REFLECTIONS / REFRACTIONS
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A Child of the 60's Visits 'the Cape':

The Launch of MAVEN

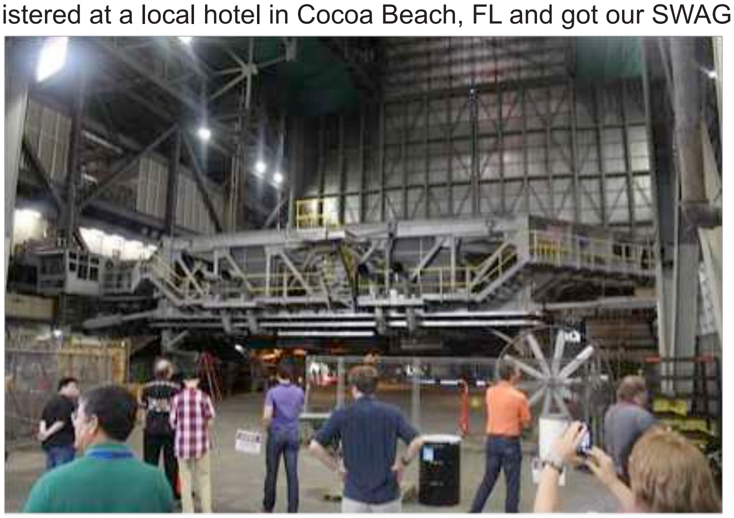
by Christopher Sarnecki

Growing up in this country in the 60s, one could hardly avoid developing an interest in space science when witnessing the flights of the Mercury, Gemini and Apollo astronauts. Many of my generation have a strong interest in space science. It's possibly why so many of our Lowbrow members are of a 'certain age'. The landing of men on the Moon was certainly one of this generation's signature events. These experiences have fostered in many of us a lifelong interest in astronomy and space travel. So imagine my surprise when I found out I was getting an invitation to attend a rocket launch at 'the Cape'. Cape Canaveral that is.

Earlier this year two of my daughters received an invitation to attend a rocket launch from a friend of theirs who happens to be a scientist working on NASA's MAVEN spacecraft. It seems that the invitation was open to anyone interested in attending as long as you were remotely connected to the folks forwarding the invitations. So my wife and I signed up. How could I refuse? I'm a child of the 60s after all.

What is MAVEN you ask? MAVEN stands for Mars Atmospheric and Volatile Evolution Mission, and is NASA's latest science mission to the red planet. The MAVEN satellite mission is designed to explore Mars' atmosphere or at least what's left of it. Scientist hope to use this information to have a better understanding of the Martian climate change over the last 4 billion years. The University of Colorado's Laboratory for Atmospheric and Space Physics (LASP) is the lead institution for the MAVEN mission science program. The MAVEN satellite will deliver eight scientific instruments to Mars. Scientific instruments were developed by LASP, the University of California at Berkeley, and NASA's Goddard Space Flight Center. The MAVEN spacecraft was built by Lockheed Martin and was scheduled to be launched on an Atlas V rocket on November 18th.

So we made our travel plans and in mid-November, high tailed it to Florida. On launch-2 (minus two) day (that's two days before the scheduled launch) we registered at a local hotel in Cocoa Beach, FL and got our SWAG (stuff we all get) - MAVEN stickers/buttons/mission patch, printed material on the mission, and our VIP guest pass for launch day.



On launch-1 day we were treated to a special tour of the Vehicle Assembly Building (VAB) and the MAVEN launch pad. Now the VAB, for those of you that aren't aware of it, is the building where the Saturn V rocket that took the astronauts to the Moon was assembled. The now cancelled space shuttles with their solid rocket boosters were also assembled in the VAB. So how is it that the general public can get into the VAB? Since cancellation of the shuttle program, it seems the VAB is no longer an ordinance storage facility as solid rocket boosters are no longer assembled there. We spent an hour inside and on the main floor of the VAB. At one time this was the largest building by volume on the planet. Now I understand it is the 5th or 6th largest structure. It has been said this building can be seen from space. As an Architect by trade, I've never seen so much cross bracing on a building. This place is vast. The layout is not how I imagined it. There are low bay areas for processing rocket motors, and four very high bays for rocket assembly. There is a main isle that runs down the middle of the VAB between the low and high bays pods. Each of the four high bay pods are accessible by very large vertical doors that move the assembled rockets out of the structure using a giant tracked vehicle called the crawler. Why four high bays you say? It seems in the early days of the Moon program NASA thought they would be sending rockets out to the launch pad at a rate that would require this many pods.

