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In the pages of the Gemini

Northwoods StarFest 2007

By Steve Emert

The Chippewa Valley Astronomical Society's (CVAS') Northwoods StarFest is a popular annual regional star party. The best part is that it is close to home, located only about fifteen or so miles east of Eau Claire at Beaver Creek Reserve's Hobbs Observatory. This year, the Northwoods StarFest took place on August 10th to the 12th. The main speaker for the event was Mel Bartels, well known in ATM circles as being the inventor of the TriDob and other ultralight Dobsonian designs, as well as the creator of the Bartels servo drive system from BBAstroDesigns.

Since this was to be my first time to the Northwoods StarFest, I took off work early on Friday afternoon to get a head start on the traffic and to get a good spot to set up my scope - and especially to get a good bunk. One of the nice things about this star party is the availability of lodges and bunk rooms in the Beaver Creek Reserve facilities, in addition to spaces where you can pitch a tent or bring a camping trailer. After picking my observing spot I met up with Mark Austin, Mark Boyd, Mark Peterson and Dale Eason and we all selected a cabin on the far end where it'd be nice and quiet when we decided to head to bed after observing - quiet at least until we rattled the cabin with our snoring.

Friday afternoon was very hot and clear skies prevailed, and it looked like it'd be a good evening for observing. We had a chance to check out the myriad scopes set up on the observing field before scarfing down a couple bratwursts the CVAS folks were selling for supper Friday evening. There were quite a few truss Dobs, both commercial and home made, as well as a good collection of regular Dobs, SCTs and a few 'factors. We admired Mark Boyd's newly built travel scope using a Royce conical mirror, Dale Eason's minimalist Dob with an uncoated mirror that he is finishing, and Ken Hugill's recently finished Telekit. There was even a portable (well, sort of) observatory dome set up in the middle of the field, made by ExploraDome in Litchfield MN. Check 'em out at their web site at http://www.exploradome.us/. They make a pretty neat small observatory dome kit.

Group photo of (most) all participants

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A Tale of Three Telescopes

By Dick Jacobson

This article describes the unusual 20" equatorial truss tube telescope that I finished building about a year ago. After Gemini editor Ron Bubany asked me to write this article, I wondered whether enough club members are interested in telescope making to bother reading it. This article will touch on a few other issues which will, I hope, make it interesting not only to telescope makers but also to telescope buyers and users.

I have uploaded several pictures to the MAS web site to illustrate this article. To access them, go to www.mnastro.org and click Discussion Forums, then Photo Album, then Users Personal Galleries, then Dick Jacobson.

First, a little personal background. Until about 15 years ago I was mostly an "armchair astronomer". I read Sky & Telescope every month and followed astronomy news with great interest, but hardly ever did any observing. This changed after reading about John Dobson and the excellent large altazimuth telescopes that he and his followers built. Thinking about these telescopes provoked the question, "Why not just tip it over and make it an equatorial?" In other words, if you had a tilted base and pointed the azimuth axis toward Polaris, the telescope would track the stars just like one of the big, expensive equatorial mounts. As far as I knew at the time, nobody had tried this.

I realized that it wasn't quite as simple as this. In order to "equatorialize" an altazimuth mount you need to do three things. Besides building a tilted base to replace the ground board, you need to reinforce the sides of the cradle to carry the lateral force and prevent the tube from tipping out of the mount when it is turned to the east or west. Finally, you need to redesign the cradle so the telescope can point below the equator.

The 10-inch

The more I thought about this, the more I was convinced that I could build a telescope that would revolutionize amateur astronomy just as John Dobson had done. It would be a telescope that combined the easy portability and low cost of the "Dobs" with the convenience of equatorial tracking. Eventually I purchased a 10" Dobsonian telescope and proceeded to build an equatorial mount for it.

It was a disaster. The mount shook so badly that it was nearly useless. Fortunately, I enjoy fixing things that don't work so I set to work reinforcing it. I doubled the thickness of the base (polar) disk, reinforced the sides of the cradle, and built a stronger tilted base. Although the mount ended up somewhat heavier than planned and wasn't as solid as the original Dob mount, it worked decently enough for serious observing, and was still more portable than a conventional equatorial mount.

Having reduced the endless "nudge-nudge" of the Dob mount to a simple "nudge", I decided to see if I could build a motor drive and eliminate all nudging. I wasn't interested in imaging and wasn't concerned about building a highly accurate drive. I just wanted something that would move the tube accurately enough to eliminate most of the hand guiding. In the spirit of John Dobson, I wanted to keep it simple and low-tech. What I came up with was a friction drive powered by a DC motor, which I'll describe later in this article. It was crudely built and not terribly reliable, but it was a big improvement. And even when the drive wasn't working, I still had the big benefit of equatorial (single-nudge) motion.

The 14-inch

After enjoying the 10-inch for a few years, Aperture Fever struck and I purchased a 14-inch Dob with the intention of converting it to an equatorial. Before doing this, however, I sawed the enormous tube in half and added some hardware to join the halves. This Split-Tube arrangement made it a lot more portable. A couple years later Discovery Telescopes stole my idea (not really) and came out with their line of Split-Tube telescopes. I believe a two-piece solid tube is the most practical way to build Newtonians in the range of about 10 to 15 inches.

With the benefit of my experience on the 10-inch, the equatorial mount for the 14-inch worked well from the outset. The main innovation of this mount was that the base was adjustable for latitudes between 25 and 50 degrees. I also improved the design of the motor drive so that it wasn't constantly breaking down. *Continued on Page 9*

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"Dale Eason speaking about Interferometry"

The MAS was pretty well represented at the StarFest. In addition to Dale and the three Marks, other MAS'ers that were there included Ben Huset, Dave Runkle, Steve Messner, Deane Clark, Dick Jacobson, Ken Hugill, Michael Kauper and Dave Berger (and probably a few others that I missed). I guess it helps being only 90 or 100 miles from the Twin Cities.

In the early evening on Friday, we went to the Wise Nature Center on the other side of the road from Hobbs Observatory and the observation field to attend the first of Mel Bartels lectures, "Universe Designed Telescopes". After the lecture, it was dark enough to begin observing. The night was pretty good with no clouds at all, although a bit hazy due to the humidity. At midnight, our hosts had a midnight snack in the lunch hall. One thing I found out was that you'd better be on time for the meals and snacks. With this many hungry amateur astronomers, the food is picked over pretty fast. We returned to observing after the midnight snack, and observed until the skies clouded up about 2:30 or so. Since rain was forecast, everyone either packed up or covered up their equipment. Some time in the middle of the night after heading to bed, I heard the thunder and rain of a really good thunderstorm. I was certainly glad that I packed up all my gear before heading to bed.

Jambalaya feed

I must have been tired, as I was one of the last people in our bunkhouse to wake and get cleaned up before heading to the brunch in the lunch hall Saturday morning. Again, I found out the results of being a few minutes late to the chow hall, getting some of the last scrambled eggs available. (Note to self: Be on time for food. Not that I need it.)

Saturday afternoon, there were several more lectures in the Wise Nature Center before the swap fest in Hobbs Observatory. The lectures this afternoon included Mel Bartels again, this time with a lecture entitled, "The Winds of Change: Amateur Astronomers in the New World". He had an interesting premise that amateur astronomy has gone through a fairly profound change every twenty to twenty-five years since really getting started in the 1920's or 1930's. First, small home made reflectors on cast iron pipe equatorial mounts prevailed. I think he said that the reflectors gave way to the first big wave of refractors. The SCT revolution followed later followed by the rise of the big Dob. He suggests that the big Dob phase is being supplanted by the increasing popularity of digital imaging. Now, it's not necessary to have a 12" to 36" Dob to get bright images - simply use a CCD or other digital camera (like the StellaCam) attached to a small, high quality refractor. Refractors are easier to fit in the smaller cars gaining in popularity due to rising gas prices, the electronics are getting more sophisticated and less expensive, and the images they can take are startlingly good. Hmm... He may have a point...

