The Compound Conical Helix as Kinematic Trace: Aspiration and Heresy

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Abstract

A cone may be spirally fluted. If the fluted body is itself wound helically toward the apex of a conical envelope, both the cone and the helices are compounded. A series of works by John Macnab explores the expressive potential and intellectual history of this proposition. The imagery traditionally manifest in Solomonic columns, heliconical spires and cosmological diagrams is aspirational, even mystical. The computation reaches back to the kinematic and parametric thinking of Albrecht Dürer but is developed here in novel directions. That the astonishing forms are encoded and executed mechanically, outside the mainstream preoccupation with the "digital" is plainly heretical.

Machine and Form

Like a potter's wheel, a woodworking lathe constrains the transverse form of the worked object to a mathematical circle while leaving the longitudinal aspect more freely formed by hand, eye, and tool. John Macnab's compound conical helices are made on machine tools, and their forms are defined purely mechanically. There's no electronic computation anywhere in the system, whether digital or analog. The parameters of a given form are encoded in a mechanical configuration; independent variables are set by beans of changeable gear or sprocket ratios, indexing patterns, cutter diameters, and the like. Antecedents for some of the mechanisms can be found the highly adaptable milling machines of the mid-twentieth century, the rose engines and ornamental turning devices of the Victorians, and the *Ars Tornandi* of the Baroque – notably examined by Joseph Connors. Macnab's *Lathe of Specific Intent* also incorporates mechanisms unprecedented in the arts of turning. Interlinked, even a few elements can generate astonishing complexity. The fluidity and vigor of the finished works belie their mechanical genesis. Some results are surprising even to the maker, and one is tempted to consider the wholly programmed forms as emergent.



(a) (b)

Figure 1: *Work and tool: (a) mechanically generated form, with part of generating mechanism in background, (b) "root-stock" of mechanism showing timing chains and belts, optional elliptical gears.*

Three Early Forms

Figure 1 (a) is non-compound: a simple cone exhibits helical flutes. The axial pitch is uniform, so that the helical slope approaches infinity or verticality at the materially unachievable apex of the cone and zero at its unimaginable base. The piece was made in two distinct phases, with the base cone turned first, and the flutes inscribed later. A patternmaker's lathe was fitted with a leadscrew, allowing steady movement of the tool along the machine's longitudinal ways. The tailstock was offset to define the cone angle and the headstock fitted with a universal joint accommodating the offset. The piece manifests an important transition from bottom to top and from ornamental turning to another realm of work. At the bottom of the piece, the flutes are cut into the cone as ornament or elaboration, in the manner of a Roman column. Toward the apex, the flutes run into each other at ridges or arrises, as in a Greek column. The flutes become the only definition of the surface, integrating form and ornament.



(a) (b) (c)

Figure 2: *Early examples: (a) helically fluted cone, (b) concave-tapering openwork form, (c) compound conical helices.*

The plainest physical cone has monumental power. JM: *A cone in its self is thrilling to me, even if it is free from helical lines, they are implied a way. I think Miro knew this when he commissioned the large concrete cone on a hill in Barcelona and poured blue paint on it.* This may be especially true when observed mathematically: as a material semi-cone, giving rise to its imaginary completion overhead. The plane spiral and the helix have their own dynamic. JM *I have always been inspired by the wondrous aspect of a spiraling form. I believe that this motion and emotion is widely recognized by mystics and even by an institution like the Catholic church as some sort link to the firmament.*

The openwork form shown in figure 1 (b) represents an effort to engage more actively with ordinary inhabited space and emphasizes that the figure in question is a surface rather than a mass. The geometry

balances the upward progression towards greater openness against the upward constriction of radius. This piece isn't conical and doesn't appear to indicate an apex. Whether the slight concavity of taper is asymptotic, converging on a cylinder upwards, say, and on a cone or an annulus downward is unclear. Could this form represent a torus patch taken from a fat donut with a tiny hole? Could the curve swept about the vertical axis be a spiral? The question is open.

