencing and began to process it in a more efficient style. They learned how to learn.

I wrote a poem many years ago about this subject of learning. It was one of my "mathematical" poems, so called because it has a very rigid form. It is a seven word sequence repeated three times. I offer it here as a closing statement:


    learn how to
    learn how to
    learn

    learn how to learn
    how to learn

    learn how
    to learn how
    to learn


*inoli*

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## ACKNOWLEDGMENT

**Fig. 49 -** *James Murphy with 'Murphy's Logo'*

## APPENDIX — ADVANCED MATH TOPICS

GENERALIZED FORMULAS

Formulas provide a convenient way to visualize highly repetitive weaving sequences. They can also serve as a stepping stone for creating hybrid figures and higher order variations. But before doing so the formula must be generalized or reduced down to its essence. A generalized formula for figures in the *Inuit Bridge* family would be:

Opening A, $[\text{X-1}^p, \text{X-2, CM, Roll}]^n$, Inuit Out, Power Lift or Caroline Extension

where X = I (Inuit), or N (Navaho), or K (Klamath); p = 0 (the basic weave), or ' (the inverse weave); and n = 1, or 2, or 3, etc.

The variables X and p affect the design itself, whereas n affects the design's complexity (limited only by the length of your string). For example, setting n = 4 adds complexity to the basic 'Inuit Bridge' figure, as seen in fig. 50:

Opening A, $[\text{I-1, I-2, CM, Roll}]^4$, Inuit Out, Power Lift or Caroline Extension



**Fig. 50 -** *Inuit Bridge with n = 4*

The corresponding 'Inuit Bowl' is shown on the title page of this article.

Next, try altering X and n. For example, try X = N, p = 0, and n = 4:

Opening A, $[\text{N-1, N-2, CM, Roll}]^4$, Inuit Out, Power Lift or Caroline Extension

The result is shown in fig. 51. When compared to the 'Inuit Bridge,' you will note that the design is different (the arch breaks in the middle, being interrupted by a diamond), and the arches are longer.
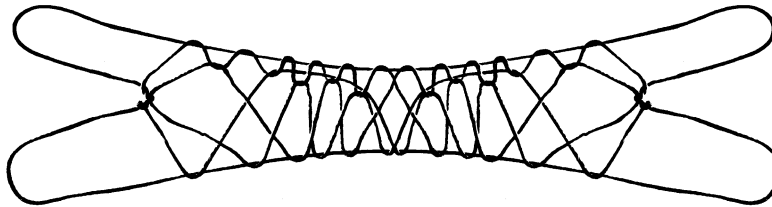


**Fig. 51 -** *Bridge with X = N, p = 0, and n = 4*

Next, try using the inverse weave (p = ')

Opening A, [N-1', N-2, CM, Roll]$^4$, Inuit Out, Power Lift or Caroline Extension

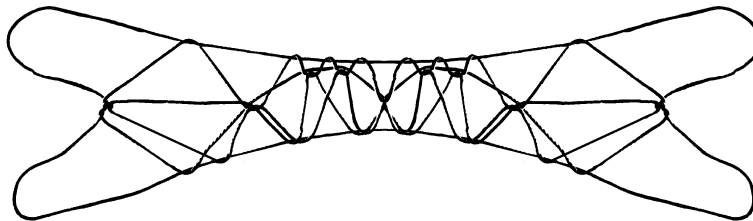The result, shown in fig. 52, is very different when compared to the non-prime version (p = 0).



**Fig. 52 -** *Bridge with X = N, p = ', and n = 4*

To examine the effects of the various weaves, try making the following six bridges:

    X = I     p = 0     n = 4
    X = I     p = '     n = 4
    X = N     p = 0     n = 4
    X = N     p = '     n = 4
    X = K     p = 0     n = 4
    X = K     p = '     n = 4

Of course you can also set p = " (the anti-inverse weave), but doing so incorporates a series of half-hitches into the design which make it difficult to manipulate and extend.