In addition to Mel's lecture Dale Eason talked about interferometry for ATM'ers. John Heasley and Bob Schmall are both NASA Ambassadors. John talked about NASA's plan to return to the Moon and to Mars, and Bob talked about robotic scientific missions including Deep Impact. Bert Moritz of the CVAS talked about his involvement in tracking NEO's (Near Earth Objects) using the 24" Newtonian reflector in Hobbs Observatory, and Chuck Forster talked about Radio Astronomy in the CVAS.

ExploraDome "portable" plastic dome observatory on observing field

After the lectures, there was a swap meet in the observatory. I think Ken was one of the most successful vendors there, although one person did sell a Meade LightBridge (I think it was an 8" one). Following the swap meet, supper consisted of a Jambalaya feed. This time, I was not going to be late! We headed over to the lunch hall with plenty of time to spare. Jambalaya was available in three variations - medium, hot, and very hot. The very hot stuff was great! It was accompanied by fresh sweet corn supplied by Steve Messner. After dinner, door prizes were awarded.

Mel Bartels and Dale Eason discussing mirror testing

Dale Eason's scope with uncoated mirror

The weather for Saturday evening was not promising. Heavy thunderstorms had gone through the Twin Cities and were heading east toward us. Lightning was flashing in the sky all around us. Since I hadn't set my scope up again, I dithered about whether I should stay to wait out the storm or head toward home. Looking at the radar weather, and calling home to find out if it had cleared yet in the cities, I decided to wimp out, and headed toward home at about 10:30. I was convinced that it wouldn't clear up until 2:00 or so in the morning. While heading home, I drove through several waves of pounding rain until it suddenly cleared up about the time I passed the River Falls exit, and I could see stars through the windshield.

Ken Hugill and his Telekit truss Dob

Later, Dick Jacobson reported, "As for Saturday night, a bunch of us sat in front of the observatory going "ooh" and "Ahh" at the spectacular thunderstorm that passed to the south. We didn't get much rain. It cleared up about 12:30 and we had pretty good observing conditions for the rest of the night. I went to bed about 3:00. Sunday morning was the traditional breakfast of blueberry pancakes." All in all, it was a good star party, even if the storms did curtail the observing sessions.

Panorama of the observing field at the Northwoods StarFest.

Home-Built Observatory Has Unique Design

By Rev. Eugene M. Brown

Father Brown in his observatory with the roof off and the sides down.

I have a 14-inch Meade LX200R in an observatory on a dark farm site near my home in Winsted, but I didn't plan to have such a setup when I first decided to purchase a telescope.

Most people buy a beginner-level telescope when they become interested in astronomy, learn on that, and then move up to one with more advanced features. I jumped in with both feet and bought as my first telescope an advanced-level, computerized, GoTo model on an equatorial wedge and with lots of bells and whistles. I thought I was buying a large telescope that I could still haul around in the back of my car (I have a Prius hybrid) to dark sites. When it came and I struggled to get it out of the box and onto the tripod (it weighs 110 pounds, and the wedge weighs another 45), I realized that I would have to locate it on a permanent site. I needed an observatory.

At the time I was chaplain of a Catholic nursing home in Ivanhoe in western Minnesota, ten miles from the South Dakota border. I found a local carpenter with a little extra time during the winter months and explained my idea for an observatory with a removable roof and hinged sides. He drew a sketch and went to work with his partner. They had the basic shed completed in two days. It is 6x61/2 feet with a roof that slopes 14 inches from a height of 71/2 feet. The roof is corrugated aluminum reinforced with 2x6s, and sheet insulation covers the interior of the roof and all four sides. The floor and sides are made of 1/2" plywood with 2x6s for support. There are two small louvers near the roof for ventilation; these can be closed in the winter. All four sides are hinged so they can be lowered to about a foot from the ground. There is a three-foot-high door on one side, below the hinge, for access to the observatory. The entire outside is painted white.

The observatory with the roof on and the scaffold in place.

When the observatory was finished and I had obtained permission from the owners of the land, we found an open site above a ravine, put down several yards of rock, and installed the shed, anchoring it to the ground with angle irons. But there was a problem. The roof weighs 100 pounds, and it would be difficult for one person to lift the roof off the observatory and set it on the ground but even harder to pick it up from the ground, hold it over one's head and slide it back on. I knew that most of the time I would be at the observatory by myself, and I needed a system by which I could not only take the roof off but replace it at 1:00 or 2:00 a.m. with only the light of a flash-

The roof on the scaffold with the corners tied down.

light.

My carpenter friend had a scaffold on wheels which he used in his construction business. He welded pipes to this scaffold to make it the same height as the low side of the observatory. Across the top he welded steel rods inside PVC pipes with a slightly larger diameter than the rods. When the roof is placed on top of the scaffold, it rolls easily over the pipes; it is then tied down at the four corners.

To open my observatory, I go in through the small door, stand on wooden planks supported by concrete blocks, and unfasten the suitcase clamps that secure the roof and the short side of the shed. I lower this side with a rope tied to the inside and then pull the scaffold to about a foot from the shed. I go back inside, lift the roof and slide it onto the scaffold. I tie down the roof and pull the scaffold about 15 feet from the observatory. I lower the other sides, take the covering off the telescope, and I am ready to observe. The LX200R on its wedge and tripod stands six feet high; it has a clear view to the horizon in all directions.

To close my observatory, I raise the three sides which were lowered last, pull the scaffold up to the open side, untie the

The roof partway off the observatory and onto the scaffold.

roof, stand on a plank across the scaffold, and slide the roof partway on. Then I go inside and slide the roof all the way on until it drops into place. I move the scaffold away, raise the fourth side, fasten all the suitcase clamps, cover the telescope and lock the observatory with a padlock.

I wish I had asked the carpenter to build the shed slightly larger, perhaps a foot longer and wider, because it is a little cramped for a 14-inch telescope. Otherwise I am happy with my observatory. It takes me 15 minutes to open it and a little longer to close it in the dark, but I have a permanent site for my telescope and a secure storage facility that can even withstand the rigors of a Minnesota winter. I know. It already has.

Photographs by Rev. Eugene M. Brown

The observatory with the scaffold moved away and the telescope ready for observing.

July and August 2007 Board Report

By Bill Kocken, MAS Secretary

Gemini Opening

As announced in the last issue of Gemini, Ron Bubany has decided to step down as the Gemini Editor. Rev. Eugene M. Brown has stepped forward to be the new editor of Gemini. He has experience with desktop publishing and being semi-retired seems to be a very good fit for the job. Ron will be handing over duties in this issue and December's issue. Thanks Ron and Rev. Brown.

Treasurer's Report:

Bob provided a treasurer's report. We have a healthy balance of funds but we are short on dues because membership is down somewhat. On the plus side, donations are up. All in all, the budget is doing OK.

ONAN News

We received 2 bids for the Onan Path project and selected Southwest Paving to do the project. The board voted to fund the project out of the Onan fund and out of the special projects fund with the provision that the special projects fund be restored for money spent on this project. We have a verbal commitment from the Onan foundation to reimburse us for the path costs over the next two years. The path has been completed, so we now have better handicapped access to the observatory and a place for members to drive up to the observatory to unload their gear. Many thanks are owed to Dave Schultz and Dave Olmstead for spearheading this big project.