The third piece (c) shown in Figure 1 is compound in a sense that the others aren't. First, the white body of the piece is conical and helically fluted, and this body is then coiled on a helical path within an invisible conical envelope. Both helices have a constant pitch measured along the primary longitudinal. The mechanism is simple: a planetary headstock traces out a trochoidal curve in plan. The orbital radius and speed are constant, so is the daily rotation revolution of the "planet". The progression of the helices is toward a single apex defined by the fixed center of the tailstock. Nevertheless, patterns of interference occur between adjacent flutes as they pass over different phases of the coil, even to the point of erasure. For us, these patterns are difficult to predict or even characterize, suggesting a high level of emergence.



Figure 3: *The flutes are formed by the operator's successive plunge cuts*

Looking closely at the texture of the flutes, we can see traces of the cutter perpendicular to the flute. These are the traces of the maker's hand and eye. The culler must remove material along its rim, as a saw does; it cannot cut efficiently on the flat, on its circular plane. The operator therefore makes a steady, succession of plunge cuts as the workpiece presents itself to the tool. It is not enough, here, to speak of hand-eye coordination. The entire arm is acting as proprioceptive sensor, assisted by the eye, the ear, the pressure sensitivity of the palm, and possibly the vibration sensitivity of fingertips. All the information thus sensed is integrated with an internally generated sense of rhythm and translated to the actuating function of arm and hand. The coordination required seems to be partly conscious, partly unconscious and may to some extent bypass the central nervous system altogether. The human mastery of a physical medium is visible in the physical results. in ways that remain hidden when the medium is code and the output is generated at metaphorical arm's length.

It's worth noting that the pieces so far were turned on a conventional lathe fitted with various adaptations, but with the primary axis oriented horizontally. This imposed absolute limitations on the length of a piece and unnecessary constraints on the slenderness. The transverse loads of the cutting action and the self-weight applied to the helical length of the bent body could cause it to fail. A vertical lathe of specific intent was built with a vertical longitudinal axis two stories high, with a more easily reconfigurable headstock (in this orientation called "root-stock"). In this machine, the relationship between planet and sun is more flexible. The planet can spin in the opposite direction of its orbit. The elliptical gears shown in Figure 1 (b) could be set up to vary the relative rotation of input and output axis. Here they are set up to maintain a constant input and output speed while varying the orbital radius to generate an oval path.

Three Intermediate Forms

Case (a) in figure 3 exhibits a certain rippling of the flutes. It may be reminiscent of the complex fluting in the previous case, figure 2 (c). However, in this case the effect can hardly be considered emergent

because it's quite directly imparted, through a longitudinal stop, somewhat analogous to a taper attachment. The taper attachment on a machinist's lathe is in principle parallel to the principal axis of a turning, but can be skewed slightly so that a tool limited by this edge generates tapers. Lathes built to turn spars for sailing vessels. These spars may incorporate a bulge or entasis as well as a taper, and, in the horizontal yards of a square rigger, the bulge is central and the taper symmetrical to both extremities. A gently curved stop is created by springing a steel bar into an appropriate elastic curve. In the case of Macnab's piece the longitudinal stop is a carefully plotted and shaped decaying sine wave, perhaps more akin to the template governing the tool path in a copy lathe. With each flute, the template was indexed an appropriate increment higher with each flute, so that in one revolution the template was elevated a full wavelength. The rippling of each flute is directly and encoded in and transferred from the template, and it is in this sense that we can't observe much in the way of emergence. But the ripples themselves, advancing longitudinally one wavelength with every revolution of the workpiece do generate a third, implicit helix, that the eye can trace almost as easily as the explicit helices of the flutes.