To add another level of complexity, try alternating various weaving units as you build the bridge. For example, during the first and third repetitions, do I-1', I-2, but during the second and fourth repetitions do K-1, K-2. The result is shown in fig. 53.
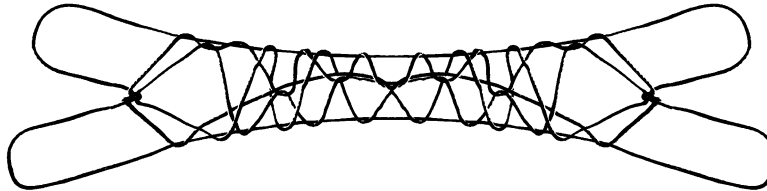


**Fig. 53 -** *Bridge with X = I and p = ' alternating with X = K and p = 0  (n = 4)*

A matrix would allow you to explore all possible combinations in this series (fig. 54):

**Second and Fourth Repetitions**

|  | I-1, I-2 | I-1', I-2 | N-1, N-2 | N-1', N-2 | K-1, K-2 | K-1', K-2 |
|---|---|---|---|---|---|---|
| I-1, I-2 |  |  |  |  |  |  |
| I-1', I-2 |  |  |  |  |  |  |
| N-1, N-2 |  |  |  |  |  |  |
| N-1', N-2 |  |  |  |  |  |  |
| K-1, K-2 |  |  |  |  |  |  |
| K-1', K-2 |  |  |  |  |  |  |

**First and Third Repetitions**

**Fig. 54 -** *Matrix for exploring bridge variations with alternating sets of weaves*

The formula for 'Cherokee Seven Stars' can also be generalized:

Opening A, [X-1$^p$, IM, Y-1$^q$, IM, rotate index loop +2/2]$^n$, Inuit Out, Power Lift or Caroline Extension.

where X = I (Inuit), or N (Navaho), or K (Klamath); Y = I (Inuit), or N (Navaho), or K (Klamath); p = 0 (the basic weave), or ' (the inverse weave); q = 0 (the basic weave), or ' (the inverse weave); and n = 1, or 2, or 3, etc.

When X = I, Y = I p = 0, q = ', and n = 4 you have 'Cherokee Seven Stars,' but by changing n, any odd number of stars can be made (i.e., when n = 1, one star results, when n = 2, three stars results, when n = 3, five stars results, when n = 4, seven stars results, and when n = 5, nine stars results, etc.).
    Many interesting variations result from changing X and Y. For example, when X and Y = K, and everything else remains as in 'Cherokee Seven Stars' (p = 0, q = ', and n = 4) a beautiful pattern results (fig. 55), the formula being:

Opening A, [K-1, IM, K-1', IM, rotate index loop +2/2]$^4$, Inuit Out, Power Lift or Caroline Extension.
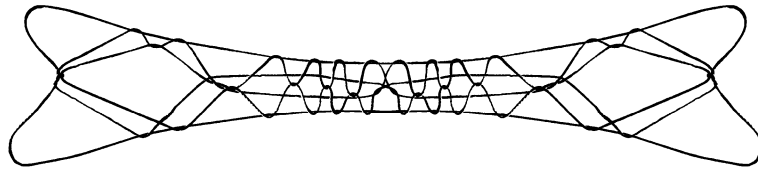


**Fig. 55 -** *Cherokee Seven Stars with X and Y = K*

But X and Y need not be the same for a viable figure to form, and you need not alternate a regular weave with an inverse weave. For example, the following figure is quite interesting (fig. 56):

Opening A, [I-1', IM, N-1, IM, rotate index loop +2/2]$^4$, Inuit Out, Power Lift or Caroline Extension.
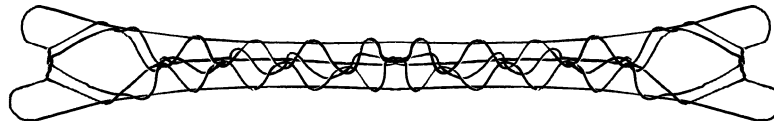