Next on our tour was a visit to the MAVEN launch pad itself. Mind you this is launch-1 day, and the Atlas V is on the LC-41 (Launch Complex-41) pad and is fully fueled up for tomorrow's scheduled launch. But first, we cross the NASA Kennedy Space Center (KSC) side to the Cape Canaveral Air Force Station (CCAFS) side of the Cape. The CCAFS is were many of the 'first' in NASA's occurred. Think Mercury, Gemini, and Apollo flights. I make a mental note that when I return home I must reacquaint myself with the rich history of this strip of land. A retired NASA employee, acting as our tour guide, lets us off the bus right next to the security fence for LC-41. The MAVEN rocket is less than a Canadian football field away (<150 yards). We get to spend another hour eyeing the rocket, launch pad, and associated launch facilities serving this site. LC-41 is served by a much smaller VAB. We notice the MAVEN Atlas V rocket is mounted on mobile launch pad supported on paired railroad tracks that lead from the assembly building to the pad. The Atlas V with its MAVEN payload perched above, tops out at just under 200 feet. Pinch me, I'm at a very happy place.

Intermission:

***Old Brown Dog Ale*, Smuttynose Brewing Co., Portsmouth, NH. - Sweet Brown Ale goodness with a moderate syrupy body (that's good by the way), and a slight bitter ending (also good!). Three thumbs up.**

***Robust Porter*, Smuttynose Brewing Co., Portsmouth, NH. - Deliciously sweet 'n smoky chocolate with no coffee bite. Damn nice lacing on this great Porter!**

***Tank 7 Farmhouse Ale*, Boulevard Brewing Company, Kansas City, Missouri - A solid American interpretation of a classic Belgium style. Full bodied with aromatic nose and well defined citrus notes. I'll defiantly have another as this is an epic brew.**

The remainder of the day is spent at the Kennedy Space Center Visitor Complex. The KSC Visitor Complex is NASA's first stop for the public when visiting the NASA side of the Cape. Here you can get bus tours to the VAB (drive by) and LC-39A/ LC-39B were the Saturn V rockets, that took the astronauts to the Moon, and the space shuttles were launched. You can also catch a bus to NASA's Saturn V Museum where you can view a real Saturn V rocket inside the building. The KSC Visitor Complex has lots of places to go and exhibits to see. Newly opened this year is the space shuttle Atlantis exhibit. The KSC spent a $100 million on this exhibit. NASA notes no public funds are expended to support any of the KSC Visitor Complex exhibits/operations. Seeing the Atlantis close up I'm awed just how massive this space craft is. Everyone who appreciates space science owes it to themselves to visit KSC. This place is a 'Wally World' for space geeks.

The next day is launch day, or at least the day of the scheduled launch. With a rocket launch there is no guarantee this train leaves on time. As one of the approximately 5,000 MAVEN VIP Guest, we assemble at four remote locations around town and await a fleet of buses to carry us the the special NASA launch viewing site. The buses disgorge their passengers on the NASA Causeway, running between KSC and CCAFS and subdividing the north end of the Banana River. Note that the Banana River not really a river. Yet another retired NASA employee, also acting as our tour guide, tells us our viewing site on the causeway is approximately 4 miles from LC-41, and it's all over water. Sweet, this is gonna be great I think. While we are waiting the approximately two hours before the launch, we listen to the pre-launch scuttlebutt NASA has provided for our listening enjoyment. Seems there is this guy named 'Roger' doing all the work. All at once, we hear "Such-and-such monitor has gone RED LINE... ...Roger". A few moments later another pre-launch specialist indicates "Go ahead and check out such-and-such monitor... ...Roger". They tell us every rocket launch has some last minute problem that can put the launch in jeopardy. Hoping for the best, another moment later we hear "Such-and-such monitor problem is cleared. Go for launch... ...Roger". See what I mean about Roger?

Now before I go on, I must digress. As my kids couldn't make this trip, I wanted to thank the rocket scientist whose round about invitation brought us our good fortune. There was only one problem. I have never met him or even talked to him. As we are waiting for the launch, my wife and I overhead the crowd next to us repeat the names of our MAVEN scientist and that of his SO. We're thinking could that be...? I decide to take a chance and walk up to this guy, surrounded by his entourage of what was about a dozen family members, and indicate "My daughter is watching your dog". Since my daughter couldn't make the trip, she agreed to watch their dog while they were out of town. Right away our MAVEN scientist knows who I am. We exchange pleasantries and we ask about his role in the MAVEN mission. Yup, we were siting next to each other in the crowd of 5,000 in attendance. Small world as they say.

