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View From The Shoulders Of Thar Masters: New Space For Ply-Split Braiding

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Ply-split braiding is a textile-making technique that involves separating the plies of one cord with a latch hook or similar tool, catching a second cord and pulling it through the gap between the plies of the first. The technique has been most fully developed by the men of the Thar Desert of Rajasthan, who use ply-split braiding, generally of 4-ply cords of goat hair or cotton, to make girths and other paraphernalia for their camels (Harvey 1976; Quick and Stein 1982). Peter Collingwood (1998) provided the fullest description of traditional textiles made by ply-split braiding and of the techniques used to make them. In the decade following the publication of his book, fiber artists in several countries – including Collingwood himself – explored the use of ply-split braiding for novel creations, many of which were three-dimensional, in contrast with the one- and two-dimensional straps and braids more typical of traditional work in Rajasthan.

Ply-split braiding has been usefully divided into three structural types, depending on the sequence and placement of cord splittings. In plain oblique twining (POT) each cord alternately splits and is split by cords that it meets along its path. In single-course oblique twining (SCOT) a cord may split or be split by several cords consecutively. In both POT and SCOT a cord typically has plies all of the same color, although cords may have contrasting colors. Between sequential splittings, a 4-ply cord typically rotates ¼ turn, although that practice can be altered for effect. In two-layer oblique interlacing (TLOI) a 4-ply cord typically has two adjacent plies of one color and two of a contrasting color. As with POT, cords alternately split and are split, but unlike POT, between splittings in TLOI cords rotate either ½ turn or not at all. Color patterning of ply-split braiding is built up of "pixels" of color at the intersections of cord pairs and depends on which type of structure is used. In SCOT, the color showing at a given cord intersection depends on which of the two cords is chosen to be split. In TLOI, the color depends on whether the split cord had no twist or a ½-twist since its immediate prior splitting; in the former case, the same color appears on the surface as previously, whereas in the latter case the contrasting color appears. In POT the color on the surface is strictly dictated by the color of the cord due to be split at that junction.

Several artists have experimented with ply-split braiding as means of creating vessel forms. Most of that work has been done in SCOT.[1] In addition to making vessels in SCOT (e.g., www.weavershand.com/psgallery6.html) Collingwood made at least two types of vessels in POT. The first was a triangular dish that he contributed to the exhibition at a convention in 2001 entitled "Expanding the Girths". Fraser (2009) took this dish as his starting point in expounding on radially symmetric vessels done in course-parallel POT, that is, POT in which individual cords travel parallel or perpendicular to the lip of the vessel. Collingwood's second POT vessel was a three-footed pot in Beyond Tradition (p. 14). In the latter vessel, cords travel obliquely toward the lip, an arrangement that Collingwood reports Speiser calls "course oblique". He had earlier described such an arrangement in a unique cheekah, or pot cover, from Rajasthan (Collingwood 1998, Figure 115). This paper takes these two examples of course-oblique POT as the starting point for the exploration of the potential for using this method for creating vessel forms, with

[1] See Linda Hendrickson, p. 15, James Pochert, p. 18, Akiko Shimanuki, p. 20, Noemi Speiser, p. 21, Pallavi Varia, p. 22, Barbara Walker, p. 23, Julie Hedges, p. 30 -- all in *Beyond Tradition* -- and Walker, pp. 288 & 374 in *500 Baskets*.

emphasis on radially symmetric vessels and the differences in possibilities offered by course-parallel and course-oblique POT.[2]


Figures 1a & b. *Starting point of POT in Clam Basket Riff is a 7-sided polygon comprising olive-colored yarns, the two free ends of which subsequently spiral clockwise and counterclockwise, respectively. As is characteristic of POT (and all illustrated examples in this paper), each cord alternately splits and is split by the cords it meets along its path. Subsequent additions are of sets of seven buff-colored cords, evenly spaced around the vessel. Where buff cords are added, one sees paired 3-sided and 5-sided enclosures, the former just peripheral to the added cord and the latter just central to the added cord. The rim of Clam Basket Riff was made by turning down the cords and binding them with a row of 2-strand weft twining.*

