Jayne in Brief

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1 Introduction

This paper gives a personal formalization of the string figures in Chapters 2 and 3 of Jayne's *String Figures: A Study of Cat's-Cradle in Many Lands* [4] using Tom Storer's string figure calculus [9]. This is a "personal" formalization because the constructions given below are not exactly, move for move, the same as those given in Jayne. There are multiple reasons for the differences in the calculus here and the constructions given by Jayne.

First, there are moves which Jayne describes step-by-step which the calculus allows us to notate directly. To give a concrete example of this, Jayne does not use the term "to navaho a loop" and explains the operation each time (e.g Many Stars, *Sixth* move, p. 50). Although she does not use the term in her writing, she remarks that, "following Dr. Haddon", one uses the verb "to navaho" conversationally (p. 20). The string figure calculus has notation for navahoing a loop and we use this notation below. By doing so, we lose potentially interesting anthropological information about whether a string figure

practitioner performed a navaho move with their mouth, or the opposite hand, or by a slight rotation of the wrists.

Second, Jayne gives step-by-step instructions for performing manipulations that can be easily summarized. For example, Jayne writes:

> *Third*: Transfer the thumb loops to the index fingers by taking up from below with the back of each index the far thumb string. (Bogobo Diamonds, p. 43)

We can summarize this in the calculus as:

$$③\ \overrightarrow{1\infty} \to 2 \equiv \overrightarrow{2}(\underline{1f})\# : \Box 1.$$

If we only gave the loop-transfer formula, then there would be a loss of information. The right hand side of the equivalence tells us about a particular manipulation to accomplish the loop-transfer.

Third, there are moves in Jayne which are difficult to notate directly using the calculus. If I've found a simpler and equivalent way to notate the figure, then I give that description of it. An amusing instance of this kind of alteration is Two Elks (§3.12). Jayne comments: "The *Fifth* and *Sixth* movements of this figure exhibit what appear to be artificial methods, and yet it is difficult to see how the same results could be produced in any quicker or more simple procedure." (p. 79) After some experimentation, I found that these moves were equivalent to a double-navaho move $\ell 1\infty \to u1\infty$ (over) : $N1$ and so I've written this simpler manipulation. To the best of my ability, I've noted where these completely fabricated moves occur.

Given these differences, this paper represents my own personal interpretation of Jayne's *String Figures*. It has no anthropological value per se and should not be used directly as a basis for comparison of string figure corpora. However, it can

be used as a guide to various moves occurring in the literature and possible ways to notate them using Storer's string figure calculus.

1.1 Who is this paper for?

String figures are a rare hobby. In my experience, very few people are interested in learning string figures from books. Even fewer yet are interested in notating string figures. The amount of time needed to learn a string figure notation system such as Storer's string figure calculus (or Arrow Code [1], or Mizz Code [5]) is so high, and the rewards are so slight, that very few string figure enthusiasts invest the time to learn a system. To the best of my knowledge, there are only two publications which have seriously deployed Storer's string figure calculus: Mark Sherman's *Rationally Designed String Figures* [8] and Eric Vandendriessche's *String Figures as Mathematics* [10]. The latter primarily uses Storer's concept of a heart sequence (or construction using loop-centric moves) to analyze string figure constructions from an anthropological point of view. To see the sort of analysis that the calculus enables, see the closing section on Caroline Island Diamonds (§4).

Who, then, is this paper for? It is for the string figure community as a proof of concept and a sign. This paper shows that the string figure calculus is a rich and expressive system capable of being used by people other than its author for a variety of purposes. It shows that LaTeX can handle typesetting the string figure calculus.

The ideal reader is someone whose repertoire includes a handful of figures from Jayne but who does not yet know Storer's calculus. One possible way to use this paper would be to play through some figures that you know and follow along with the

notation. This is essentially Pete Seeger's advice for learning how to read sheet music: sing through a printed collection of songs that you already know and follow the notation [7].