Now back to the launch. The day started out clear and sunny, and just like observing in Michigan, the clouds started rolling in. Not just a single layer of clouds, but two layers of clouds. An upper layer of overcast and a layer of under running cumulus like clouds. Everyone around us is wondering if a launch will take place with such clouds hanging over the pad. The pre-launch announcements were still proceeding. From a couple of hours, to a half hour, to minutes, to... "We're GO for launch... ...Roger". The count down begins. The masses join in at "5 - 4 - 3 - 2 - 1!". Then it's LIFTOFF! But not before the Atlas V seems to sit on the pad ejecting an enormous cloud of smoke off to one side. Finally, after what seems like forever, MAVEN lifts itself off the pad, clears the tower and the lighting protection catenary, and rises slowly at first. Then an instant later the rocket gains momentum and quickly disappears into the bottom of a cloud. Just then we hear the delayed acoustic signature of the Atlas V and watch the rocket heal over to the east through a lucky hole in the clouds. Awesome!

Basking in a MAVEN launch afterglow, I e-mail our MAVEN scientist thanking him for everything and send him a few of my photos. He responds with a message indicating the launch "was the most precise trajectory launch for the Atlas V in the vehicle's history." He informs us that if we want to follow the MAVEN mission further we can do as at the folding web site - http://lasp.colorado.edu/home/maven/

For anyone with even a passing interest in space, you owe it to yourself to visit KSC and see for yourself the rich history this nation has in space travel and space science. I understand the annual tax each of us pays for support of NASA amounts to the cost of a large candy bar. For my money, NASA does an amazing job.

The Meade 2045
102mm 1000mm F/10 Schmidt Cassegrain Telescope

By Tom Ryan

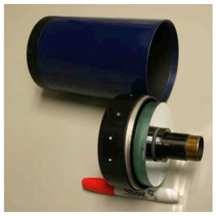
Over the years, I've designed, built, and used a lot of telescopes, but I've only purchased one or two commercial telescopes, and those were usually for some single purpose, like measuring the number of photons returned from Rayleigh scattering of laser beams in the atmosphere or making my brother-in-law jealous of what he assumes are my toys. After fulfilling their purpose, the telescopes were placed in storage. The telescopes I designed were mostly for special government projects. As a result, I know a lot about how to make an excellent, purpose-built telescope, but almost nothing about how to make an economical, commercial one. There is a huge difference between the two. In a purpose-built telescope, price is not the biggest consideration. Instead, the telescope must accomplish the task it was designed to do, perfectly and without compromise. In commercial telescopes, the telescope must do the same thing, but additionally, must do it at a low cost, be attractive enough for people to want to buy it, and reliable enough to last far beyond its initial use. It is also nice if it doesn't weigh too much and is easy to operate. Making a telescope a commercial success is far harder than making a telescope a technical success, and every time I think of that fact, I'm reminded of the words of Walter Hassan, Jaguar's main designer of the company's V-12 engine. After designing the racing engine for Jaguar's short-lived racing effort in the 1960's, he said he faced the much harder task of converting his racing engine design into one that would power their road cars.

When one of my customers needed a physically short, one meter focal length telescope of about 100 mm aperture, I recommended we make an expedition to eBay, where we found a used Meade 2045 from 1986 or so, for $320.00. (For this customer, this price is very close to Free, especially when compared to the cost of one that I designed.) And to learn the Secrets of the Commercial Manufacturers, I immediately started to conspire to come up with reasons to take it apart and reverse-engineer it.

Coming up with a reason for taking it apart proved to be fairly simple. The telescope was to be mounted on this manufacturer's particular Engine of Destruction to serve as both a finder and a tracker, so it had to be fitted to the existing mechanical parts. (We threw the mount away.) Alignment was critical enough so that we couldn't rely on the single ¼-20 camera mount that the Meade came with; we would have to drill into the scope itself to solidly brace it, and we didn't want to hit anything critical. This required that we know what was inside the tube, and this required that we take it apart.

I will admit that I took it apart further than what was strictly necessary, but I did it on my time, not my customer's, so I feel that the exercise was not entirely unethical. Also, the Meade had focus-shift, and that needed to be fixed, if possible.

Focus-shift, for those who are not familiar with commercial Schmidt-Cassegrain telescopes, is a phenomenon whereby the image in the telescope's eyepiece or camera shifts laterally across the field when the telescope's focusing knob is turned. It is annoying to visual observers, a real problem for photographers, and completely unacceptable to people using these things for target acquisition and tracking. I felt quite confident that, with my background and experience in bespoke opto-mechanical design, I could disassemble the mechanics and optics, analyze the problem, devise a fix, and reassemble it, better than new. After all, it is a simple mechanical device. What could possibly go wrong?