Work on radially symmetric POT vessels (whether course parallel or course oblique) begins in the center of the bottom, where a set of n cords forms a regular n-sided polygon, as each splits the next in sequence. Thereafter, the structures diverge. In course-oblique POT, typically each cord turns around the center point so that in time one of its working ends meets and crosses the other working end (and one of the working ends of all the other cords), as one follows a clockwise and the other a counterclockwise spiral. (Fig. 1) To create this spiraling, the two cords that intersect any given cord in the original n-sided polygon next intersect each other, creating a triangle with cord intersections at each apex. Such a (virtual or actual) space immediately surrounded by cord intersections and the cord segments that join them will be called here an "enclosure", in this case a 3-sided enclosure. Subsequent cord additions are generally marked by paired 3-sided and 5-sided enclosures. Each of the latter creates a small fenestration. This spiraling contrasts with course-parallel POT, in which each cord follows a path roughly tangential to a limited number of adjacent sides (usually one; occasionally two or more) of the growing polygonal work. In course-parallel POT the two working ends of a given cord never meet each other. As a consequence, all enclosures in course-parallel POT (aside from the original n-sided polygon) in which cords parallel a single side are 4-sided; where cords follow two or more sides, paired 3-sided and 5-sided enclosures are created as a cord moves from paralleling one side to paralleling the next. In course-oblique POT the tendency for the two working ends of a given cord to spiral clockwise and counterclockwise can be delayed or, in special cases, thwarted entirely by the placement of

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[2] A few others, including Ann Norman, Pallavi Varia, James Pochert and Errol Pires, have made vessels, posted on the Web, that have been done partly or completely in course-oblique POT. www.weavershand.com and http://thecuriouseye.blogspot.com/2009/09/errol-pires-and-strange-allure-of-camel.html

subsequent cord additions. The 5-sided enclosures associated with cord additions can deflect existing cords from their spiraling path. (Fig. 2) Several vessels posted on the Web are of hybrid form, beginning as course-parallel POT (generally based on a square, with sets of four cords added at each stage), and then changing to course-oblique POT by having one cord in each of adjacent cord pairs split the other (creating a circumferential row of 3-sided enclosures). If no additional cords are added but course-oblique ply-splitting continues, this pattern yields a distinctive form, with a flat, square base underlying a vertical, cylindrical vessel.   Course-oblique POT is easier to work than is course-parallel POT. In the latter, one has to turn the work 90 degrees after each splitting, whereas in the former one can complete an entire row in one orientation before turning the piece over for the next row.

Figures 2a & b. *In Peter's Preference cords are added in pairs along each of three radii. Each cord is deflected by the 5-sided enclosures created by the addition of cords in the next two rows.*

If in course-oblique ply-split braiding cords are consistently added in sets of n evenly spaced around the perimeter, a new set of cords can be offset from the prior set. If the points of insertion of the new set are more or less equidistant from the points of insertion of the prior set, the result is a polygonal vessel of 2n sides (Fig. 1). This arrangement yields a shape that more closely approximates a circle in horizontal section than in course-parallel POT vessels made with sets of n cords, in which the insertion points of cords in subsequent sets are not offset, yielding a polygonal vessel of n sides. When viewed from the vessel's side, an added cord in course-oblique POT initially follows a V-shaped path, with one working end going up and to the left and the other going up and to the right as illustrated in figure 3. In contrast, in side view a newly added cord in course-parallel POT initially follows a horizontal path.

If a course-oblique POT vessel is begun with cords of one color, the addition of sets of cords of a contrasting color creates a dynamic plaid arrayed on the diagonal. Each added set changes the dimensions of the blocks of color in the plaid by adding cords of the second color on both diagonals. The form and regularity of the resulting plaid depends on the spacing of the new cords around the perimeter of the vessel and on the number of rows of ply-splitting since the insertion of the previous set of cords (Fig. 3).