**Fig. 56 -** *Cherokee Seven Stars with X = I, Y = N, and p = '*

A matrix (fig. 57) would allow you to explore all possible combinations in this series (you can set n equal to whatever number you wish).

$$\mathbf{Y\text{-}1^q}$$

|       | I-1 | I-1' | N-1 | N-1' | K-1 | K-1' |
|-------|-----|------|-----|------|-----|------|
| I-1   |     |      |     |      |     |      |
| I-1'  |     |      |     |      |     |      |
| N-1   |     |      |     |      |     |      |
| N-1'  |     |      |     |      |     |      |
| K-1   |     |      |     |      |     |      |
| K-1'  |     |      |     |      |     |      |

$\mathbf{X\text{-}1^p}$

**Fig. 57 -** *Matrix for exploring Cherokee Star variations*

One final note: Throughout this discussion we have ended each figure with *Inuit Out*. There is no reason why this cannot be replaced with *Navaho Out* or *Klamath Out* as a means of altering the design motifs at either end of the figure. You might also want to experiment with adding an extra roll just prior to the extension in order to invert the final figure (as i do when making 'Inuit Bowl').

The formula for the 'Navaho Cage' can also be generalized:

> Left DNA Opening, Katilluik thumb and little, [N-1 (non-tv only), N-2 (over near and far index), CM]$^n$, N-1 (non-tv only), N-2 (over near and far index), drop index, widen middle finger loop with index.

where n = 1, or 2, or 3, etc.

Each repetition of the bracketed sequence adds more complexity to the cage. The figure extends best when n is an odd number.
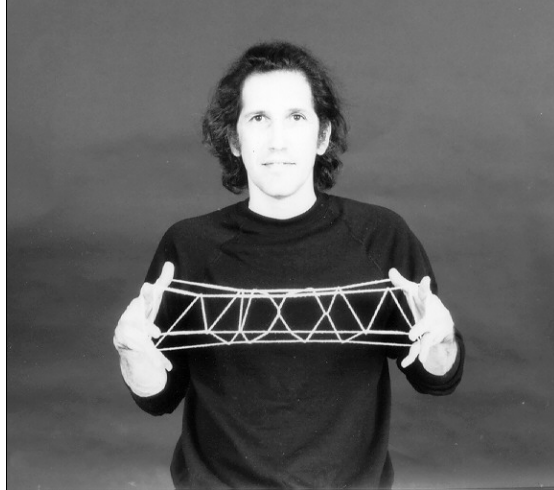
**Fig. 58 -** *Inuit/Navaho Hybrid Cage*

An interesting variation results from doing I-1 and I-2 during the first itera-
tion. For example, try the following:

> Left DNA Opening, Katilluik thumb and little, I-1 (non-tv only), I-2,
> CM, N-1 (non-tv only), N-2 (over near and far index), CM, N-1 (non-tv
> only), N-2 (over near and far index), drop index, widen middle finger
> loop with index.

The resulting cage is shown in fig. 58.

FOUR-LOOP VARIANTS

In next year's Bulletin i will present nets made with four- and five-loop
looms (vertical nets, tennis nets), as well as my unique "circle notation" for
recording their construction methods. For many of these i use a four-loop
version of the Inuit Net sequence as a way of finishing off the design (*Four-
Loop Inuit Out*). Since the weaving sequence for the three-loop version is
still fresh in your head, i present the four-loop version here so you can prac-
tice. i also describe how one might rotate a four-loop figure on the hands.

*Four-loop Inuit Net* (fig. 59)

*Forming the Loom*
- Begin with Opening A.
- Create a fourth loop as follows: transfer the index loop to the middle
  finger; transfer the thumb loop to the index finger; insert the left thumb,

from above, into the right index loop and return with the right near index string (rotate thumb toward you and up); insert the right thumb, from below, into the left thumb loop and extend.

