

The Nature of Telescope Design

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A beautiful telescope opens the Cosmos, opens our soul, makes us feel alive. Our search for this beauty, for this quality, is the essence of designing, building and using a beautiful telescope. Patterns of beauty are all around us: in the Cosmos, in us. The stark vastness of the sky surrounds us; objects both bright and dim are simply wonderful. The telescope in our hands feels alive; we have a sense of the telescope: it feels good.

A telescope, from an engineering perspective, looks quite simple: an optical assembly that points up and down and rotates side to side. Yet a telescope mirror is arguably the most precise surface made by man or machine. It is accurate to two millionths of an inch [0.05 microns]. Guiding on an object calls for accuracy to one part in a million. We need to find objects in the sky to one part in 20 000. Most amateur telescopes built today are not precision machined. Instead they are built with simple materials and tools. How can this be? And what new telescope designs wait to be uncovered?

Patterns, Symmetry and Process

A “living” approach results in a better designed, more usable and compelling telescope. Nature uses patterns, symmetry and process. A “living” approach results in measurable, objective beauty and quality. It is the emotional and compelling experience of using the scope. A “living” design repeatedly unfolds.

Design today, both hardware and software, unfortunately is sometimes thought of as an application of engineering principles and adjustments based on algorithms. It is not an organic process, the very process of Nature. This is a sign that something is wrong. Mimicking nature, design should be alive by growing organically through incremental development, filling in details later. This tends to yield working systems. Especially with robotics and comprehensive sensors, telescopes are becoming more aware of their surroundings. Therefore the design must be simple and the implementation simple. The design should be correct; however it’s better to be simple. Consistency and completeness are important but must be sacrificed when necessary for simplicity. Designs fail one element at a time.



My 20 inch through three iterations from 1994 to 2000. The initial design experimented with a single upper ring and computer control. Subsequent designs lightened the design.



Two of my A-frame designs: a 12 inch and a 24 inch that was trailered (1980).

A definition of elegant design is the optimal telescope that is achieved with the simplest, minimalist, least expensive effort. Elegance is the simplicity found on the far side of the complexity rainbow. The designer must avoid temptations like swinging for the fence to hit a home run, being too clever and solving frivolous problems. The result will be innovation. Don't sit in a bathtub waiting to yell Eureka.

Patterns

A pattern is a quality reusable solution to a common problem. Examples include stairs, gardens, model-view-controller and trusses. Advantages of patterns: begin work at conceptual level, worry about details at the last responsible moment, incorporate knowledge gained during designing and building and better anticipate changes, language that users understand, and judge what is of higher quality and more beautiful.

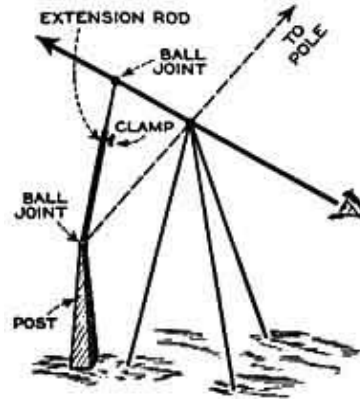
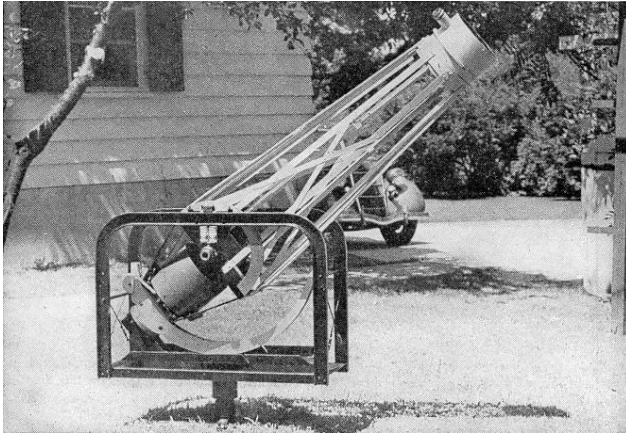
Common telescope patterns: trusses, rockers, image plane adapters, filters, observatories, thin mirror making, the Dob (breakthroughs occur when process used to vary symmetry breaking across many patterns, eg, John Dobson)

Symmetry

Nature unfolds by breaking symmetry yet preserving structure. Breaking symmetry is a structure preserving change that strengthens centers and sharpens boundaries. Beautiful scopes have common characteristics: strong centers, clear boundaries, local symmetries and voids.