A word of warning is necessary here. The string figure calculus is not well suited to learning figures. It is much better suited for remembering the steps of a figure that you've learned from some other source. The written calculus can help jog the memory and help the fingers remember.

And so, this paper is for someone who wants to learn Storer's string figure calculus. The figures in Jayne are generally well known in the string figure community. If you're curious about the string figure calculus, then you can "read" along with the figures that you already know. When I first started learning Storer's calculus, it would have been immensely encouraging to have such a source. I would have appreciated seeing more calculus and various ways of employing the calculus. And so, this article is written for someone who was like me about five or ten years ago. That is to say, it is for a person with mathematical or computational inclinations, who is curious about string figures and finds Storer's calculus exciting.

1.2 Why formalize Jayne?

Jayne's monograph is the foundational work of the study of string figures. It launched the enterprise of serious large-scale collecting and recording string figures. The articles that proceeded Jayne's work were brief and isolated, each containing only a few figures from specific regions. Jayne contains many figures from around the world, which she gathered at the 1904 World's Fair in St. Louis. In particular, Chapter 3 contains a beautiful complex of Navaho figures.

Everyone who endeavours to learn string figures eventually

acquires a copy (or several) of Jayne. And so, it is the common heritage of the string figure community. Formalizing Jayne, reading every line carefully, trying and re-trying every construction, was a way for me to honour that heritage. This work is technical and formula heavy, but *á chacun son goût* [3].

1.3 On the formality of the calculus

My perspective on the string figure calculus is that it is a semi-formal domain specific language for notating string figures. Much like the notation used in knitting, the string figure calculus is well-suited to describing the manipulations involved in its domain. It is not a total and all encompassing formal system.

The world of string figures is so varied and diverse that there are things which are difficult or impossible to annotate in the calculus. When necessary, I've used English to describe some of these manipulations. I have also taken the liberty of re-working some figures to make them easier to annotate. Re-working figures is one of the great joys of playing with string figures; it is similar to giving constructions for figures known only from their final positions but with the added advantage that one has a construction on hand. It is a pleasant, methodical, sort of tinkering.

Even at its most formal, the string figure calculus is rich and expressive. There are often multiple ways to write down a manipulation. One can include or omit information to make the calculus more or less informative. To pick a concrete example, I notated dropping both thumb loops as $\Box 1\infty^{(2)}$ in the figure Osage Diamonds (given below in §2.4) even though the default interpretation of $\Box F$ is to release all the loops on F. One is free to write $\Box 1$ or $\Box 1\infty^{(2)}$. Throughout this paper, I've preferred annotations which are more informative as they can be used

to check the validity of a string figure construction "on your hands". If there are not two loops to drop, and one encounters $\square 1 \infty^{(2)}$, then something has gone wrong.

As I worked on these figures, I found it helpful to freely add line breaks to the calculus. As in poetry, line breaks can impact rhythm and flow. Adding line breaks was both a stylistic choice to improve readability, and a technique for highlighting "phrases" or "passages" (to use Braunstein's term [2]) in the constructions.

I hope that this paper inspires others to learn the string figure calculus and use it for analysis. It is a wonderful framework for writing, storing, and comparing figures. I feel that it is underutilized in the string figure literature because it has a significant learning curve and is difficult to typeset. However, it is now possible to typeset the calculus in LaTeX. This paper is intended to help ease the learning curve of the string figure calculus.

1.4 Table of Notation

The following table shows what notation we use in this paper. This table is not meant to be used as an introduction to the string figure calculus. The reader is encouraged to consult Storer [9] for a more detailed discussion.

Notation	Interpretation
$\underline{O}.X$	Opening X. Usually, $\underline{O}.A$ or $\underline{O}.1$.
:	Continue the construction.
$\overrightarrow{F}$	The functor F passes away (in the ulnar direction) over the strings.