(a) (b) (c)

Figure 4: *Intermediate examples: (a) compound conical helices with rippled flutes. (b) compression of helical pitches – four flutes – inverted cones, (c) compression of helical pitches – three flutes*

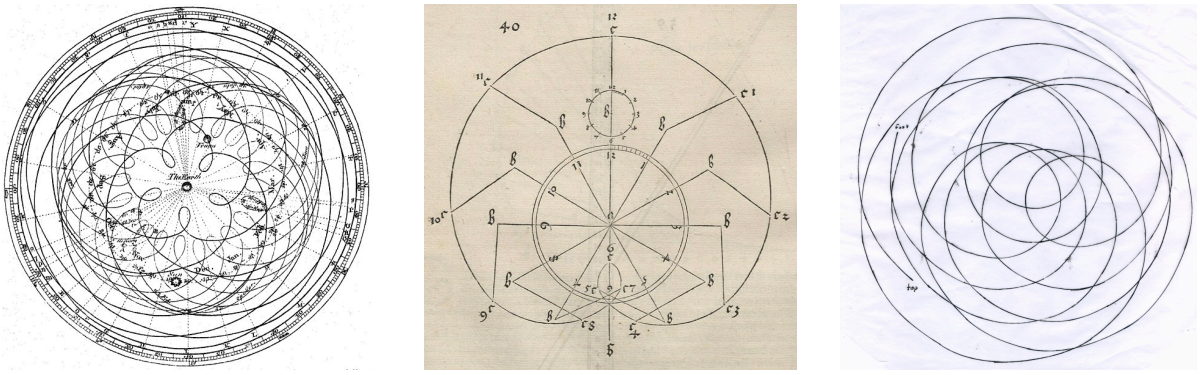
The pieces in (b) and (c) are characterized by axial pitches lengthening toward the apex. In both pieces, both pitches increase in concert: that of the winding or corkscrew helix of the body in its enveloping cone, and that of the flutes on the body. This is achieved by a fusée mechanism inserted between the root-stock gearing and the leadscrew. A fusée consists of two pulleys or drums, the input drum gathering in a cable and the output drum (arranged to offer resistance, thus keeping the cable taut) which turns as the cable

unspools If one of the grooved drums is cylindrical and the other is conical, then the effective 'gear' ratio between them gradually changes. If both drums are conical and opposed to each other, then the acceleration or deceleration of the output drum is intensified.

The split piece (b) is inverted from the conventional position of a cone. The void cleavage and the diameter opening as it rises implies a vessel rather than a flame, a flower rather than a shoot. At the base the body of the piece approaches a cylindrical form with the almost vertical flutes suggesting an ordinary Greek Doric column. The body of the piece fattening as the pitches compress changes the proportions entirely, evoking the Solomonic columns in the Baldachino of St. Peter's. The earlier columns now framing the crossing niches, or gothic columns at, for example the west front of Orvieto, also exhibit helical bodies and flutes of constant pitch and radius, but photogrammetry of St. Peter's shows a certain diminution. Compared to the earlier pieces, the flutes shown in (b) and (c) remain distinct even as they grow shallower. This is accomplished by changing the attitude of the circular cutter, as it climbs the leadscrew.

Cosmography

That compound orbits trace out trochoidal paths has been understood for some time. Ferguson's sky-chart in Figure 5 (a) below shows astronomical trajectories interpreted as geocentric orbits. Albrecht Dürer's "spider-line" is in the grip of eight apparent arms, each with an elbow joint, and with a forearm shorter than the humeri. In fact, the arms represent phases, 30˚ apart, of a single instrument that becomes invisible in its two straight and vertical moments. That the elbow and shoulder can rotate independently or as related by different functions is shown by the two dials. As an illustration introducing kinematics to the world the ratio of the imaginary gearing is 1:1. in these and related diagrams, Dürer consistently divides cycles into 12 or 24 hours, which makes the celestial reference quite explicit. Figure 5 (c) shows Macnab's nachine used not to move a workpiece relative to a tool, but to move a sheet of paper under a pen. We can see patterns emerging that never get to complete themselves before the vertical portion of the machine reaches its apical limit.