LLCC

The 30" Obsession has been picked up. Greg Haubrich installed additional accessories and 4 training sessions have been held in John Marchetti's driveway for interested users. We delivered the scope to the LLCC for the 8/17 star party. The scope is currently securely locked in a Wells Cargo trailer at LLCC. An 18' by 24' concrete pad is being poured this fall to provide better storage for the trailer this winter. Next spring, we will construct a garage to be shared by us and the LLCC. We will have a separate 12x24 stall that will allow us to store the assembled scope. This will allow us to just roll the scope out and observe. We will also have enough room for additional storage.

Many thanks to Greg Haubrich for spearheading the project and installing the ArgoNavis stalk, anti-dew heaters and other electrical systems. Also thanks to John Marchetti for housing the scope for several weeks and holding training sessions in his driveway. Finally, thanks to the Anonymous Benefactor for the donation of such an incredible scope and accessories.

Metcalf

We have two volunteers to co-head a Metcalf/Belwin task force, Jim Fox and Andy Fraser. They will coordinate our use of the Metcalf site and explore the possibility of housing a 10" refractor at that site or another site in the area. If you are interested in helping, please contact them.

Other

Parke Kunkle, of the Minnesota Planetarium, has approached us about helping them to solicit Planetarium support. We agreed to place an insert in a future issue of Gemini.

ATM

Ben Mullin has begun the sale of a substantial amount of ATM supplies from Sherm Schultz's donation. Please check his posting in the discussion forums.

Large Scope Training

By John Marchetti

The Minnesota Astronomical Society (MAS) is a very fortunate amateur astronomy organization. Many people in MAS know about the generosity of our Anonymous Benefactor (AB) and the truly amazing instruments that he has donated to us. This level of giving is sometimes almost overwhelming, at least to me. His most recent gift is an Obsession 30 inch telescope with a Servo Cat drive system and many accessories such as the laser Barlow Collimator, Argo Navis DSC, power supply, heaters, finder, and even a Telrad, as well as some of the best eyepieces ever made. The AB also donated a fine Wellscargo trailer to tow and store this scope. This complete package means that MAS has a beautiful 30"scope "ready to go."

However, I would venture a guess that fewer than 10% of our members have looked through a scope of this size, which leads me to the topic of training on the 30 inch Obsession that is now located at LLCC, our Dark Sky Site. When I mentioned above that the scope was "ready to go," that was a small misnomer because Greg Haubrich, Lauren Hoen, and I actually spent many hours doing a great deal of work to make it "user friendly." For example, there was a great deal of final wiring that had to be done so that the "stalk" could be used easily. Although the scope could probably have been handled by a person alone who knew what to do, the reality was that we anticipated the possibility of having many MAS members use it, and so we prepared a training session designed to make using the scope as functional and error-proof as possible. Without going into detail about the process and steps we took to do that, I will say that we hope we provided some solid instruction on basic use of this magnificent scope. Lauren Hoen is in the process of creating an operator's manual similar to the one for the 24" BAD scope located at Cherry Grove. Hopefully the manual will help those who took the three-hour training session to recall how to set up and use the scope.

The Obsession training was scheduled for two Wednesdays and Thursdays during the first weeks of August, and it took place at my home in Blaine since I had room to store the scope and trailer. It should be noted here that although my wife knew we were going to be storing a large telescope in our garage, she was unaware that the agreement included having a large trailer stored in our driveway for about a month. I somehow forgot to mention that part of the deal to her. However, that issue was neatly solved when Greg Haubrich called the house while he, our AB, and two other MAS members were hauling the scope to Minnesota. Greg told my wife that they would be arriving in about a half hour with the trailer. Although she was surprised to hear about the trailer, it actually worked out pretty well because fortunately, she is pretty understanding and supportive of astronomy being a passion of mine.

Anyway, back to the saga of training on the scope. We had wanted to keep the training session limited to six participants per night. The first Wednesday filled up rather quickly; then there were a few who wanted to do the first Thursday and another larger group on the following Wednesday. At first no one signed up for the second Thursday. On the first Thursday with only two people attending, we did a little impromptu outreach event as a group of 7 or 8 neighborhood adolescents walked by and wanted to take a look. Ben Huset was present that night and as usual he had his camera and has now posted the photos on the MAS web site. We had several sets of keys made for the lock on the trailer and charged $5.00 per person to cover the cost.

The first Wednesday Greg, Lauren and I were ready when the people began to arrive for the training at 7:30. It was nice to have the longer days of summer so that we could setup the scope in daylight. The main part of the training consisted of assembling the truss tubes and the top ring to the scope. Unlike the BAD, there is an intermediary ring that goes on before the upper tube assembly is attached. This is a very useful addition since connecting up the upper tube assembly that high off the ground could be difficult, if not dangerous. This was the trickiest part of the training since every person had to attach several of the clamps to get the proper "feel" for it. Once this was done, the scope would be pulled down (a 30lb weight was attached to this ring) and then the upper tube assembly was easily put on the scope while the scope was aimed at about 20 degrees above the ground. After this was done and the shroud and some of the accessories were put on, the next phase of training was connecting up the stalk that has the Argo Navis DNC system and then attaching all the wiring. Then training would begin on how to use the Argo Navis and how to do the two star alignment, which most people have done often with other DNC systems. However, a few things about the Argo Navis had to be stressed such as getting the scope perpendicular to the base and entering that information into the Argo Navis before the star alignment could be done. Then we proceeded to use the "go to" and tracking systems.

Since this was done in the heat and humidity of August, the mirror was never at equilibrium, so we usually looked at M13 and M57 as well as Jupiter. The views were rather good considering the mirror temperature and the fact that the scope was sitting on a hot asphalt driveway. We never did have a cooling fan on the mirror until the last training date, and it wasn't on long enough to make a real difference. It was still amazing to resolve stars down to the core of M13, and numerous people saw the central star of M57. After a few quick views we had to tear the scope down and put it away which goes much faster than assembly, usually around 20 minutes.

As I said earlier, six people attended the opening Wednesday evening, with only two people attending on the first Thursday. The following Wednesday, we had five people and the last evening, Thursday, we had eleven people. Although we wanted the maximum to be six, we felt that we couldn't really turn anyone away. Maybe we were getting better at it or we had an unusually good group the final evening, but things actually went very well that night. With that many people it could have been difficult to try to cover everything, but the group of people was great to work with, even though they had procrastinated by signing up so late. We made rapid and thorough progress and had the scope in the trailer at about 10:30 p.m.. This means that 23 people, plus several of us on the committee, have been trained on the 30 inch scope as of now. Since the scope has been moved to LLCC, we hope to do some additional training at LLCC, possibly in late fall or early spring of next year.

Just in case you haven't already heard, our goal is to get the scope into a garage and leave it assembled between uses. This "garage raising" could take place next spring or summer, and we may need the work of some talented MAS carpenters. Having a garage for the scope would make the whole process easier by allowing us to focus on teaching about the use of the Argo Navis and the Stellar Cat systems that are necessary to operate this amazing instrument. We expect to have many wonderful years of viewing both the more familiar objects that we have seen before, as well as many more obscure objects that require this kind of aperture. This is a new chapter in viewing the heavens for our members, and on behalf of all MAS members, I just want to close with a statement of grateful appreciation for our AB's generosity.

Thirty Years Ago in Gemini

From the archives of Bob Schmidt

Letter To The Editor

I was delighted with your recent article on astronomically large numbers. For those who, like myself, find this subject fascinating, let me recommend two essays by Isaac Asimov: "Adding a Dimension," Essay no. 1, and "Of Matters Great and Small," Essay no. 17. The difference between how entertainingly I write and how entertainingly Asimov writes is greater than the ratio between a googol and a googolplex (more about this later). Therefore, I recommend that you stop reading my letter and immediately read those essays; for that matter, read all of Asimov's almost 200 books.

If you are foolishly still with me, let me tell you a little of what Asimov says.