$\underset{\leftarrow}{F}$	The functor F passes towards (in the radial direction) under the strings.
$\overrightarrow{\overrightarrow{F}}$	Pass the functor F to the right over any strings.
$\underset{\leftarrow\!\leftarrow}{F}$	Pass the functor F to the left under any strings.
$\overset{\text{s}}{\triangle}$	A small triangle in the figure.
$\diamondsuit$	A diamond inside a figure.
∞	A loop surrounding a finger.
$< F\infty$	Rotate the F loop half a turn towards.
$> F\infty$	Rotate the F loop half a turn away.
$\#$	Return hands to normal position.
$\mid$	Separate the hands and extend the figure.
I	Perform a final extension of the figure.
$\square$	Release the specified loops.
$F_1 \star F_2$	Use functors F_1 and F_2 to pinch the string.
$\neq$	Loops need not be kept distinct.
$\textcircled{n}$	The nth move in Jayne's construction.
$\bigtriangledown$	A small triangle in the figure.
$\mathbb{P}$	The Pindiki extension.

2 Jayne's Chapter 2

2.1 Apache Door (p. 12)

① $\underline{O}.A$
② $2\infty \longrightarrow W$ (over)
③ $\overrightarrow{1}(\underline{5n}) \neq \# : \overleftarrow{5}(\underline{1f}) \neq \#$
④′ $\overleftarrow{1\infty^{(2)}}(Wn) : \underrightarrow{1\infty^{(2)}}(Wf) : \overleftarrow{1\infty^{(2)}} \to 1$
⑤ $\square W$ and rub hands together magically : I

The move ④′ is non-traditional. It is loop-move equivalent to the *Fourth* move in Jayne's construction. Traditionally, this is accomplished by positioning the hands so that all the strings of the figure run between $R1$ and $R2$ and then lifting off $1\infty^{(2)}$ carrying them over this mass of strings and then resetting them on 1.

2.2 Fighting Head-Hunters (p. 16)

① $\underline{O}.A$

② $\overleftarrow{5}\,(\underline{1n}) \;\neq\; \#\,\square 1|$

③ $\underrightarrow{1}(\underline{5n}^{(2)}) \;\#\,\square 5\infty^{(2)}\;|$

④ $\overleftarrow{5}\,(\underline{1f}^{(2)}) \;\#$

⑤ Arrange so that a central $\bigtriangledown$ appears.

$$\overrightarrow{2}\uparrow(\bigtriangledown) : \overleftarrow{2}\,(\underline{s}^{(2)} : 1n) \;\#$$

⑥ $N\ell 2\infty \;: \square 1\infty^{(2)}\;|$

⑦ $[\gg 2]^3$ until tight : $\square 2\infty^{(2)}$

⑧ Use 5 to tug figure apart. "They fight and they fight..."

For additional narration, to add color to ⑧, see Jayne p. 20.

2.3 Sunset (p. 21)

This figure requires a longer than normal string.

①$-$④ as in Fighting Head-Hunters.
⑤ $X2$
⑥ $\overleftarrow{3}\downarrow(2\infty) : \overrightarrow{3}(\underline{1f}^{(2)})$ #
$\quad \Box 1\infty^{(2)} : \Box 2 : \overleftarrow{3\infty}^{(2)} \to 1$
⑦ Locate $\bigtriangledown$ with base $5f^{(2)}$.
$\quad \overleftarrow{2}\ (\underline{s}^{(2)} : \text{sides of } \bigtriangledown)$ #
⑧ $\overleftarrow{3}\downarrow\left(2\infty^{(2)}\right) : \overleftarrow{3}\ \left(\underline{1f}^{(2)}\right)$ #
⑨ $\Box 1 : \Box 2 :$ Extend via $\underset{\rightarrow}{2}\uparrow\left(3\infty^{(2)}\right)$ #

2.4 Osage Diamonds (p. 24)

① $\underline{O}.A$
② $\square 1\ |$
③ $\underset{\rightarrow}{1}(\underline{5f})\ \#$
④ $\overrightarrow{1}(\underline{2f})\ \#$
⑤ $\square 5|$
⑥ $\overleftarrow{5}\,(2n) : \overleftarrow{5}\,(\ell 1 \underline{f})\ \#$
⑦ $\square 1 \infty^{(2)}|$
⑧ $\overrightarrow{1}(\underline{5n})\#$
⑨′ $\overrightarrow{1}(\underline{2n})\#$
⑩ $N1$
⑪ $\overleftarrow{2}\downarrow\left(1 - \text{Ⓢ}\right)\ :<2(\#) : \square 5$ I (palms away)

For a thorough analysis of this figure, see Storer p. 55-106. For the sake of comparison, here is the calculus given for this figure.