(a) (b) (c)

Figure 5: *Celestial trochoids: (a) Ptolemaic orbital paths as visualized by Ferguson in 1770, (b) Epitrochoid constructed by Dürer, (c) graphic trace of Macnab's* Lathe of Specific Intent*, 2005.*

Buckminster Fuller, in Figure 6, shows a four-orbit system of the moon about the earth about the sun about our galactic centre. A memory of this image, in fact, contributed to the concept of the planetary headstock. Fuller lived at a time when more complex systems were readily imaginable, including, say, a spacecraft or some cosmic gravel orbiting the moon, and our galaxy orbiting around larger centers of cosmic structure. Presumably for the sake of clarity, Fuller's diagram does not show the influence of "third" bodies or incidental transients. Nor does it show the expansion of spirals, whether from the big bang or other explosive event, or their decaying to a terminal point as orbital energy is lost to collisions and other effects. Fuller's text completes the image with the observation that systems add or subtract features, elements, and influences to and from one another and that they are "self-annihilative".

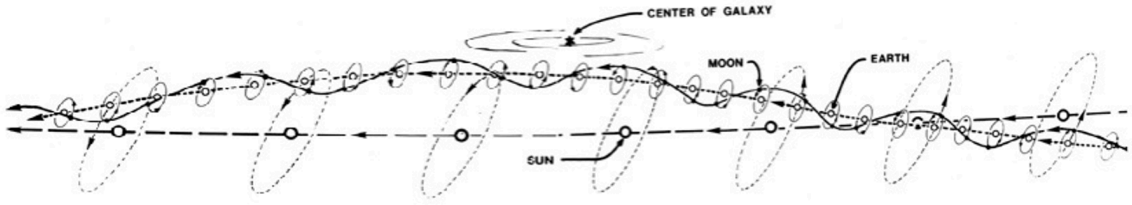


Fig. 1130.24 Reality is Spiro-orbital: All terrestrial critical path developments inherently orbit the Sun. No path can be linear. All paths are precessionally modulated by remotely operative forces producing spiralinear paths.

Figure 6: *Illustration of Spiro-Orbital reality from Buckminster Fuller's* Synergetics 2

Double-Ended Pieces

The vertical orientation of the pieces described so far restricts their formal associations to other vertical and grounded figures: the human, the plant, the flame, the obelisk, and what have you. Wall mounted horns or recumbent seashells were considered but seemed even more inclined to pictorial interpretations. Helices expanding from one point and contracting to the other could be more comfortably suspended than placed on a pedestal, expanding possible understanding of the pieces into a broader and more abstract realm.



Figure 7: *Compound helices appearing and disappearing.*

It must be understood that such pieces demonstrate an extreme level of geometric and woodworking virtuosity, as the two halves are made separately yet must be brought together so that both the body helices and the flute helices pass smoothly and seamlessly over the literal seam. Setting up the machine and laying out the out the pieces to enable such a fit is all the trickier when the helices graduate in pitch over the length of the piece. The suspended piece in Figure 7 is enveloped by a symmetrical pair of cones that transition into one another through a middle barrel form. As the enveloping radius passes through a single wavelength, the coincident pitch of flute and corkscrew helices decreases (or increases) dramatically: the shortest cycle is less than 25% the length of the longest. Macnab has made four or five forms in this family, each one exploring on a different relationship between envelope radius and body diameter and between bodily wind and fluted twist.