The rate at which cords are added determines the curvature of the vessel as viewed from the side: rapid addition results in a flatter silhouette; deceleration of the rate of addition generates convexity of the vessel; halting cord addition yields vertical sides. Provided that the cords are so tightly plied that they are not further compressible - and ignoring distortion caused by gravity - the addition of evenly distributed cords in sets of n every t^{th} row results in a conical vessel that can be predicted to yield an angle, θ, between the horizontal and the side of the vessel such that $\cos(\theta)= n/t\pi$.[3] As an example, for n=6 and t=2, θ≈17º, so the resulting platter is nearly flat. A vessel can be made to re-curve inward if the number of cords is reduced, but eliminating cords is challenging in POT as there is no shed, as there is in SCOT ,[4] in which to hide cord ends. One tactic for reducing the number of cords is to drop pairs of cords out of the ply-splitting sequence immediately after one has split the other. (Cords must be dropped in pairs, because dropping a single cord results in violation of the POT rule that cords alternately split and are split by cords they encounter along their path.) Repeating this process permits the removal of whole blocks of a color from the vessel. If the dropped cords are left outside the vessel, they can be worked together to create straps or other structures that move colors to new locations and in the process contribute architectural elements to the vessel (Fig. 3). Alternatively, excluded cords of stiff material can be untwisted to create a dramatic fringe. (Fig. 4) If the re-curving of the vessel is sufficient to hide loose ends, the dropped cords can be left inside the vessel and cut off.

Figure 3, left. *The body of Volcanic Flower involves the addition of sets of five black cords to the starting set of red ones. Each added black cord initially follows a V-pattern, with one free end going up and to the left and the other going up and to the right. Each added set widens the black diagonals by one cord as one moves up the body of the vessel. The red straps comprise the initial sets red cords after they are subsequently excluded from the body near its top, leaving only the black cords to form the fenestrated cone at the top. The black cone flares because of the progressive increase in size of the fenestrations. The spiky fringe of the black cone is fixed with a series of overhand knots.*
Figure 4, right. *The chaotic tuft atop Yellow Coral consists of cords of polypropylene that have been excluded from the work and then unravelled.*

One might attempt to apply these principles to the construction of a cylindrical vessel that consists of one color at the base and a contrasting color at the top. Wherever one drops out cords of the bottom color, one could add cords of the top color, until all of the cords of the bottom color have been substituted for. In the interest of creating a vessel with smooth sides, one might require that the substitutions be distributed evenly around the circumference and at regular intervals up the side. But is such a set of substitutions possible? That question can be posed in the form of a mathematical puzzle: Given a checkerboard of n x n squares that is folded into a cylinder, for which n (if any) can n checkers be placed on the checkerboard so that no two checkers are on the same horizontal row, no two checkers are on the same vertical column and no two checkers are on the same diagonal in either direction? And for an n for which there is such a

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[3] After tk rows, the hypotenuse, h, of vessel's triangular profile will be $[x\sqrt{2}]tk/2$, where x is the length of the side of each diamond-shaped cord intersection; the circumference, c, of the conical basket will be $nkx\sqrt{2}$; and radius, $r=c/2\pi$, of the cone will be $nkx\sqrt{2}/2\pi$ - so $\cos(\theta)=r/h=n/t\pi$.
[4] Harvey (1976) discusses use of such sheds on pp. 42-43.

solution, how many unique solutions are there? It seems that for even n's there is no solution. The smallest n for which there is a solution is 5 – and there is only one unique solution for n=5. For n=7 there are two solutions and for n=11 there are four (Figs. 5, 6, 7).[5] The pictured vessels actually present three such (identical) checkerboards joined horizontally, in order to yield a vessel with a pleasing ratio of height to diameter. For Modulo 11 all substituted cords are left inside the vessel and cut off. For Modulo 5 and Modulo 7, at every third locus of substitution, the substituted cords are left on the outside and worked into straps that are joined at the vessel's top to form a hollow cylindrical plug.