Osage Diamonds: O.A:□1| 1→(5f)# 1→(2f)#□5| 5←(1f)#□1| 1→(5n)#| 1→(2n)#
N1|::2←↓(1-Ⓢ): <2(#):□5| (palms away).

Notice the stylistic differences. The original version does note include line breaks and step numbers. The text is much more compact. One might say that the notation given here is a dialect of the original string figure calculus.

2.5 Osage Two Diamonds (p. 28)

① $\underline{O}.A$
② $\square 1$ |
③ $\overrightarrow{1}(\underline{5f})$ #
④ $\overrightarrow{1}(\underline{2n})$ #
⑤ $N1$
⑥ $\overleftarrow{2}\downarrow\left(1-\text{Ⓢ}\right)$: $\square 5$: $<2(\#)$: I (palms away)

2.6 Dressing a Skin (p. 30)

① $\underline{O}.A$
② $\square 5 \rightarrow h\infty$
③ $\overleftarrow{h\infty}(1n)$ by swinging loop over figure.
④ $\overrightarrow{1}(\overline{s}:2f-h\infty)$ $\overrightarrow{1}\downarrow(1\infty)$: $\square\ell 1\infty$ I

2.7 A Fish-Spear (p. 32)

① $\underline{O}.1$
② $\overleftarrow{\overleftarrow{R2}}(\underline{Lp})\# : \ll R2\infty$
③ $\overrightarrow{\overrightarrow{L2}}\downarrow(R2\infty)$: $\overrightarrow{\overrightarrow{L2}}(\underline{Rp})$ #
④ $\square R1$: $\square R5$ I

2.8 King Fish (p. 39)

① $\underline{O}.A$
② $\square R2$ |
③ $\overrightarrow{\overrightarrow{HL2}}(Lp) : \overrightarrow{\overrightarrow{HL2}}{\downarrow}(L2\infty)$
$\overrightarrow{\overrightarrow{HL2}}(\overline{Lp})$ $\#(H2)$ $\square L1 : \square L5$ |
$\#(HL2)$
④ $HL2\infty \rightarrow L15$
⑤′ $\overrightarrow{\overrightarrow{L2}}(\overline{Rp})$ $\#$
⑥ $\overleftarrow{R2}{\downarrow}(R1\infty) : \overrightarrow{R2}(\overline{R5n})$ $\#$
⑦ $\left\{ \begin{array}{l} \overleftarrow{HL5}(\overline{L2f}) \\ \overrightarrow{HR5}\left(\overline{s} : \text{base of } \triangle\!\!\!\!\text{S} \text{ on } R2\infty\right) \end{array} \right\} \#(H5)$
⑧ $\square 1$ I

2.9 Bagobo Diamonds (p. 43)

① $\underline{O}.A$
② $\square 5$|
③ $\overleftarrow{2}\,(\underline{1f})\# : \square 1$
④ $\overrightarrow{1}\,(\ell 2n) : \overrightarrow{1}\,(\underline{\ell 2f})$ $\#$
⑤ $\overrightarrow{1}\,(u2n) : \overrightarrow{1}\,(\underline{u2f})$ $\#$
⑥ $\overleftarrow{3}\,(u2n) : \overleftarrow{3}\,(\underline{\ell 2n})$ $\#$
⑦ $N1$
⑧ $> L$ relative to R to extend.