Creativity is redefining us and our reality; it takes courage and endurance. Ideas can change; more than this they must change. We must master order so as to be open to chaos. To gain insight, we must love truth more than we hate error. Set high goals then identify critical functions, then eliminate or improve functions then refactor then repeat. Example is the telescope tube: optics on both ends held with cylinder; cut away portions of the cylinder keeping only those portions that transmit load, leaving a truss or bay pattern. A large single cylinder can be replaced with numbers of smaller cylinders.

Example: Morse mounting from the 1940's that used a mechanical drive system for an altazimuth mounting. This is the mechanical analogy to today's software that translates between equatorial and altazimuth coordinates.

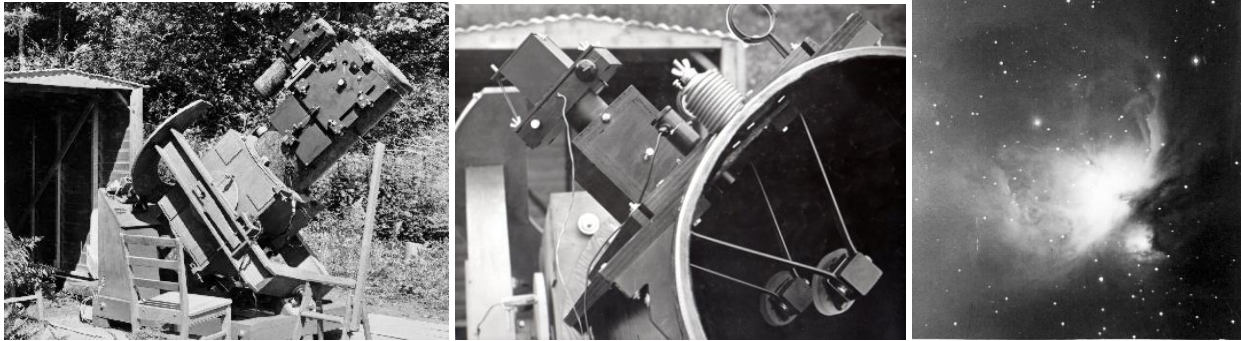


The Morse equatorial to altazimuth mechanical computer. Look at the car in the background to set the age of this mechanical computer.

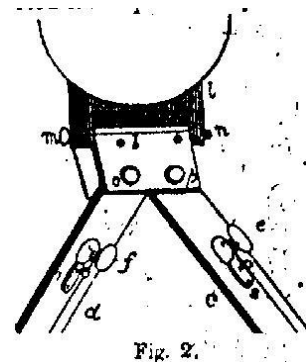
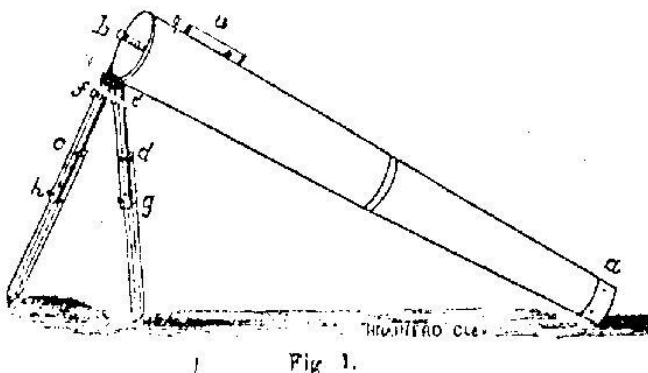


Patterns of equatorial mounts: a horseshoe 8 inch and a fork 10 inch with cold camera (1975).