Figure 5, left. *Modulo 5. See text.*
Figure 6, center. *Modulo 7. See text.*
Figure 7, right. *Modulo 11. See text*

A versatile feature of course-oblique POT is the ease with which fenestrations can be made. In POT a hole in the pattern is created when at a given potential intersection of two cords, instead of one cord splitting the other, each turns back and continues on the opposite diagonal path as it is worked into the next row. If such turnings back occur in the same place in successive alternate rows, the size of the hole increases. Collingwood (1998) describes a traditional Rajasthan trapping, a fringe (mukhiarna) to keep flies out of horses' eyes, constructed as a fenestrated array of holes made by turnings back on two successive alternate rows. The mukhiarna is planar, but fenestrations can be readily incorporated into course-oblique POT vessels. Fenestrations both provide a decorative patterning of a course-oblique POT vessel and contribute to its shaping, as holes of increasing size progressively increase the circumference of a fenestrated vessel (Fig. 3 & Fig. 8) For fenestration patterns that extend around the full circumference of a vessel one must

Figure 8. *The globular body of Salmon Hedgehog is shaped by increasing and then decreasing the size of the fenestrations.*

[5] Mathematically inclined friends of mine have been helping me work on solutions for higher n's. Henry Glick has shown that for n's with at least one solution the number of solutions tends to grow as n grows - and that not all solutions have the same form. Joshua Gruenspecht and Chandler Fulton have shown that the smallest non-prime n that has a solution of the form in the vessels pictured in Figures 5-7 is 25.

ensure that the number of cords in the vessel is an integral multiple of the horizontal period of the fenestration pattern. The fenestration pattern is readily diagrammed on graph paper oriented diagonally (Fig. 9) where the straight lines of the graph paper denote cords traveling through course-oblique POT without encountering fenestrations and pairs of adjacent curved lines that are convex toward each other denote cord pairs that turn back – creating a hole – rather than engage each other. Fenestration patterns readily combine holes of different size, provided that the horizontal periodicity is constant. Patterns of different periodicity may flare at different rates as hole size increases.

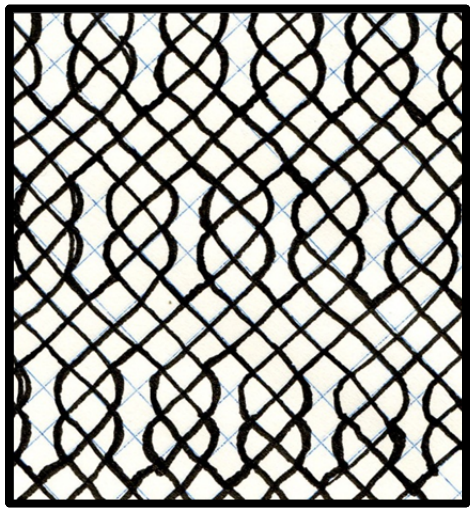

Figure 9. *Fenestration patterns are readily diagrammed on graph paper turned diagonally. Each dark line represents one of the two free ends of a cord. The three diagrammed ranks of fenestrations are two rows tall and have a horizontal period of two cord pairs and a vertical period of 8 rows.*

Fenestrations need not extend fully around the circumference of the vessel (Fig. 10) relieving one of the periodicity constraints and permitting creation of asymmetric forms.