I took the Meade apart and made a CAD model of the tube assembly and analyzed the optical components in an interferometer and on a radius-measuring bench. Figures A and B show pictures of the CAD model.

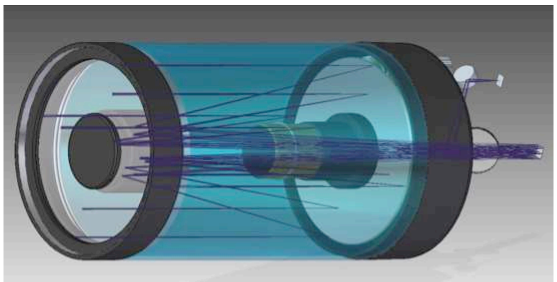


Figure A

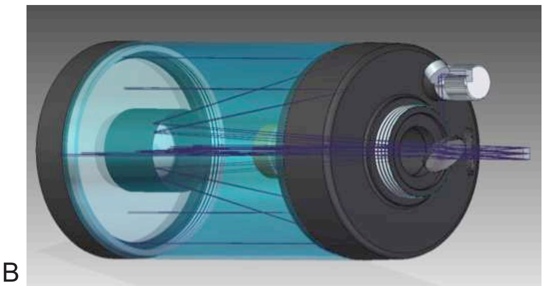


Figure B

The CAD model I made is just of the tube assembly, and as such, does not have the right-angle diagonal prism or the ¼-20 mounting base or the fork mount that came with the scope. However, it does include the optics and light path for simultaneously imaging in the visible while tracking in the infrared.

The Meade Schmidt-Cassegrain Optical System

The optical system proved to be extremely interesting. I believe that both the primary and secondary mirrors are spherical, although I was not able to measure the convex secondary's figure during the time I had it. I'm basing my conclusion solely on the sense I got from seeing how the rest of the scope was manufactured. Commercial products, like the companies that produce them, are a result of the design philosophies and operational constraints of the company's director. The iPhone, Apple, and Steve Jobs are an obvious example of this chain, as is Windows, Microsoft, and Bill Gates. (See, for example, the TED talk here: http://www.youtube.com/watch?v=ppDWD3VwxVg, where Bill Gates releases mosquitoes into an auditorium while saying they are not infected with the Malaria virus.) Setting aside analogies between Windows and "virus-free" mosquitoes set loose in an auditorium full of people, every product reflects its maker, and the Meade is no exception to this rule. Briefly, the scope is economical in the extreme. Two screws are not used when one will do. This is not to say that the design is bad. It is actually quite good, because it is difficult to make something simple and still have it work.

I had always thought that the secondary had to be elliptical in a Schmidt-Cassegrain, but it turns out that I was mistaken. A spherical secondary is possible and would be one of the things that makes these instruments commercially feasible. Spheres are falling-off-a-log easy to make, and convex ellipses of revolution are not. The difference between an elliptical and a spherical secondary can be taken up by slightly changing the figure on the corrector plate. In this scope, the corrector plate is basically a disk cut from a reasonably nice piece of inexpensive commercial float glass, but it has a fourth-degree curve on it with inflection points which should be at the 87% zone to minimize chromatic aberrations. This curve makes these instruments almost impossible for amateur telescope makers to make by free-form hand polishing methods, but easy as pie for a commercial firm that plans to make hundreds or thousands of these and can invest in some special tooling to make their production simple.

In 1930, Bernhard Schmidt, the inventor of the Schmidt camera (and by extension, the telescope we are dissecting) invented a simple method for making the fourth-degree curve on a corrector plate. He deformed the corrector plate by supporting it at its edge and applying a vacuum on one side. When one side is polished to a sphere in the deformed state and the plate is then released from the vacuum, it has the correct curve on one surface. Tom Johnson of Celestron improved on this method in U.S. patent #3,837,125, as did John Krewalk of Criterion (Pat #3,932,148), and the Japanese optical company that made the Meade 2045 optics was surely not ignorant of these methods. Thus, all three optical surfaces in the Meade could be produced by making spheres, and this fact, more than anything else, is why these instruments cost less than $10,000 and are (usually) diffraction-limited.

I placed the optics on a radius bench, measured the radius of curvatures of the primary and secondary mirrors, and with the advertised claim that the instrument is f/10, reverse-engineered the optical prescription using the Zemax optical design program. The optical layout appears in Figure C.