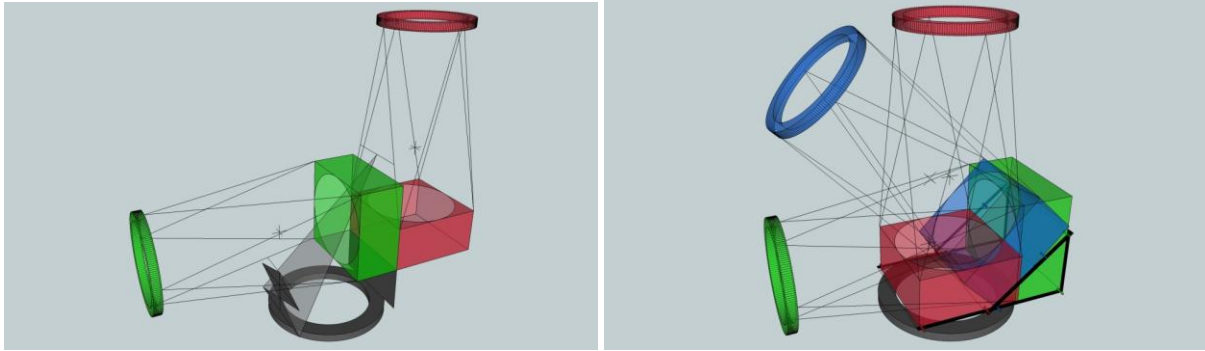
Example: the focal plane pattern. By providing a flexible interface, I could swap between visual and cold camera imaging. The imaging platform featured a centered guiding double diagonal arrangement where the second diagonal caught the light that squeezed past the initial diagonal. I did five minute nearly unguided images with a touchup of Declination adjustment due to slight polar misalignment with my 14 inch telescope.



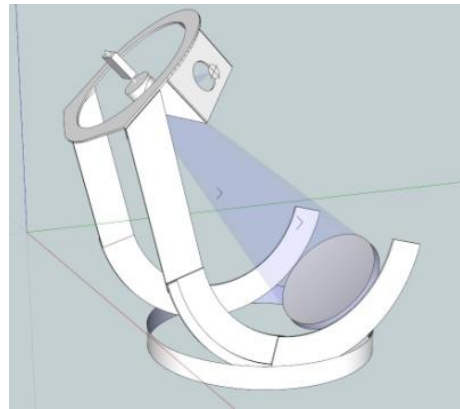
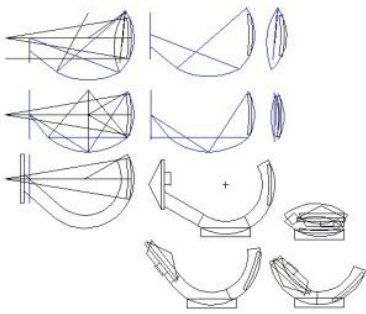
Example: originally I was bothered by micro slippage in roller drives used on ultralight telescopes. I cast about looking for ways to turn the curved drive arcs into linear motions. Inspired by Holcombe, I studied scissors mount because of the large change in leg length. I discovered that lateral changes in the center of gravity are objectionable. Consequently, I created the glide mount that negated the lateral CG changes but allowed vertical changes, the vertical changes being symmetrically equivalent. This also dove tailed with my investigation of elliptical altitude bearings in that the center of gravity moves up and down but not laterally. Still, I was not able to overcome the cantilevered situation at either the horizontal or vertical position without complicating and compromising the design by adding a third support point, creating an inverse altitude rim. At this point, the symmetrically equivalent large Dob altitude rims seemed simpler. Center of gravity at mid-point along with a minimized eyepiece swing and strengthening the altitude rims to become the optical tube assembly become most important factors to elaborate from. I added folding or Origami concept for transport. The unifying concept was to squeeze air out of the telescope. Taking the iterative, one step at a time, I choose to use familiar materials with a restricted budget to stay within the three strikes (innovations) you're out rule. This first decision is the first design and often involves the budget and materials. Any other sequence would have resulted in a different telescope.