Asimov discusses several large numbers, including the smallest number which would over-flow Kevin's calculator (10 exp 100). It was named a googol by two mathematicians — Edward Kasner and James Newman. They also named a number which is much, much larger than a googol, a googolplex (10 exp googol), which is 999999999999999999999999999999999999999999999 999999999999999999999999999999999999999999999 00 times larger than a googol. As you remember, this is also the ratio

of my writing skill to that of Asimov's. I was going to say that Kevin writes 100 times better than I do, but since that would make his ratio to Asimov 999....99999898, I changed my mind. Remembering that a number is much larger than the number of zeroes that it takes to write it, consider that this number has more (many more) zeroes than all the atoms in the known universe.

Of necessity Asimov introduces a new type of notation to deal with these large numbers. (Actually he introduces two new types, but I will only mention the one that I prefer.) Taking standard scientific

notation, he first writes everything on one line with a slash separating the number from the exponent (for example, 10exp100 becomes 10/100). Then he writes the exponent itself in exponential form (thus

10/100 becomes 10/10/2 and a googolplex becomes 10/10/10/2).

The largest number known to have turned up in the course of a mathematical proof is Skewes' (pronounced Skew'ease) number (10/10/10/34 or 10/10/10/10/1.53).

Since it is enormously, ENORMOUSLY larger than the number of particles in the known universe (approximately 10exp80 or 10/10/1.9), Skewes' number may be the largest number to have any useful meaning. Asimov calls it a quadruple 10 number (and a googolplex a triple 10 number) for obvious reasons. In an attempt to relate Skewes' number to the real world, Asimov invents a series of ways of measuring the universe.

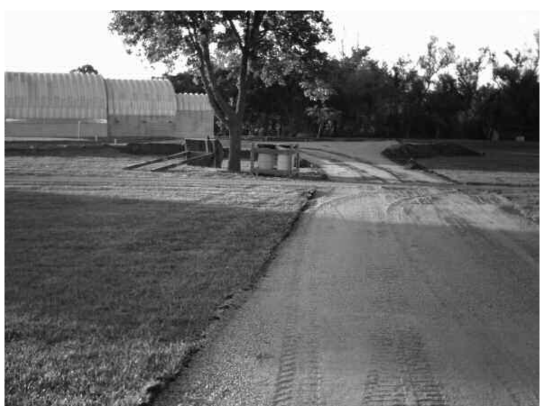
For example, he computes the total number of "vacuons." This attempt is as interesting as Kevin's attempt to overflow his calculator, but it cannot be summarized. Therefore, anyone who hasn't read Asimov's two essays by the next club meeting will have to stay afterward and write googolexpgoogol out in full on the blackboard.—Bill Larson

New Onan Driveway

By Dave Olmstead

Asphalt! Oh Yeah!

Okay, it is just tar for heaven's sake, but for years now the comments have kind of sounded like this, "DANG, when are WE going to get a driveway?!" and " Would you PLEASE get that driveway done so I don't have to haul my gear up from the parking lot!!" Well, it has taken years of planning, head scatching, more planning and some begging, but it is done. I am very pleased to announce that we finally have a driveway at the Onan Observatory! AND, if you haven't seen it yet, I have to tell you that it is big!



For several years now many of us have worked towards making this happen, and golly, it's done! Quite a few individuals have had a hand in this project. Here is kind of how it happened...

It all started with a sketch provided about four years ago by the architect of the observatory, Ralph Nelson. Initial reaction from the Onan Committee and the MAS Board was good, but of course we had no money to proceed. Since then we have been saving as much as possible and noodling the design. Early this year we contracted a site planner to develop the design further. Discussions proceeded between Carver Parks, the site planner, MAS member, David Schultz and myself to make sure the driveway met handicap specifications (very important) and would also function well as a drop off for club members who just so happen to have lots of gear. In years past this meant that all gear needed to be ferried by hand from the parking lot - not fun, and that handicapped individuals were in for a tough journey from the parking lot to the observatory - most definitely not fun.

This summer the plan and the discussions finally came together along with cash from the Onan Fund, and some help from the Special Projects fund. A contractor was hired and there you go, a driveway. At long last a driveway! A few finishing touches need to be worked out like signage, extra grading, cement stops and markings, but we are essentially there!

Rules regarding usage still need to be hammered out, but for now we have two designated parking spots right up by the observatory. One spot will be designated for handicapped individuals to park in, and one will be available to drop off and pick up equipment. Current thinking is to return your car to the parking lot once you have finished dropping off your scopes and other (very necessary) equipment.

So there you have it, with a couple construction photos (minus asphalt) included! Lots of folks made it a reality. I know, it is just tar for heaven's sake, but the heavens are much more accessible to ALL of us now! Clear skies, and please observe the speed limit signs folks! Dave Olmstead Onan Committee Chair.

Continued from Page 2

One of the biggest lessons that I learned from the 10-inch was that for big equatorial Newtonians, it is almost mandatory to have a way to rotate the tube. Otherwise, the eyepiece ends up in awkward positions that make it nearly impossible to view certain areas of the sky. Building a rotating tube cradle for the 10-inch would have added a lot of weight and size, so instead I chose to just rotate the upper end of the tube. I sawed off the top 16 inches or so of the tube and wrapped a sheet of polypropylene around the area of the cut. The polypropylene was cut from a large artist's portfolio which I found at an office supply store. This system was kind of ugly, but it worked. The partial-tube rotation didn't seem to disturb the optical alignment.

Since the rotating eyepiece section worked well on the 10-inch, I decided to use the same approach on the 14-inch. One day I was in Rockler Woodworking and happened to see a large "lazy susan" ring bearing whose inside diameter just happened to match the tube of the 14-inch. I got my saw out again and bisected the upper half of the 14-inch tube and installed the bearing. It worked like a dream! These bearings are very high quality and are currently available with inside diameters of about 6, 10, 15, 20, and 26 inches. I believe they will become very widely used for telescope tube rotation and maybe other parts of mounts, once more people become aware of them. The best source for them that I know of is at www.leevalley.com.

The 20-inch

This brings me (finally) to the main topic of this article. In this section I will describe in some detail the unusual features of my 20-inch scope. Those who are not interested in telescope making might want to skip down to the next section.

My telescope seems to be a rare bird these days - a large equatorially mounted Newtonian. Commercial manufacturers and amateur telescope makers alike seem to have largely given up on equatorial mounts for Newtonians larger than 10 inches. This is not hard to understand. It's typical for an equatorial mount to weigh twice as much as the telescope it supports. In contrast, the simple Dobsonian altazimuth mount can weigh only half as much as the telescope and perform superbly. What I've done is build equatorial mounts that are only slightly larger and heavier than a Dobsonian yet perform quite well in terms of low vibration and tracking performance.

The best term I've come up with to describe my design is the Narrow-Fork mount. Mechanically, it's very much like a traditional fork mount, but the arms of the fork are narrow side-to-side. The fork hugs the sides of the mirror box or tube and is shaped very much like a Dobsonian tube cradle. There is no polar axis shaft at the bottom of the fork. Instead, the base of the fork is a large circle. The base is supported at three points - two bearings at the perimeter, and a small center pivot. This follows the principle of achieving stiffness through large, boxy structures instead of massive steel shafts.

Fork mounts are notorious for having vibration problems, but my fork doesn't seem to vibrate at all. There is some vibration that seems to originate in the base, which I'll talk about later. Another benefit of the Narrow Fork is that it is more portable and doesn't get in your way as much when observing near the zenith.

Bill Kocken has dubbed my scope a "Dob-Quatorial". This is an apt description because I tried to follow Dobsonian principles of simplicity, compactness, low-tech and low cost. Although it is shaped very differently from Dobsonian scopes, many of the details are similar.

