THE NEARLY PERFECT REFLECTOR

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In my two articles about Yolo reflectors, I neglected to mention another tilted component design, the Stevick-Paul telescope. This telescope lacks the all-spherical basis of the other tilted component designs, but the paraboloid on the first mirror is very mild and even if it is eliminated, it doesn't mess up the design too much. The key element is the nearly parallel ray bundle between the second and third mirrors. Anywhere there is parallel light, the preceding elements must be viewed as correction optics for the following focusing elements. In other words, the first two first mirrors only put on a negative aberration to the final focusing mirror. This is somewhat contrary to the optical philosophy of Newtonian or Cassegrain optics, which apply a strong focusing power to the first optical element, and in the case of the classical Cassegrain never entirely gives it up.

In a way, the Stevick-Paul resembles a Mersenne-Cassegrain telescope, a design that takes a parallel beam of light and sends it out as another parallel beam of light, just like the ordinary telescope including eyepiece. The Mersenne has the peculiar property of allowing you to look through it and see the target in focus, albeit with a large exit pupil that won't entirely get in the eye, and with a narrow field of view, which we supposedly left behind when we abandoned Galilean eyepieces in favor of Keplerian (inverting) eyepieces. The Mersenne is generally followed by a third focusing element (a simple achromat) and an eyepiece. It is like a pair of binoculars looking through another weak telescope.

More detail about the Stevick-Paul design is found at what seems to be a copy of David Stevick's missing web site at http://www.amsky.com/atm/telescopes/spscopes/spt.html (orig. URL at top)

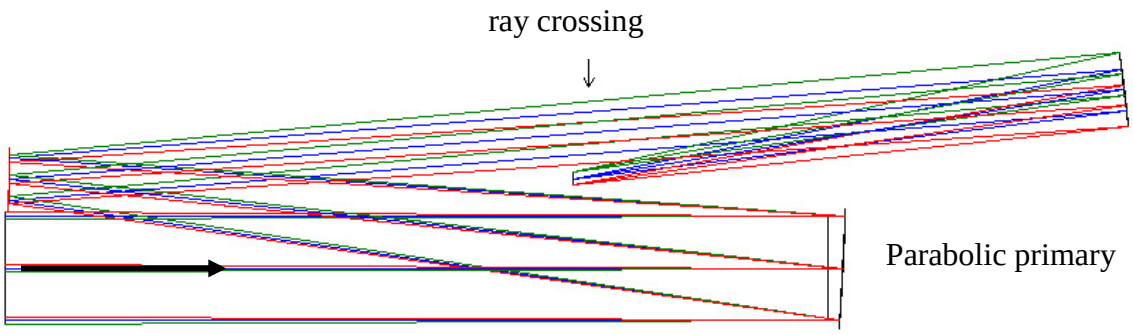
I took an 8-inch design listed there, cut it down to 7-inches for more clearance, and optimized various parameters, but it is still the same design as appearing there. It is listed in the Table and shown in Fig. 1.

There are a number of features that we should pick off the design table. First and foremost is the severe tilt of the final focus. It is tilted at an angle of 9.07 degrees. Now, some people don't know what this means, and think that a skewed focuser will cure it. What is happening is that the focal plane (actually a mild sphere) is tilted with respect to the central ray sent right down the bore of the telescope. If we have the desired condition of racking the focuser back and forth along this ray so the field of view doesn't shift, only a thin line is in focus.

		7 inch	f/13.5		
Mirror	Diam.	Radius	Figure	Tilt	Dist. to next surface
pri.	7	-188	Para	3.04	-56.4
sec.	4.25	-75.255	Sph	-5.32	75.255
tert.	5	-75.255	Sph	-2.28	-37.6
focus	0.83	-123		9.07	

Stevick's 8-in design reduced to 7 inches for greater clearance of optical beams

Thus, the only way of dealing with the tilt is to make a special focuser that tilts the eyepiece alone the correct amount. The eyepiece adapter should have a tilted hole drilled in it.



ZEMAX drawing of Stevick's design
Figure 1: Layout diagram of 7-inch f/13.5 Stevick-Paul reflector.

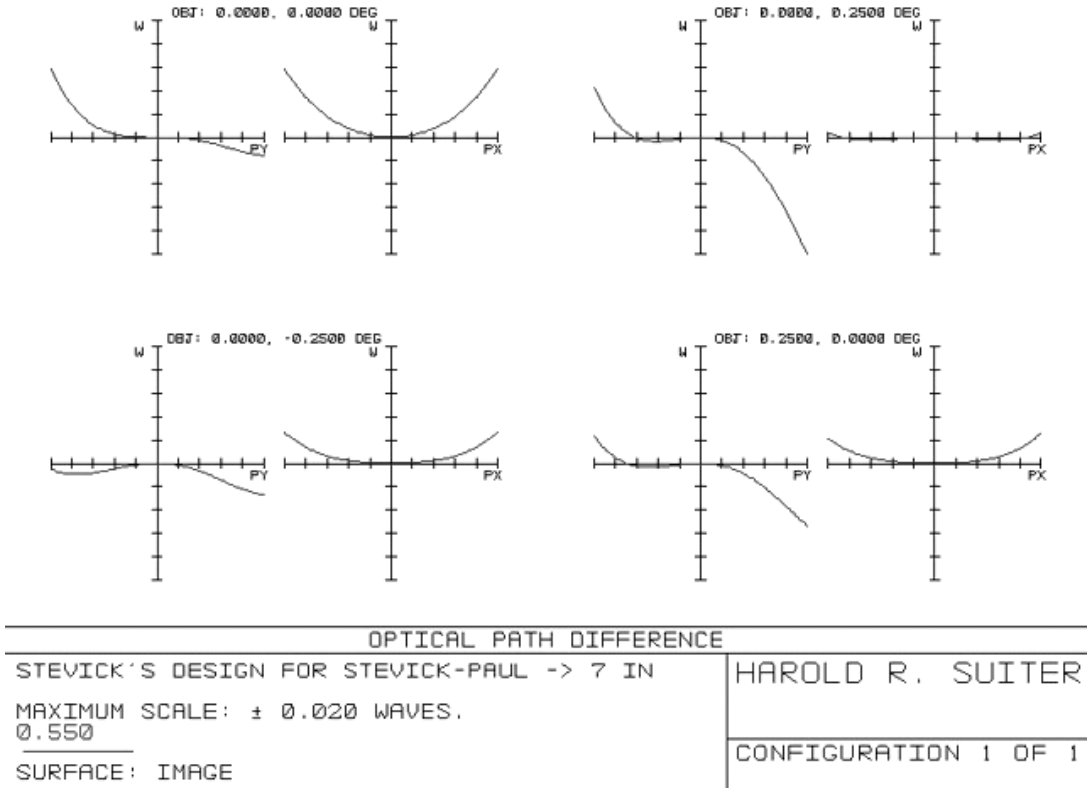


Figure 2. The wavefront of the Stevick-Paul over an area as large as the full moon.
The error never exceeds 1/50th wavelength of yellow-green light.

The other difficulty is shown by the ray diagram. There is very little clearance between the optical path and the focal plane. You can place a diagonal up to about 5 inches inside focus and lead the focus either up or out of the plane of the paper without interrupting the center of the field of view, but as you go sideways the diagonal nibbles an edge out of the pupil. Now all of this perhaps depends on the position of the stop, which Stevick didn't mention. I tried moving it from the front of the telescope to the main mirror, but it made little difference, so I don't think moving it will help. Incidentally, the place where the indicated ray crossing occurs is an alternate position of the stop. It is analogous to the position of the exit pupil behind the eyepiece of a normal telescope.