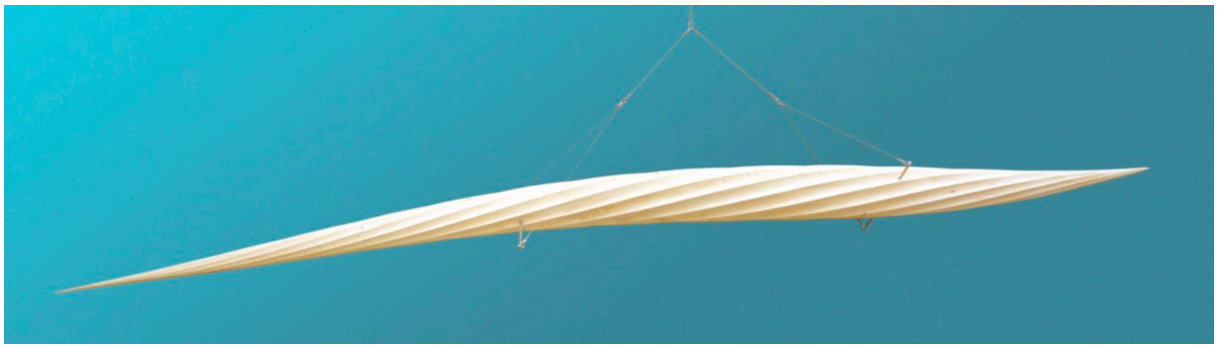


Figure 8: *Long-wavelength double cone*

A brief description of this piece: the greater challenge (I think?) of mating the two parts.

The emergence of an animal gesture of propulsion through air or water.

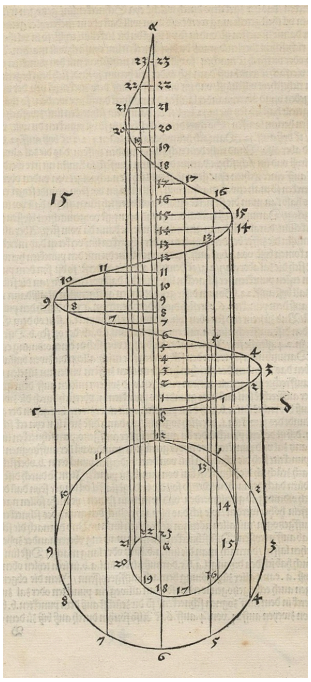
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The

Non-Repeating Form

In this section I want to talk about those pieces with fewer flutes, elliptical orbits, and other features that lead to those pieces with totally surprising results like that little semicircular tab that appears one piece.

The four-cornered cone would be another one to show as leading up to the example below? I think there's room for one more set of vertical images here. but I don't think there's room for another vertical image. Or is there? But we need to talk more about the relationship of machine and form, because there's a lot I don't yet get. I could compare the kinetic thinking of Dürer astounding for its day with the standing piece of yours that I believe (we need to talk about that) goes the farthest.



four-
cornered
helix or similar

Figure 9: *Kinematic thinking.*

This piece I find should go last. To me, as the coincidences between functions get more complex and little gets to repeat, they depart entirely from that sense of mathematical diagram, and yet they are just as



Figure 10: *Four-fluted suspended turning*

mathematically grounded. It also seems like a more realistic trajectory of a being through existence. I will want to expand that explanation for the simple reason of filling some text under the prime image to protect it visually from the “references” which are a kind of posterior.

Summary and Conclusions

John Macnab’s compound conical helices can be seen as gestures of aspiration, in the early pieces that’s quite straightforward. As the pitches and radii of the two (or) three helices develop non-coincident and even opposed trajectories, the implicit ends become more complicated and perhaps more lifelike. The suspended pieces develop another ambiguity, as they reach a high point in the middle as well as questions at either beginning and/or end. As complicated as they are, the various patters of repetition reflect an ideal process sooner than an actual existence. The progressions are there but hard to detect. The viewer shares in the aspiration to grasp, to realize what is happening in the piece. This matches the makers aspiration to realize the work literally, which means not only mastering the material, but devising and refining a machine so that it operates in tough reality. Aspirations are attained. becomes evident in this physical realm where the toolmarks remain and the process to those who haven’t seen it remains remains completely baffling. That this is done in a way that integrates encoding and execution in. as single device, rather than separating a disembodied code through adhesive deposition or some other ”digital”, and that the encoding is as fundamentally parametric as block-and-line software, in this day and age constitutes a heresy. But the heretic is not one who rejects a faith, they reject dogma and hold the faith more deeply.

Acknowledgements

What should be included – funding? Other assistance? This space id\s for you more than for me.

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