I'll begin the detailed description of the scope with the first part I built, the ring bearing for the secondary cage. Then I'll work my way down to the base. I built the ring bearing first because I anticipated that it would be the most difficult part (I planned on purchasing the optics). If it failed to work, I wouldn't have any other time or money invested in the project.

How do you build a large (24-inch inside diameter) rotating bearing? I've read about some telescope makers building them out of plywood and Teflon. I'm sure this is workable, but I was hoping to duplicate the smooth, nearly frictionless rotation of the 15" bearing on my 14" scope. I decided to try bending a piece of aluminum angle into a circle. To do this, I constructed a simple "ring roller". Commercial ring rollers bend metal into rings by forcing them through a series of three rollers. The center roller pushes on the metal in the opposite direction to the end rollers, forcing the bar or tube into a ring. I built my ring roller from three polyurethane keel rollers (used on boat trailers) on a wooden frame. The center roller could be tightened using a screw thread apparatus. I pulled the bar back and forth through the rollers, gradually tightening the center roller so the bar bent into a ring. After several hours of hard physical labor (a little at a time), I had a 24-inch diameter aluminum ring! The corner of the aluminum angle pointed outward. The quality of the ring was quite good, within 1/16 inch of a perfect circle. I joined the ends of the ring together using one of the end scraps (the last several inches on each end do not bend accurately because of the space between the rollers.)

I made a second, outer ring for the bearing using another aluminum angle. Between the two rings are four pairs of smaller bearings. After trying Teflon pads and small nylon rollers, I found that roller skate bearings worked best. The hub of each skate bearing is mounted to the outer aluminum ring, and the outside of the skate bearing runs along the outside of the inner aluminum ring. Each pair of skate bearings criss-crosses at about a 90-degree angle, one bearing rolling along either side of the aluminum angle. Together, these eight bearings hold the inner ring firmly in position and allow it to rotate with very little friction.

This will be Continued next issue

Onan Public Night Schedule

Public nights are scheduled for Saturdays only. Astronomy Days are Friday evening and Saturday. Public Nights and Astronomy Days are held whether it is clear or cloudy. For Directions to the Onan Observatory, at Baylor Regional Park, please see the Star Party Schedule.

Date	Starts	Ends	Comments
6/9/07	7PM	10PM	Public Night at Onan
6/23/07	7PM	10PM	Public Night at Onan
7/14/07	7PM	10PM	Public Night at Onan
7/28/07	7PM	10PM	Public Night at Onan
8/11/07	7PM	10PM	Public Night at Onan
8/25/07	7PM	10PM	Public Night at Onan
9/8/07	7PM	10PM	Public Night at Onan
9/22/07	7PM	10PM	Public Night at Onan
10/13/07	7PM	10PM	Public Night at Onan
10/27/07	7PM	10PM	Public Night at Onan
11/10/07	7PM	10PM	Public Night at Onan
11/24/07	7PM	10PM	Public Night at Onan

For maps and further details about the sites, please go to our website at www.mnastro.org/facilities.

Baylor Regional Park

To reach Baylor Regional Park, head west on Minnesota Highway 5, through Chanhassen and Waconia, to the town of Norwood-Young America. Turn right onto Carver County Road 33 and continue approximately two miles north. Baylor Regional Park is on the right side of the road, marked with a prominent sign. When entering the park, stay to the right and follow the road approx 1/4 mile.

When visiting the Baylor Regional Park, MAS members are requested NOT TO PARK OR DRIVE on the grass. There is a parking lot just past the observatory.

For an alternate route from the southern suburbs, take U.S. Highway 212 west to Norwood-Young America. Turn right at the second traffic light onto Carver County Road 33. Continue two miles north to the park entrance.

For an alternate route from the northern suburbs, take Minnesota Highway 7 west approximately 30 miles from I-494. Turn left to go south on Carver County Road 33. Approximately 8 miles south, Baylor Regional Park will be on your left after a short series of curves.

Cherry Grove Observatory

Cherry Grove is located south of the Twin Cities,in Goodhue County, about 20 miles south of Cannon Falls. To reach Cherry Grove, head south on Highway 52. On 52 about six miles south of Cannon Falls, and just past the Edgewood Inn, is a large green highway sign for Goodhue County Rd. 1 “WEST”. Turn right, and follow County 1 straight south for about sixteen miles until you arrive at a “T” intersection with County A. The observatory is immediately at your right, nestled in the shoulder of the “T”. Parking is permitted on the site or along the road, preferably on County A.

Metcalf Observing Field

To reach Metcalf, head east from St. Paul along Hwy. 94. About four miles east of the I-694 / I-494 crossing is Minnesota State Highway 95, also known as Manning Avenue (exit 253). Turn south (right turn) and then almost immediately turn left onto the frontage road (Hudson Road S). Continue east on the frontage road for about one and one-half miles. Turn right onto Indian Trail, checking the odometer as you turn. Follow Indian Trail south for just about one and one-tenth miles, where you’ll see an unmarked and unlocked chain-link gate on the right, opening onto a dirt driveway with a slight up-slope. This is the the entrance to Metcalf.

Long Lake Conservation Center from Western Twin Cities

Take I-94 west to Rogers/MN 101. Go north/right on MN 101 through Elk River, where MN 101 becomes US 169. Continue north on US 169 approximately 90 miles to Aitkin. At stoplight in Aitkin, turn east/right onto US 169/MN 210 and go out of town eight miles. Then turn east/right, following MN 210 toward Duluth. Proceed seven miles. A large green highway sign marks the turn off 210 to Long Lake Conservation Center. Turn north/left on County Rd. 5. After three miles, turn east/right on gravel County Rd. 88. It is approximately one mile to the LLCC gate.

Long Lake Conservation Center from Eastern Twin Cities

Go north on I-35 to Finlayson/Exit 195. Turn west/left and go one mile to County Rd. 61 and MN 18. At stop sign turn right/north and go two miles. Follow MN 18 west/left and continue 19 miles to MN 65. Turn north/right on MN 65 and proceed 30 miles to McGregor. Intersect with MN 210 and follow 210 west/left (through McGregor) for seven miles. A large green highway sign marks the turn off MN 210 to Long Lake Conservation Center. Turn north/right on County Rd. 5. After three miles, turn east/right on gravel County Rd. 88. It is approximately one mile to the LLCC gate.

Minnesota Astronomical Society 2007 Star Party Schedule

Date*	Location	Special Event	Long Lake Conservation Center Dates**	Astronomical Twilight Begins	Moon Rise	Moon Set	Moon % Illuminated
4-May	Metcalf			10:22 PM	11:22 PM	6:41 AM	97%
11-May	Cherry Grove		11-May and 12-May	10:36 PM	3:10 AM	2:17 PM	38%
18-May	Onan			10:50 PM	6:39 AM	11:38 PM	3%
8-Jun	Onan		08-Jun and 09-Jun	11:27 PM	1:34 AM	1:21 PM	53%
15-Jun	Cherry Grove		15-Jun and 16-Jun	11:34 PM	5:22 AM	10:18 PM	0%
22-Jun	Metcalf			11:37 PM	1:33 PM	1:00 AM	47%
6-Jul	Metcalf			11:29 PM	12:19 AM	12:27 PM	66%
13-Jul	Cherry Grove		13-Jul and 14-Jul	11:20 PM	4:11 AM	8:56 PM	2%
20-Jul	Onan		20-Jul and 21-Jul	11:08 PM	12:24 PM	11:35 PM	31%
10-Aug	Cherry Grove		10-Aug and 11-Aug	10:25 PM	3:08 AM	7:33 PM	8%
17-Aug	Onan		17-Aug and 18-Aug	10:10 PM	11:14 AM	9:57 PM	17%
24-Aug	Metcalf			9:54 PM	6:18 PM	1:33 AM	80%
7-Sep	Onan		07-Sep and 08-Sep	9:22 PM	2:10 AM	6:08 PM	18%
14-Sep	Cherry Grove	Mini Messier Marathon at CG	14-Sep and 15-Sep	9:07 PM	10:07 AM	8:21 PM	7%
21-Sep	Metcalf			8:52 PM	4:50 PM	1:00 AM	65%
5-Oct	Onan		05-Oct and 06-Oct	8:24 PM	1:14 AM	4:39 PM	31%
12-Oct	Cherry Grove		12-Oct and 13-Oct	8:11 PM	9:01 AM	6:48 PM	1%
19-Oct	Metcalf			8:00 PM	3:19 PM	12:28 AM	49%
2-Nov	Onan		02-Nov and 03-Nov	7:40 PM	1:00 AM	3:06 PM	46%
9-Nov	Cherry Grove		09-Nov and 10-Nov	6:32 PM	6:58 AM	4:17 PM	1%
16-Nov	Metcalf			6:26 PM	12:48 PM	10:28 PM	33%
30-Nov	Metcalf			6:18 PM	11:24 PM	12:30 PM	63%
7-Dec	Cherry Grove			6:18 PM	5:55 AM	2:48 PM	6%
14-Dec	Onan			6:18 PM	11:16 AM	9:31 PM	19%