*First Inuit Weave*
- Pass each thumb away from you *over* the near index string and *under* the far index string, *over* the near middle finger string and *under* the far middle finger string, then pick up the near little finger string and return.
- Pass each ring finger toward you over both middle finger strings and both index strings and down through the upper thumb loop ("dip into the well"), then pick up the lower far thumb string and return.
- Drop both thumb loops and extend.

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

*Shifting the Loops*
- Drop the index and middle finger loops.
- Transfer the ring finger loop to the little finger;
- 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).

Now *Fix the Bottom* and *Clean the Top* as in the three-loop version of the Inuit Net. See fig. 59.



**Fig. 59 -** *Four-loop Inuit Net*

A fast way to make the same figure is to set up the four-loop loom as described above, then conflate the index and middle finger loops as follows:
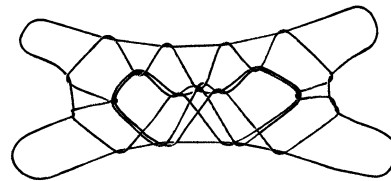
- Transfer the index loop to the middle finger.
- Transfer both middle finger loops to the index, maintaining their relative order.

You now have something that resembles Opening A on your hands, the index loop being doubled. Now do all the weaves of the three-loop Inuit Net, starting with the first weave (treat the double index loop as if it were single). The

disadvantage of the fast method is the loss of the extra loop, which you can manipulate during the weaving phase to add richness to the design. Can you devise a method for making a four-loop Navaho Net or four-loop Klamath Net?

*Rolling a Four-Loop Figure*

- Transfer the thumb loop to the top of the middle finger, inserting the middle finger from above (this introduces a +1/2 spin).
- 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 spin).
- 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 spin).
- 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 spin).
- 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.

Given this information, can you now devise a method for making a four-loop version of the *Inuit Bridge*? (Try n = 2, as shown in fig. 60).
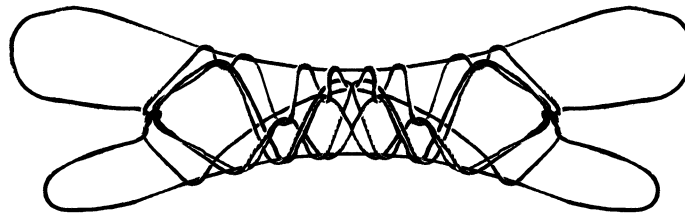


**Fig. 60 -** *Four-loop Inuit Bridge (n = 2)*

*Four-loop Iteration Move* (IM-4)

- Pass each thumb away from you under all the strings, pick up the far little finger string, and return; drop the little finger loop (this transfers the little finger loop to the thumb and introduces a +1/2 spin).

- Transfer the upper middle finger loop to the thumb (over the index loop), inserting the thumb from below, then retransfer this loop to the little finger, inserting the little finger from above (this move shifts the middle finger loop to the little finger while simultaneously introducing a +1/2 spin).
- 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 spin).
- 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 spin).
- 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.

Given this information, can you now devise a method for making a four-loop version of 'Cherokee Seven Stars'? (Try n = 2. Surprisingly, the result is four stars rather than three since the center octagonal star splits into two stars, see fig. 61).
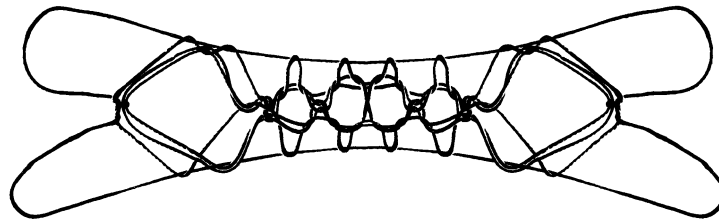


**Fig. 61 -** *Four-loop Cherokee Seven Stars (n = 2)*