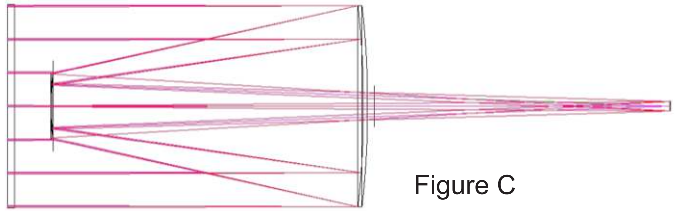
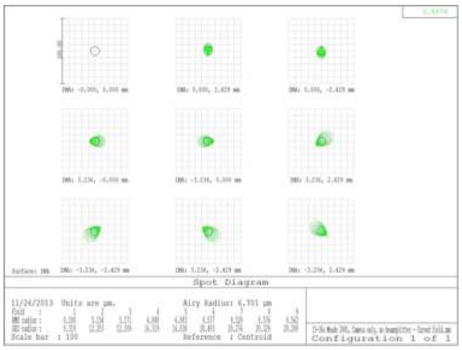
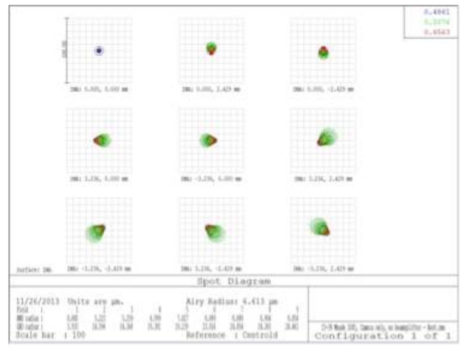


Figure C

The monochromatic spot diagram (the colors you can see with night vision – basically blue-green) appears below, along with the polychromatic spot diagram. As you can see, the Meade can be diffraction-limited at the center of the field, and is really, really good near the edges of the field. There is some coma, but not a lot, and the comatic tails are faint enough to be visually hard to see.





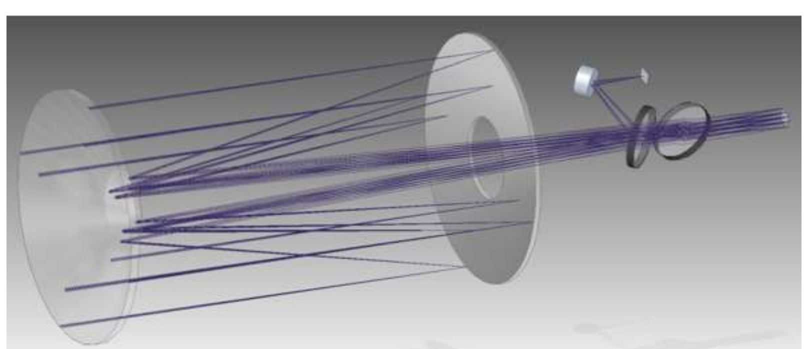
<u>Modifying the Optical System for Imaging and Tracking</u>

This particular telescope, you may recall, was intended to be used as an imager in the visible and a tracker in the infrared. The best way to make a telescope into a dual purpose system like this is to insert a beam splitter into the optical path and direct the photons toward two detectors. If both detectors use the same wavelengths, then the beam splitter will divide the photons and each detector will get half the light, but if the detectors use different wavelengths, as these do, then the beam splitter can be designed with a coating which will reflect one wavelength band and transmit the other, and both detectors will end up with all of their respective photons.

There are (at least) three ways to make a beam splitter. The first is to use a pellicle, which is a bubble-thin film of acetate held at 45 degrees to the beam, and which adds no aberrations to either the reflected or the transmitted beams. Unfortunately, it is a bubble-thin film of acetate, and therefore is not very durable. The second is to use a cube beam splitter, which is cheap and durable, but which adds ghost reflections to both beams, along with all of the aberrations associated with passing a converging beam through a thick plate. The third method is to use a plate beam splitter, which adds aberrations only to the transmitted beam, which is sometimes OK, and is the method I used here.

Normally, beam splitters which split by wavelengths are designed to transmit the longer wavelength and reflect the shorter, because these coatings are easier to make. This works out well for the optical designer who is trying to get a nice, sharp image in the visible, because the reflected light is not aberrated when reflected off a flat surface. Unfortunately, CVI did not offer a coating that met the wavelength division requirements in a long pass beam splitter, but did in a short pass beam splitter. This meant that the reflected, infrared tracking beam would be perfect, and the transmitted visible imaging beam would have all of the coma and astigmatism that can be added by passing a converging beam through a tilted parallel plate. According to Zemax, the resulting images were not at all pretty.

Fortunately, many years ago I had read, in the Annals of the Lowbrows, in ancient literature recounting the final inspection of the 24" telescope mirror, that the optical testers had corrected the aberrations of a tilted plate, used in the test, by adding a second tilted plate to the optical path. At the time, I didn't know what they were talking about, but now I began to wonder. I added a second tilted plate, at the same tilt angle (45 degrees) as the first plate, but rotated 90 degrees along the optical axis and viola! the imaging returned to its original quality. Or at least, to almost its original quality. These two plates, beam splitter and corrector, are shown in the image of the optical layout on the right.