2.10 Bagobo Two Diamonds (p. 46)

① $\underline{O}.A$
② $\square 1|$
③ $\overrightarrow{2}(\underline{5n})\# : \square 5\ |$
④ $\overrightarrow{1}(\ell 2n) : \overrightarrow{1}(\underline{\ell 2f})\ \#$
⑤ $\overrightarrow{1}(u2n) : \overrightarrow{1}(\underline{u2f})\ \#$
⑥ $\overleftarrow{3}(u2n) : \overleftarrow{3}(\underline{\ell 2n})\ \#$
⑦ $N1$ I

3 Jayne's Chapter 3

3.1 Many Stars (p. 48)

① $\underline{O}.A$
② $\overrightarrow{1}(\underline{5n})\ \#$
③ $\overleftarrow{3}\downarrow(u1\infty) : \overleftarrow{3}(\underline{\ell 1f})\ \# : \square 1\infty^{(2)}\ |$
④ $\overrightarrow{1}\downarrow(2\infty) : \underrightarrow{1}(\underline{5f})\ \# : \square 5\ |$
⑤ $\underrightarrow{12}(\underline{3f})\# : \square 3\ |$
⑥ $N1 : N2$
⑦ > 1 and hook down base of Ⓢ near thumb to extend.

3.2 An Owl (p. 53)

① $\underline{O}.1$
② $\overleftarrow{\overline{R2}}(\overline{Lp})\ \#:\ll R2\infty$
③ $\overrightarrow{\overline{L2}}$(on the near side of R2) : $\overrightarrow{\overline{L2}}(\underline{Rp})\ \#$
④ as in Many Stars ② – ⑦.

3.3 A Second Owl (p. 54)

① $\underline{O}.A$
② $\gg 2\infty$
③ as in Many Stars ② – ⑦.

3.4 A Third Owl (p. 55)

① – ③ as in Many Stars.
④ $\underrightarrow{1}\uparrow(2\infty) : \underrightarrow{1}(\underline{5n}) : \square 5\ |$
⑤ – ⑦ as in Many Stars.

3.5 Seven Stars (p. 56)

① – ⑤ as in Many Stars.
⑥ $\square u1\infty$
⑦ $\underrightarrow{1}\left(\underline{2n^{(2)}}\right) \neq\ \#\ : N\ell 1\infty$
⑧ $\underleftarrow{H3}\uparrow\left(1\infty^{(2)}\right)$: ($\overline{s}$: upper transverse string of $\bigtriangledown$)
$\square 1\infty^{(2)} : \overrightarrow{2}(\overline{2f})\ \#(H3)$

3.6 Two-Horned Star (p. 58)

① – ⑤ as in Many Stars.
⑥ $\Box u1\infty$ |
⑦ $N2$
⑧ $\overrightarrow{1}(\underline{2n})$ # : $N1$
⑨ $\underleftarrow{H3}\uparrow (1\infty^{(2)})$: $\overleftarrow{H3}(\overline{s}$: upper transverse string of $\bigtriangledown)$
$\Box 1\infty$: $\overrightarrow{2}(\overline{2f})$ #$(H3)$

3.7 Two Coyotes (p. 63)

① – ③ as in Many Stars.
④ $\underrightarrow{1}\uparrow(2\infty)$: $\underrightarrow{1}(\underline{5f})$ # : $\Box 5$ |
⑤ $\underrightarrow{12}(3n)$: $\underrightarrow{2}(\underline{3n})$# : $\Box 3$ |
⑥ $N2$
⑦ $\overrightarrow{1}(\underline{2n})$ # : $N1$
⑧ $\underleftarrow{H3}\uparrow (1 - \bigtriangledown)$: $\overleftarrow{H3}(\overline{s}$: upper transverse string of $\bigtriangledown)$

3.8 Big Star (p. 64)

① $\underline{O}.A$
② $\overrightarrow{1}\downarrow(2\infty)$: $\underrightarrow{1}(\underline{5f})$#
③ – ⑦ as in Many Stars.

3.9 North Star (p. 65)

① $\underline{O}.A$
② $\overleftarrow{3}\,(\underline{1f})\ \#\ :\square 1\ |$
③ – ⑦ as in Many Stars.