* The Onan, Cherry Grove and Metcalf Star parties take place on the date listed in the schedule above, which is always a Friday. If the event is clouded out, the following night is used as a backup. For status of the star parties, call the information line at 952 467-2426.

** LLCC events are for members only. Vehicle ID card is required - contact Board of Directors or Dark Sky Committee members for a pass.

Due to the relative distance and driving time to LLCC, in 2007 the MAS will include both Onan or Cherry Grove and LLCC parties on LLCC weekends in order to accommodate those who can take the time to travel to very dark skies as well as those who wish to observe closer to home. LLCC weekends will include both Friday and Saturday night.

This schedule is subject to change. You can also check the MAS online calendar at www.mnastro.org/events for a complete schedule of all MAS star parties, Onan Public Observing nights, monthly meetings and other events.

In 2007, daylight saving time begins on March 11 and ends on Nov 4. The times listed above are adjusted for DST.

Onan Public Nights are shown on a separate schedule.

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The MAS list has about 40% of the membership on it.

The completed bearing sat in my basement for a year or two until I finally got serious about finishing the project. I made a front ring for the secondary cage by bending some 7/8" aluminum tube into a ring using the same ring roller. The spider is attached to this ring. A "mini-truss" of eight 1/2" diameter aluminum tubes connects the front ring and the inner ring of the bearing. The aluminum framework of the secondary cage is very strong yet weighs only 6 pounds including the bearing. The focusser board is a trapezoid shaped piece of plywood that fits into one of the eight triangle-shaped areas formed by the mini-truss. The finder is a half-binocular. I made a dewcap for the finder from a PVC pipe fitting; this is attached to the front ring of the secondary cage. Two threaded rods connect the back end of the finder to two of the mini-truss tubes, using turnbuckles to align the finder. I mounted a 5-pound lead acid battery on the opposite side of the secondary cage. This provides power for my anti-dew heaters and counterbalances the focuser, finder, and the binoviewer that I usually use. The focusser board, finder, and battery are attached to the small aluminum tubes using electrical cable clamps so I didn't have to drill holes through the slender tubes. I couldn't think of a good way to work a Kydex light shield into all this apparatus, so instead I used a piece of black fabric which is attached to the frame with safety pins. Part of the light shield extends beyond the front of the scope on a piece of aluminum tube that I bent into an ellipse. The light shield does a good job but it's kind of ugly and I might replace it if I think of something better.

The rotating secondary cage has proved to be a tremendous convenience. It makes it much easier to find a comfortable eyepiece position when standing on a ladder. This works in all sky locations except very near the zenith, where rotating the cage doesn't have much effect on eyepiece height. When using the finder, I usually rotate the cage to get the finder in a comfortable position, and then spin the eyepiece into position. Even if I were building a conventional Dob, I would seriously consider including a rotating secondary cage. Instead of going to the trouble of building the bearing myself, though, I would probably try to find a suitable commercially made one.

Moving on down to the truss, I did a few unusual things here too. The truss tubes are 1" square aluminum tubes. I used square tubes for two reasons. There was an article in Sky & Telescope quite a few years ago that claimed that square tubes don't vibrate as much as round ones. And it was a lot easier to work square tubes into my design. My eight truss tubes are permanently connected in pairs. At the top of each pair is an aluminum plate. One of the tubes is rigidly connected to the plate with two bolts. The other tube is connected with a single bolt and lock nut, and is free to pivot. For compact storage and transport, the two tubes pivot together. (I can hold the entire truss in one hand.) When clamped into the mirror box, each pair of tubes forms a completely rigid triangle. A single knob and a small piece of oak clamps the bottoms of two tubes into each corner of the mirror box. There are shims at the base of the tubes which cause them to angle outward, preventing them from intruding into the light path despite the fact that the mirror box is a compact Obsession-style design.

The plate at the top of each truss pair has a slot for clamping the secondary cage bearing outer ring. Four bolts and clamping knobs extend out from the outer bearing. Since the mount is equatorial, the clamping points are at the north, south, east, and west sides.

You would expect all of the clamping slots to point upward when the tube was vertical. Instead, only the north plate has the slot pointing upward. The east and west plates have their slots pointing north, so they are sideways when the tube is vertical. The south plate is the most bizarre of all. It has a large hole in the middle, with a slot adjacent to and above the hole pointing downward. The reason for this strange design is that I don't like the idea of climbing a ladder while holding a big clumsy secondary cage out at arm's length. The system I designed lets me attach the cage with the scope horizontal. Here's how I do it.

Once all the truss pairs are clamped into the corners of the mirror box, they form four rigid triangles. First, I grab either the east or the west truss pair and pull the tube down so it is horizontal. While holding it down with one hand, with the other hand I set the secondary cage into the slots of the east and west trusses. (If you were paying attention to the previous paragraph, you will realize that these slots are pointing upward when the tube is horizontal pointing south.) At this point, the bolts at the east and west points of the secondary cage are supporting it, but the cage is pointing downward at a crazy angle. Then, I rotate the cage into position. The north bolt approaches the slot in the north truss, and at the same time the south clamping knob passes through the large hole in the south plate and its bolt enters the slot from "below" (that is, from the mirror box side). Due to inaccurate construction, it takes a little bit of wrestling to get all the knobs in position, but once they are there and clamped, I've got my secondary cage attached without setting foot on the ladder!

The usual solution for avoiding secondary-cage ladder vertigo, which is used on the club's new 30" Obsession, is to clamp a small lightweight wooden ring onto the tops of the truss tubes with the scope vertical, and then pull the tube down horizontal, hold it down with a heavy weight, and hang the secondary cage on the wooden ring. My system eliminates the need for this ring.

The mirror box is pretty much a standard, "by the book", Obsession style box. ("The book" is "The Dobsonian Telescope" by Kriege and Berry. This book is packed with valuable information and is indispensable regardless of whether you follow their design ideas or take off on a tangent like me.) I made the box a few inches shorter than normally needed for balance, because I planned to add a removable fan/battery/counterweight assembly on the back. An 18-point cell made exactly to the Kriege-Berry specifications supports the mirror. Instead of the usual "ladder" frame supporting the mirror cell, I made a triangular frame out of square aluminum tubes. This frame is about half the weight of the standard frame and is, I think, stiffer because of its triangular shape. The collimation knobs are recessed into the corners of the triangle so there is no force on them when the box is lying on its back.