The Holcombe Mount, popular in the 1800's



Evolution of my Glide Dob design



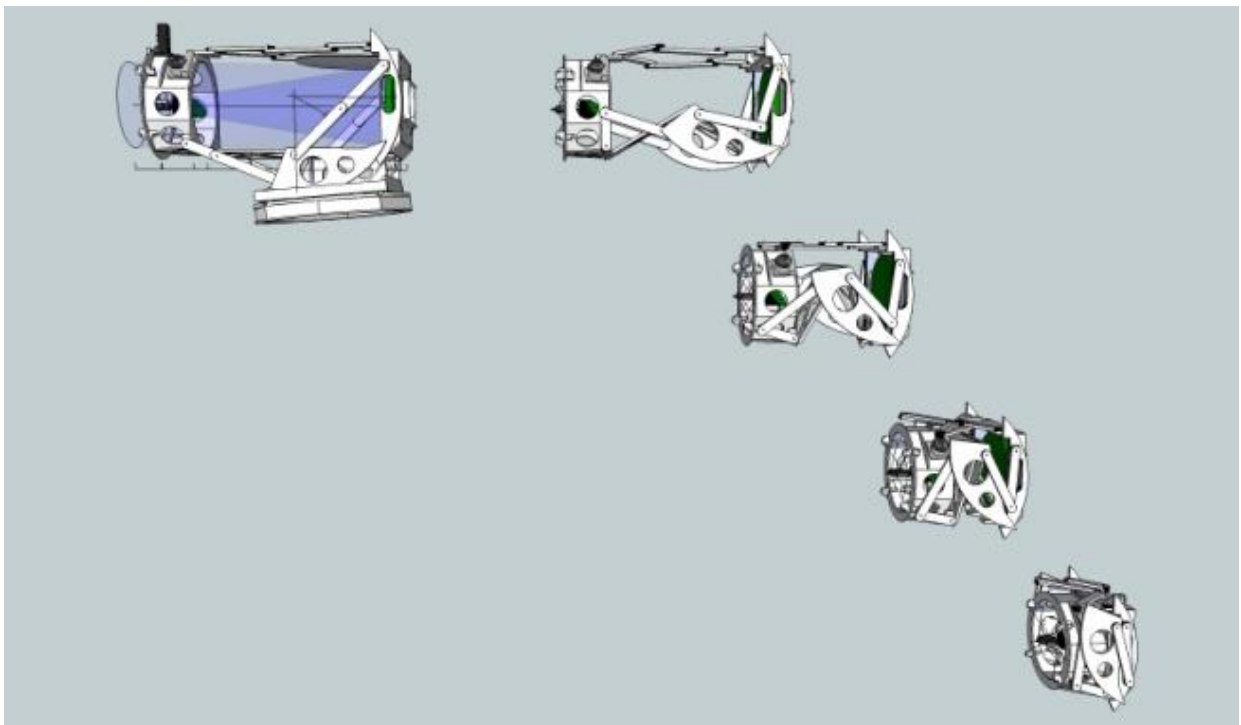
Origins of the folding design.



Star testing and mirror mount test stand. An original Coulter 13. My F3 mirror is a slumped Coulter mirror.



The ZipDob, observing at the Oregon Star Party and carrying the scope across the yard.



The Scissor or Spider Dob design

Process

Process is deliberate approach to symmetry breaking or structure preserving changes using patterns to create beautiful, living telescopes. Simplifying, removing and combining are periodically necessary. This beauty or quality is objective in that we observe it in nature and agree when we see it.

The process is simple: do the one most important thing in the simplest possible manner while preserving symmetry and structure; then repeat. Knowing what is the one most important thing to do comes with a strong unifying vision or product design and many hours of practice. To create new, living designs, it is also vital to be both a designer and builder, to have experience building as many components of the telescope as possible, whether grinding the optics or coding the control software or designing and building the mounting.

John Dobson imagined that the compelling purpose of a telescope on a sidewalk was to show the sky. That meant aperture. He gave up tracking, precision construction and Pyrex full thickness mirror blanks in order to fulfill his vision. He substituted low cost hand carry-able plate glass blanks. He substituted hand pushed stiction bearings for clamp with fine motion assemblies. He re-purposed concrete Sonotubes in place of aluminum and fiberglass tubing. He substituted binocular eyepieces for expensive telescope eyepieces. The culmination of all these changes was a new telescope design, compelling in its purpose. It's dominated telescope design for the past 40 years.

Conclusion

Telescopes ten years from now will look different than today. With patience and perseverance, you can create and build a new telescope design. Even a simple accessory like the Telrad can change amateur astronomy. I invite you to join others and me on the journey of amateur telescope making.

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