3.10 Carrying Wood (p. 66)

① $\underline{O}.A$
② $\overrightarrow{12}(2f) : \underrightarrow{12}(\underline{5n})\# : \square 5|$
③ $N1 : N2$
④ > 1 hook down base of ⚠ near thumb and extend.

3.11 Owl's Net (p. 69)

① $\underline{O}.A$
② $\overrightarrow{1}\,(\underline{2f})\#$
③ $\overleftarrow{2*3}\downarrow(u1\infty) : \overleftarrow{2}\,(\overline{\ell 1n})\ \#\ :\square 1\infty^{(2)}|$
④ $\overrightarrow{1}\ \downarrow(\ell 2\infty) : \underrightarrow{1}(\underline{5f})\# : \square 5|$
⑤ $\underleftarrow{H345}(\overline{1n})\#(H345) : \square 1| : \overleftarrow{u2\infty} \to 1$
⑥ $\underleftarrow{H3}(\overline{1f})\#(H345) : \square H45\infty\ : \overleftarrow{H45}\uparrow(H3\infty) : \square H3\infty$
⑦ $\overleftarrow{H3}(\overline{s}$: lower string of pendant loop on $s : 1f - H45)$
$\square H45 : \overleftarrow{H45}\downarrow(H3\infty)\ \#H345$
⑧ $\underleftarrow{3}\uparrow(2\infty) : \overleftarrow{2*3}(\overline{1n}) : \square 1$ I

3.12 Two Elks (p. 75)

① $\underline{O}.A$
② $\overrightarrow{2}(\underline{5n}) : \overrightarrow{1}(\ell 2\infty) : \underset{\rightarrow}{1}(\underline{5f})\# : \square u2\infty$
③ $\overleftarrow{2 * 3}\downarrow(u1\infty) : \overleftarrow{2}(\overline{\ell 1n})\# : \square 1\infty^{(2)}$ |
④ $\overleftarrow{u2\infty} \rightarrow 1$
⑤′ $\overrightarrow{1}(\underline{5f})\# : \ell 1\infty \rightarrow u1\infty$ (over) : $N1$
⑥′ $\overrightarrow{1}(\underline{5n})\# : \ell 1\infty \rightarrow u1\infty$ (over) : $N1$
⑦ $\square 2$ I tightly while rotating wrists back and forth

The moves ⑤′ and ⑥′ are not traditional. They are loop-move equivalents to the Fifth and Sixth moves in Jayne's construction. Jayne comments: "The *Fifth* and *Sixth* movements of this figure exhibit what appear to be artificial methods, and yet it is difficult to see how the same results could be produced in any quicker or more simple procedure" (p. 79). To turn this problem on its head, we note that it is difficult to present the given moves using the string figure calculus.

3.13 A Rabbit (p. 79)

① $\underline{O}.A$
② $\overleftarrow{2 * 3}(1f) : \overleftarrow{2}\,(\overline{1n})\ \# : \square 1|$
③ $\underrightarrow{1}\uparrow(5\infty) : \underrightarrow{1}(\underline{5n + u2f + \ell 2\infty})\#$
④ $\overrightarrow{1}\,(2n) : \square 1\infty^{(4)} : \underrightarrow{1}(\underline{5f})\#$
⑤ $\overrightarrow{1}\,(\underline{u2n})\# : N1$
⑥ $\square u2\infty$
⑦ $\overleftarrow{H234}\downarrow(1\infty) : \square 5$ (gently) $\#(H234)$
$\overleftarrow{2}\,(\overline{1n}) : \square 1$