The biggest innovation inside the mirror box is the system for supporting the edge of the mirror. Since my equatorially mounted tube has to tip in all directions, the usual nylon or kevlar sling that is used to support Dobsonian mirrors would not work. (In my 10" and 14" scopes, made by Discovery, the mirror is glued to the cell with silicone glue so edge support is not an issue.) I was skeptical about using silicone glue on a mirror this large, and wanted to use a conventional flotation cell. To support the edge gently in all directions, I used four overlapping slings. The slings are made of 3/32" galvanized wire rope. I used the plain, uncoated rope, not the vinyl covered type, since the high friction of vinyl could put unwanted stress on the rim of the mirror. Picture four U-shaped slings with the open ends up, down, left, and right. Two of the slings have a wing-nut tension adjustment so I can separately adjust the east-west or north-south pair. By this means I hoped to avoid any possible astigmatism caused by uneven force, and might even be able to correct the "potato-chip" distortion that occurs when big mirrors are aimed below 15 degrees. So far I haven't put this theory to the test and have just left the wires alone; they seem to work fine.

Instead of the usual 180-degree half-moon side bearings, mine are 270-degree "Pac-Man" bearings. The "mouth" of the Pac-Man points toward the top of the tube. These bearings let me rotate the tube all the way from the southern to the northern horizon. Actually it wouldn't have been necessary to make them this large, since the fork can rotate in a complete circle. I could reach the northern horizon by turning the fork upside-down in effect. But then the 150-pound tube would have been supported by the two aluminum straps that anchor the centers of the declination bearings to the fork sides, and I wasn't crazy about that. I could have saved several pounds by making the declination bearings out of aluminum bars bent using my ring roller, but I wasn't sure what thickness would be needed to avoid vibration, so I played it safe and just made them out of plywood.

I already mentioned the fan/battery/counterweight assembly that snaps onto the rear of the mirror box. This is on an aluminum frame that runs all the way crosswise and is thin enough front-to-back so it doesn't scrape the bottom of the fork as the tube is rotated toward the pole. For counterweights I used 3/4" threaded rods, nuts and washers. These allow me to carefully balance the counterweight horizontally and vertically if necessary. I had to add several pounds more counterweight than planned because when my mirror finally arrived, it was 1.75" thick instead of 2" as planned. Fortunately, 3/4" washers are cheap!

Now that you know more than you ever wanted to know about the tube, I'll describe the mount. Just as with the mounts for my 10" and 14" scopes, the mount consists of a fork that rests on a base. The two parts are not fastened together but are just held together by gravity.

The base of the fork is primarily two layers of 3/4" plywood glued together. The bottom layer is a 24" circle. The top layer is approximately square, but the part that is highest above the ground is cut away to match the curve of the bottom layer. I added some 1" boards around the periphery of the square part to provide reinforcement and also provide a larger area for attaching the fork arms to the base. I was careful to check that the Baltic Birch plywood circle was perfectly flat. A warped base would cause inaccurate tracking.

The fork arms are made from 1x16 edge-glued oak boards (actual thickness 3/4"). Two boards are glued together so the finished thickness is 1.5". I used solid wood instead of plywood since the arms are stressed like cantilevered beams and most of the strength should be in the longitudinal direction. I did not glue the arms to the base because I thought I might need to rebuild one or the other. Instead, I joined the arms very tightly to the base using eight lag screws on each side. This seems to work very well. When I turn the fork 90 degrees so the tube's weight is against one fork arm, the arm deflects about 1/4". This is not enough to cause an imbalance problem about the polar axis and I don't think there is any risk of the arm coming off.

Each arm has two Teflon pads that support the tube. In addition, there is a Teflon pad on the inside of each fork arm to support the mirror box laterally when the fork is turned sideways. The mirror box has a semi-circular strip of Ebony Star Formica adjacent to the outside of the declination bearing on each side.

The base supports the bottom of the fork at three points. At the center is a 1/2" bolt inside a bronze bearing. The other two support points are roller bearings (on the base) near the edge of the 24" diameter circle. The roller bearings roll against an aluminum track. The track is made from 10 aluminum plates cut from 1/8" x 2" bar. I was concerned that there could be a bump as the bearings moved from one plate to the next, so I cut each plate so the seams are not radial but are 18 degrees away from radial. This may sound complicated but actually was very simple. Each plate is cut at a right angle at one end, and at 54 degrees at the other end, so that when the plates are laid down end to end there is a 36 degree curve at each joint (times 10 makes 360 degrees). This has worked out just as planned; there is no perceptible bump or jerk as a bearing passes from one plate to the next. On my 14" scope I had originally just used smooth laminate for the bearing surface. This worked okay, but adding an aluminum track greatly reduced friction and vibration.

If you have seen the picture of my fork, it will be obvious that the fork is not symmetrical about the polar axis. It is very bottom-heavy. To restore the balance, I offset the declination axis 1-1/16" above the polar axis, so the weight of the tube balances the entire assembly. This was the most exacting calculation of the whole project. I had to carefully weigh or estimate the weight and center of mass of everything that rotated about the polar axis, to determine how much offset I needed. As it turned out, I was right on target. If I had miscalculated, there are many ways I could have brought it into balance.

This brings me, finally, to the foundation of the entire scope, the tilted base. Overall, the base consists of two wooden triangles. The lower triangle rests on the ground and is made from two Douglas Fir 4x4 beams bolted together (one side of the triangle is missing). The upper triangle is made from three layers of 3/4" Baltic Birch glued together. A hinge along the lower edge of the upper triangle connects the two triangles. The hinge is simply a piece of 3/4" galvanized pipe which is bolted to the upper triangle and is connected to the 4x4 beams by a pair of strap clamps. The biggest mistake I made when I first built the mount for the 14" scope was to use door hinges to connect the triangles. These proved to be much too flexible. The peak of the upper triangle is connected to the peak of the lower triangle by a turnbuckle. The turnbuckle makes it easy to adjust the angle between the two triangles, providing latitude polar adjustment from 25 to 50 degrees. (The upper triangle faces the North Pole.) I used a forged turnbuckle, which is much stronger than the usual bent-wire turnbuckle. These are available at Fleet Farm, Beisswenger's, and a few other hardware stores.

While the turnbuckle enables north-south polar alignment, there is no mechanism for east-west adjustment. Before the tube is in place, I can easily shove the mount to the right or left. With the tube in place, I would probably need to use a crowbar. In practice, I just align it by setting the base on the ground and visually aligning it with Polaris. This is good enough for visual observing. On my 14-inch, I attached a polar alignment scope to the side of the fork, but I never used it much so haven't done the same on the 20-inch.

If you've been able to follow all of this, you have probably figured out that the upper triangle supports the fork by means of the three bearing points. At the peak of the triangle is an aluminum plate with a V-shaped slot in the top. The bronze bearing at the bottom center of the fork rests in this V-slot. When the scope is resting on the fork, gravity tries very hard to pull the bearing out of the slot (towards the north.) To resist this, the bearing has a flange on one end. For safety, in case the flange somehow pulls loose, I added a much wider washer behind the flange.

The two lower bearings are trailer wheel bearings, available at marine stores and other places that sell trailer equipment. I used a pair of bearings back-to-back at each bearing point, because otherwise the bearings fall apart, the outer races being separate from the rollers. For axles, I used short pieces of 5/8" threaded rod and nuts. The outer points of the nuts just happen to fit perfectly into the 1-1/16" inside diameter of the bearings.

The whole polar bearing system - bronze center pivot, trailer wheel bearings, and aluminum track - is extremely efficient. It takes only about 8 ounces of force at the eyepiece to turn the 200 pounds of rotating weight. Low friction is important because I use a friction mechanism to drive the scope about the polar axis.