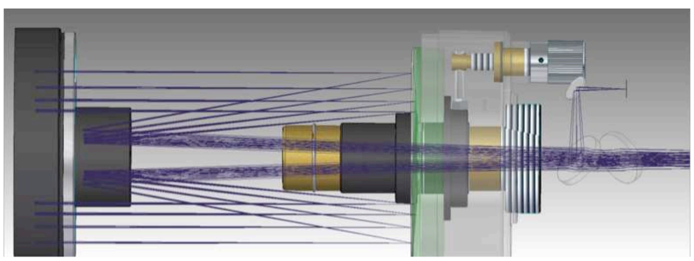
Focusing the Standard Meade Schmidt-Cassegrain

Some very smart person at Celestron decided to make their telescopes focus by moving the primary mirror along its axis, and of course, Meade copied it, patented it, and sued Celestron for using the idea that Meade had so cleverly patented. No, wait! That was the go-to electronics system on the mount. But in any case, being the innovators that they are, Meade also copied this very unusual focusing method, and for good reason. Celestron hadn't patented it (the fools!) and it allows the optics to focus on objects much closer to the scope than would be possible for a normal draw tube mounted on the back. (This opens up the birding and squirrels market, which is actually much, much bigger than amateur astronomy.) It also made a single, stable mounting point for any equipment that the user wanted to mount on the scope. It did have one drawback, however. If the mirror doesn't slide in a perfectly straight line as it is being focused, the image shifts sideways.

Opto-mechanical engineers lie awake at night trying to solve problems like this, which are created by overly clever optical engineers and supported by executives with degrees in art and advertising who have a decidedly imperfect understanding of how difficult it is to do some things, but who are sure about how much they like bright, shiny objects. (This is why your scribe fills both roles. One side can tamp down the insanity of the other.)

Moving the mirror accurately presents a problem. How much of a problem can be seen by doing an analysis of the mechanical and optical system tolerances. That is, by looking at what happens when your optics aren't placed where your optical design program, accurate to 64 decimal places, thinks they should be placed. I did this analysis for the Meade 2045, and the results indicate that, in order to keep the image motion down to the diameter of the Airy disk (which you can see when you try to split double stars, and is comparable to atmospheric seeing errors), the tilt on the sliding mirror mount has to be kept to 25 millionths of an inch along its length, or less. That is about one wavelength of green light, by way of adding some perspective. Let's see how the Meade engineers solved this problem.

In the ghost view (right), you can see that the chromed focusing knob is firmly attached to a captive cylindrical brass nut. When the knob is turned, a non-rotating screw inside the nut advances or retracts. At the end of the screw is a hole with a slip fit for a pin which is locked to the sliding central hub. As the screw advances and retracts, it pushes on the pin and thus causes the hub to slide forward and back. The hub, which carries the primary mirror, slides on the brass baffle tube, which in turn is firmly screwed and glued into the rear casting.

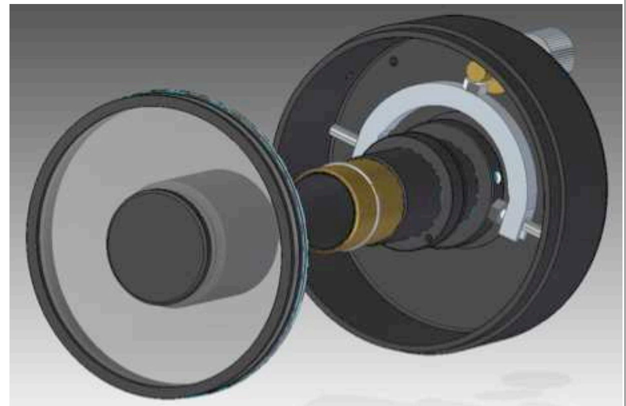


Note that the screw pushes on only one side of the hub carrier, far from the axis of motion. This makes for an overturning moment, very similar to opening a long drawer by pulling on only one of the drawer pulls. If there is clearance between the hub and the baffle tube, this moment arm will cause the hub and the mirror to tilt back and forth on the baffle tube. Meade attempted to reduce this tilt by making the sliding clearance between the hub and the baffle tube small, and by filling the space with grease.

Grease plus optics is usually a bad idea. Note that the grease has migrated across the back of the rear casting in this scope, which is what grease does. Removing the grease allowed even more play between the hub and the baffle tube. I measured the clearance as 0.0015", which might not sound like much, but it translates to a focusing shift of about 1.5 mm in the image plane.