3.14 The Sun (p. 82)

① $\underline{O}.A$
② $\overleftarrow{2 * 3}(1f) : \overleftarrow{2}\,(\overline{1n})\ \# : \square 1|$ $\qquad [\equiv \overrightarrow{1\infty} \to 2]$
③ $\underrightarrow{1}(\underline{\ell 2\infty})\ \neq\ \#$
④ $\overrightarrow{1}\downarrow(u2\infty) : \underrightarrow{1}(\underline{5f})\#$
⑤ $\square 5|$
⑥ $\underleftarrow{H345}(\overline{1f}) : \square 1\#(H345)$
⑦ $\overrightarrow{1}\,(\underline{u2n})\ \#(H345)$
$\overleftarrow{H3}(\overline{u2f + \ell 2\infty})\#(H45) : \square H45 \to h\infty$
$\overleftarrow{H45}(\overline{u2f + \ell 2\infty})\#(H45)$
⑧ Raise thumbs to extend until "The sun appears."
When $h\infty$ pulls through, "The sun sets."

4 Caroline Islands Diamonds

> "A good notation has a subtlety and suggestiveness which at times make it almost seem like a live teacher."
> — Bertrand Russell [6].

The point of this final section is to show how the calculus can be used to analyze string figures. We turn our attention to the figure Caroline Island Diamonds (p. 260) from Chapter VI of Jayne. Throughout this chapter, there are many openings other than $\underline{O}.1$ and $\underline{O}.A$. Generally, it is difficult to render openings using the string figure calculus. The manipulations involved usually do not lend themselves to annotation. However, it is often possible to give an alternative construction of openings.

Caroline Island Diamonds is a wonderful example of a figure with a simple re-construction. The manipulations below are entirely fabricated, and bear little resemblence to moves used in the original figure. The figure begins with a unique opening shown in Figure 606 (p. 262) of Jayne. One can construct this opening from $\underline{O}.A$ as follows:

$$\underline{O}.A : \square 5 : > 1\infty \to W : \overrightarrow{2\infty} \to 5$$

The original construction then continues ② $W\infty \to 1$ (over). Let us call this position $\underline{O}.X$.

$$\underline{O}.X \equiv \underline{O}.A : \square 5 : > 1\infty \to W : \overrightarrow{2\infty} \to 5 : W\infty \to 1 \text{ (over)} \equiv ①②$$

In this construction, the W moves feel extraneous. We move a loop to W only to immediately move it back. Notice that the position $\underline{O}.X$ is closely related to $\underline{O}.A$. We would like to make some moves to get "closer" to $\underline{O}.A$. To do so, we lift the 5∞ through the 1∞ and return it to the 5. This is closer to $\underline{O}.A$ but

the 1∞ is twisted. Correcting for this twist gives the following equivalence:

$$\underline{O}.X : \underset{\leftarrow}{5\infty}\uparrow(1\infty) \to 5 :< 1\infty \equiv \underline{O}.A : \Box 5 : \overrightarrow{2\infty} \to 5$$

This is an equivalence of manipulations, none of which involve W. Moreover, the left hand side of the equivalence consists entirely of loop manipulation moves. Storer calls this kind of loop manipulation construction is called a heart sequence construction. An important property of loop specific manipulation moves is that they are formally invertible. Thus, we can formally write:

$$\begin{aligned}
\underline{O}.X &\equiv \textcircled{1}\textcircled{2} \\
&\equiv \underline{O}.A : \Box 5 : \overrightarrow{2\infty} \to 5 : [\underset{\leftarrow}{5\infty}\uparrow(1\infty) \to 5 :< 1\infty]^{-1} \\
&\equiv \underline{O}.A : \Box 5 : \overrightarrow{2\infty} \to 5 :> 1\infty : \overleftarrow{5\infty}\downarrow(1\infty) \to 5
\end{aligned}$$

Thus, we have a constuction of $\underline{O}.X$ which consists almost entirely of loop manipulation moves. The original construction continues ③ $\overleftarrow{1}\,(\underline{5n})$ # ④ $\mathbb{P}$. Adding these steps, we get an alternative (re)construction of Caroline Island Diamonds.

$$\underline{O}.A : \Box 5 : \overrightarrow{2\infty} \to 5 :> 1\infty : \overleftarrow{5\infty}\downarrow(1\infty) \to 5 : \overleftarrow{1}\,(\underline{5n}) : \mathbb{P}$$

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