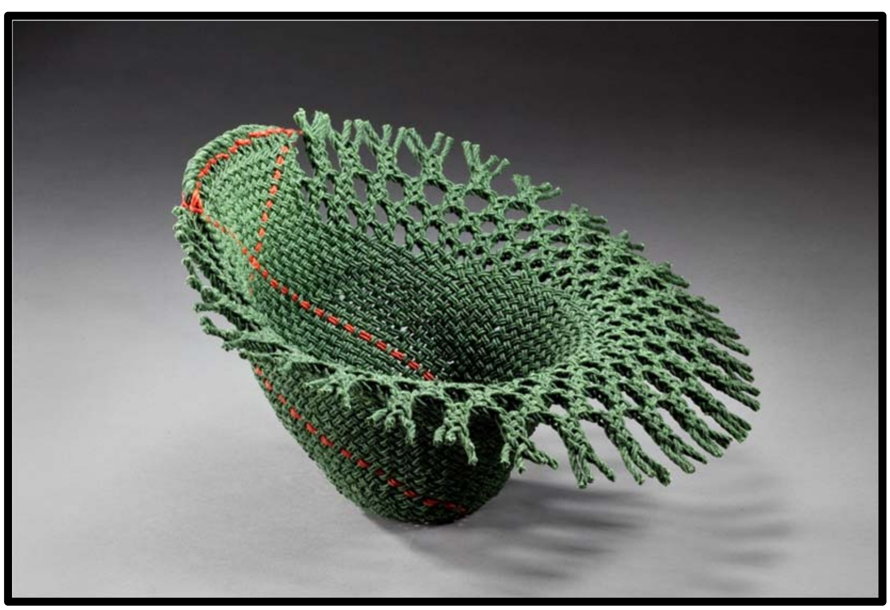

Figure 10. *The fenestrations in Goldfish Bowl extend only part-way around the vessel.*

The path of a given cord through a complex fenestration pattern may be challenging to anticipate. If unanticipated paths add to a design, this may present no problem (Fig. 11)). However, if one desires to anticipate the path, it may be useful to deconstruct each fenestration pattern and calculate the shift in horizontal position and direction of each cord as it passes through a (horizontal) set of holes of a given size. In figure 12, knowing the future path of cords permitted four separate cords to be dyed that later came together in a designated channel in the fenestration pattern, before diverging again.

Figure 11, left. *The yellow cords in Encounters meander through the areas of fenestration.*
Figure 12, right. *The dark green cords in Racines were created by dyeing selected yellow cords during the working of the vessel. Care was taken to anticipate which cords would come together at the transition line between yellow and purple.*

The 5-sided enclosures intrinsic to the adding of cords in course-oblique POT can be arrayed so as to create finely grained fenestration patterns based on a principle other than the turning-back of cord pairs. Clustering cord additions at selected angles around the center of a vessel arrays these fine fenestrations radially while affecting the silhouette of the vessel as viewed from above (for example, the triangular shape of the vessel in Figure 2).

The density of cord ends provides both challenges and opportunities in the finishing of course-oblique POT vessels. The simplest finish is just spiky ends, which generally require stiff (or short) cords ends and securing the last set of cord intersections with, for example, a series of square knots or a row of running knots or twining (Figure 3). The finish can effectively be hidden if after decreasing the number of cords in order to re-curve the top of the vessel one creates a short straight-sided collar with a constant number of cords and then inverts the collar (Figure 7). End finishes typically used in wickerwork or twined basketry can also be adapted to course-oblique POT, as in folding one cord down around the one next to it and binding both in a row of 2-strand weft twining (Figure 1b)[6]; engaging intersecting cord pairs in 4-strand weft twining, while bending one of the pair backward with the previous cord pair and the other forward with the subsequent cord pair (Figure 2a); or braiding the cord ends as diagrammed by

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[6] Such a finish is illustrated in Figure 38b in J. M. Adavasio. *Basketry Technology: a Guide to Identification and Analysis*. Chicago: Aldine Publishing Co., 1977.

Harvey.[7] In the last case, however, the high density of cord ends necessitates creating a double braid, the outer one comprising cords traveling on one diagonal and the inner one comprising cords traveling on the other diagonal (Fig. 13).

Figure 13. *The rim of Pierced Pumpkin was made with two braids, one comprising cords that had travelled on one diagonal and the other comprising those that had travelled on the opposite diagonal.*

POT (both course parallel and course oblique) imposes constraints of color patterning on ply-split braided vessels, but within those constraints a wide range of forms and patterns is possible, including color substitution with or without architectural flourishes. Very different possibilities, however, are offered by course-oblique and course-parallel POT. Most dramatic in course-oblique POT are opportunities for fenestration, shaping (by additions and deletions of cords as well as insertion of fenestrations of various sizes), dynamic plaids on the diagonal, and braided or hidden finishes.

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[7] See Figures 7-56 through 7-59 in Virginia I. Harvey. *The Techniques of Basketry.* New York, Van Nostrand Reinhold Company, 1978.