Modifying the Standard Focusing Arrangement

My goal was to eliminate the clearance between the hub and the baffle tube. I drilled and tapped three radial holes in the hub's rear flange, filled the holes with Teflon buttons, and pressed the buttons against the baffle tube with setscrews. I was only able to do this on one end of the hub, because the front end is too thin to support this modification. The Teflon buttons eliminated the clearance at one end of the hub, but increased the sliding friction, and overall, the hub became harder to move. I decided that the increased friction from the Teflon and the overturning moment could be reduced by pushing on the hub through its centerline. To this end, I made a yoke, supported and driven by the focusing screw and acting on two pins on opposite sides of the hub, to drive the hub straight along its axis.



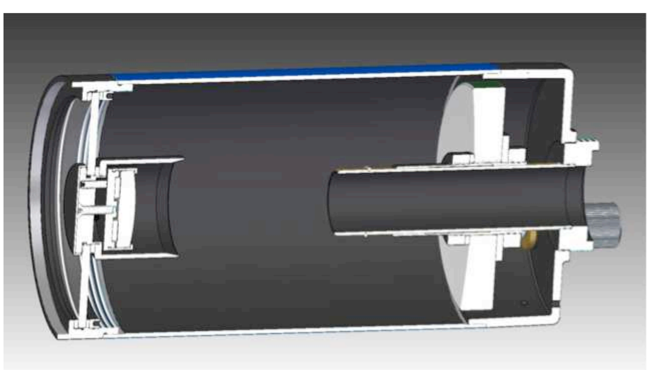
This didn't work at all. The yoke's floating pin was too small in diameter to support the moment arm and bent when trying to move the hub. A larger diameter pin would not fit inside the focusing screw.

My next attempt extended the yoke to the other side of the hub and pinned its opposite side to the rear casting. This turned the bending moment on the focusing screw into a pure push, and this worked very well. The drawback is that the focusing range is cut in half, but this particular scope is only focusing on objects between one and ten kilometers away, so this was not the drawback it would ordinarily be. I replaced the grease (bad Tom, but only at the front of the hub) and I carefully cleaned off all of the excess. When I re-measured the total tilt of the hub due to focusing back and forth, I found it had been reduced to 0.000,180", which is not the 0.000,025" desired, but is what I could achieve with the amount of time and resources I had. (I do believe that putting Teflon pads in the front would take it the rest of the way.) The resulting tilt error was too small to visually notice when I star tested it with a 26 mm eyepiece, but I still need to look at it under higher power to see how much tilt remains.

When I reassembled the scope, I had to realign it, but that was simple because there is only one adjustment; tilting the secondary. People say that they've improved the scope's performance by rotating the corrector plate, but that seems fairly nuts to me. Rotating refractor lenses in a doublet makes sense, because the individual lenses can have wedge, but there is nothing in the Schmidt-Cassegrain design that lacks axial symmetry. However, I wasn't there when they rotated their optics, so I can't say for sure if it helped.

In any case, I just reassembled it and put it on a tripod and looked at a star. I loosened and tightened the three set screws on the back of the secondary until the out-of-focus star image in the middle of the field had the shadow of the secondary centered, and that was that. In focus, stars were round and pin-pointy near the middle of the field, slightly less so near the edges, which could be the eyepiece.

One thing to note from the CAD drawing cutaway is the fact that the secondary is held in place by a single central screw pulling it toward the corrector place, and three tilt-adjusting screws near the edge which push it away from the corrector plate. Thus, if you loosen the central screw too much, the secondary will drop off the end of the screw and will fall onto the primary mirror. A careful designer might consider this a design flaw, but a frugal one would not.



Conclusion

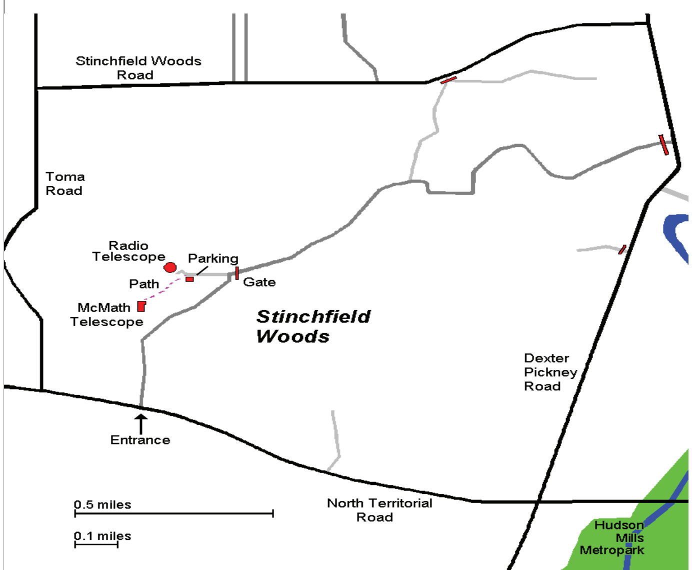
I've always believed these scopes offer an incredible amount of value for the price, and I've always wondered how their manufacturers did it. After taking one apart, I would say that they did it through a combination of clever optical manufacturing processes (make everything spherical, and bend it if it isn't), of keeping everything simple, and by manufacturing everything either on a CNC lathe (which is inexpensive to run on a production basis) or on what would be simple drilling fixtures. In 1985, a nice CNC mill would have cost around $180,000, would have run on punched tape, and would have been slow, and I'm pretty sure that for those reasons, no part of this scope ever saw a CNC mill.

The focusing device I made (on a mill) would have reduced focus shift, but also would have increased both weight and cost, so they left it out. The result was still a brilliant commercial success, and remains a really nice scope today. As for fixing its minor flaws with solutions which increase cost and complexity, Steve Jobs said that a successful product designer's most important tool is the word 'No".

Places & Times

Dennison Hall, also known as The University of Michigan's Physics & Astronomy building, is the site of the monthly meeting of the University Lowbrow Astronomers. Dennison Hall can be found on Church Street about one block north of South University Avenue in Ann Arbor, MI. The meetings are usually held in room 130, and on the 3rd Friday of each month at 7:30 pm. During the summer months and when weather permits, a club observing session at the Peach Mountain Observatory will follow the meeting.

Peach Mountain Observatory is the home of the University of Michigan's 25 meter radio telescope as well as the University's McMath 24" telescope which is maintained and operated by the Lowbrows. The observatory is located northwest of Dexter, MI; the entrance is on North Territorial Rd. 1.1 miles west of Dexter-Pinckney Rd. A small maize & blue sign on the north side of the road marks the gate. Follow the gravel road to the top of the hill and a parking area near the radio telescopes, then walk along the path between the two fenced in areas (about 300 feet) to reach the McMath telescope building.



Public Open House / Star Parties

Public Open Houses / Star Parties are generally held on the Saturdays before and after the New Moon at the Peach Mountain observatory, but are usually cancelled if the sky is cloudy at sunset or the temperature is below 10 degrees F. For the most up to date info on the Open House / Star Party status call: (734)332-9132. Many members bring their telescope to share with the public and visitors are welcome to do the same. Peach Mountain is home to millions of hungry mosquitoes, so apply bug repellent, and it can get rather cold at night, please dress accordingly.

Membership

Membership dues in the University Lowbrow Astronomers are $20 per year for individuals or families, $12 per year for students and seniors (age 55+) and $5 if you live outside of the Lower Peninsula of Michigan.

This entitles you to the access to our monthly Newsletters on-line at our website and use of the 24" McMath telescope (after some training).

A hard copy of the Newsletter can be obtained with an additional $12 annual fee to cover printing and postage. Dues can be paid at the monthly meetings or by check made out to University Lowbrow Astronomers and mailed to:

The University Lowbrow Astronomers

P.O. 131446

Ann Arbor, MI 48113

Membership in the Lowbrows can also get you a discount on these magazine subscriptions:

Sky & Telescope - $32.95 / year $62.95/2 years

Astronomy - $34.00 / year or $60.00 for 2 years

For more information contact the club Treasurer at:

lowbrowdoug@gmail.com

Newsletter Contributions

Members and (non-members) are encouraged to write about any astronomy related topic of interest.

Call or Email the Newsletter Editor: **Jim Forrester (734) 663-1638 or jim_forrester@hotmail.com** to discuss length and format. Announcements, articles and images are due by the 1st day of the month as publication is the 7th.

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Lowbrow's Home Page

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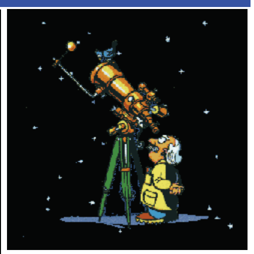
Reflections & Refractions



Website
www.umich.edu/~lowbrows/

Lowbrow astrophotographers never cease to amaze: ***Mike Radwick*** gives us this shot of the Milky Way, looking west, at the Great Lakes Star Gaze September 2012.

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Ann Arbor, MI 48113

LOWBROW MONTHLY MEETING--Friday, January 17, 2014 Laura Chomiuk, Assistant Professor of Astronomy and Astrophysics, MSU-- “Stellar Life After Death: Violent Explosions on White Dwarf Stars