This brings me to the motor drive for the polar axis. As I mentioned before, I wasn't trying to build a highly accurate drive for imaging; instead, I just wanted it to be accurate enough to eliminate most of the nudging. It turned out to exceed my expectations.

In keeping with the low-tech approach, I used a simple DC gearhead motor. Through a pair of external gears, the motor rotates an ordinary threaded rod (available at any hardware store). The rod passes down the center of a 1" square aluminum tube (you may have noticed by now that I love square aluminum tubes!) A pair of ordinary plastic tube end caps connects the rod and tube. I drilled and threaded a hole in the center of each end cap to match the thread of the rod. The square tube presses against a round polyethylene tube that is wrapped around the rim of the 24" plywood base disk of the fork. As the motor rotates the rod, the square tube is pulled toward the east, causing the polar axis to rotate by friction between the aluminum tube and the polyethylene tube.

To control the speed of the motor, I built a small control box containing a potentiometer. The motor is rated at 23.5 volts but I usually run it at about 10 volts. The control box also contains a double-throw switch and a little 9-volt battery. In one position, the switch routes power from the main external battery through the potentiometer. In the other position, the 9V battery is switched in series with the main battery, approximately doubling the motor speed. This gives me a simple but effective speed control. Considering that only voltage and not frequency control the motor speed, the motor is surprisingly accurate. I usually have to tweak the potentiometer several times early in an observing session to get the right speed, but once that's done the drive speed hardly varies at all. The motor should run for about 50 hours on a charge of the small 12V lead-acid battery (attached to the underside of the upper wooden triangle of the base).

The drive runs for about 3 hours before the square tube reaches the drive gear, at which point a small switch cuts power off. To reset the drive, I unscrew the threaded rod from the coupling nut that attaches it to the drive gear. Then I flip the rod-and-tube assembly end over end and screw the other end of the rod into the drive nut. This takes a couple of minutes.

The main problem that I've had with these friction drives on my three scopes is that there isn't always enough friction for reliable tracking. On the 20-inch, it takes something like 20 or 30 pounds of force between the aluminum and the polyethylene to track reliably. Ideally, there should be just enough force to track, yet the force should not be excessive so it is easy to push the scope back and forth around the polar axis. There is an adjustable spring that provides tracking force. I usually have to adjust the spring a few times during an observing session. Despite the occasional tracking problems, I really like the friction drive because I can move the tube at any time without needing to disengage anything.

One other problem, which I first encountered and fixed on the 14-inch, involved the polyethylene tube. The drive would run for about half a minute and then stall. I finally figured out that the hollow polyethylene tube was developing a flat spot. To correct it, I slit the tube lengthwise along the inner side (toward the plywood) and forced a piece of rope into the tube to keep it from collapsing. In retrospect, it would have been simpler to just obtain a solid polyethylene rod from a plastics supplier, but I wanted to stick with the approach of building everything with stuff I found at the hardware store.

This completes the description of the telescope itself, but there is one additional very important part. The mirror box for my 20-inch weighs 105 lbs. I have never even tried to lift it. For me, that would just about guarantee a back injury. Instead, I modified a small, light-duty 2-wheel hand truck to help me handle the mirror box. I attached two wooden brackets to the hand truck which hold the mirror box by the top and bottom, keeping it 17 inches above ground level. With the help of this truck it's easy to gently lower the mirror box onto the fork bearings, which hold the bottom the mirror box 14 inches above the ground. It's also easy to load the box into the back of my wagon which is 21 inches high - I just tilt the box up slightly and tip it in. No ramp is needed.

Performance

Overall, I'm very happy with the performance of my 20-inch scope and am not planning any major changes. It's easy to observe visually at 640x with it. I don't have any plans to use it for imaging. I suspect that if I tried to do imaging, I might be disappointed with the accuracy of the drive or the steadiness of the mount.

Optical performance: John Hall, the optician at Pegasus, claims that my mirror has a Strehl ratio of .985, which would be outstanding. I have no way of verifying this, but I haven't seen any hint of optical deficiency in my observing so far. I believe that whatever optical defects exist are insignificant compared with the problems caused by the atmosphere or turbulence at the warm mirror surface. The job of the telescope is to hold everything in alignment and the scope seems to perform well in this regard.

The only significant problem I've had since completing the scope was a problem with the rotating secondary cage. I would collimate the scope with the eyepiece on one side of the tube. Then when I swung it around to the other side it was obviously out of alignment. When I finally bought a laser collimator, put it in the focusser and spun the cage around, it was obvious what was causing the problem. The axis of rotation of the secondary cage had missed the target, the center of the main mirror, by about an inch! I had to adjust the length of the truss tubes so the cage would point squarely at the center of the mirror. I had already trimmed the tubes four times and they were starting to get too short. To fix the problem, I drove eight flat-headed wood screws into the gusset plates where the bottom of the tubes rest. The tubes now rest on the screw heads. This enabled me to precisely adjust the position of the bottoms of all the tubes, which solved the problem. The laser spot still wobbles about an inch or two as I rotate the secondary cage, probably because my bearing is less than perfect, but this doesn't cause any visible problems. (Interestingly, the web site for the JMI NGT scopes, which also have rotating secondary cages, also mentions that the laser spot moves as the cage is rotated, so the problem isn't unique to me!)

The scope seems to hold alignment very well. Since it is always assembled exactly the same way (the east truss on the east side of the mirror box, etc.), only a small collimation adjustment is usually needed, and I can get by without collimation if necessary.

Mechanical performance: I think the biggest shortcoming of the scope is that the drive, at this point, isn't as reliable as I'd like it to be. Most of the time it works fine, but it's not unusual for it to slip due to wind, tube imbalance, or excess friction. I don't think this is an inherent design problem; instead, it just needs a little more work. I should probably use a stronger spring and maybe a larger diameter polyethylene tube.

Imagers are concerned with measurements of the drive error. I don't have any quantitative measurements to offer here. I have experimented a little with trying to hold a star at the exact edge of the field. After quite a bit of tweaking of the potentiometer, I can get the drive rate just right so the star just wanders slightly back and forth. I'd guess maybe 10 or 20 arcseconds of variation. I'm not sure if this is a periodic error or a random variation. The longest period in the drive is the 46 seconds that it takes for the drive rod to rotate once, so there isn't much time for a periodic error to accumulate (compare this to the 4 minutes for a 359-tooth worm drive). My point of view is that if you're serious about imaging, it's best to purchase a good commercially built mount.

Another shortcoming is that the mount is not as solid as a well-built Dobsonian. This should not be surprising. On my mount, the bearing points for the polar axis form an equilateral triangle 11 inches on a side, and the bearings are mounted on a wooden plate tilted up from the ground. By contrast, a typical 20-inch Dob would have azimuth pads in a triangle about 17 inches on a side, resting directly on the ground. My design has an inherent disadvantage here. I'm pretty sure that I could improve the mount's performance by replacing the wooden 4x4 base legs with metal tubes. But in my view, the relative lack of solidity is not a practical problem. When you thump the tube, it vibrates for 3 to 5 seconds. The vibrations are quite small and decay rapidly enough so I don't consider them a problem. There is maybe 2 or 3 arc minutes of "rebound" when moving the tube. This might annoy someone who is accustomed to a rock-solid mount, but I don't consider it a problem. And of course, since the tube is motor driven, I rarely need to push it except when moving to a different object.

An interesting point about bearings. When I move the scope around the polar axis, most of the friction comes from the polyethylene ring rubbing against the aluminum drive tube. The declination axis uses the traditional Ebony Star Formica running on Teflon pads. I've found that the polyethylene-on-aluminum polar axis has a much better feel than the teflon-formica declination axis. The polar axis seems totally free of "stiction" while the declination axis is stickier than I would like. Maybe I used the wrong brand of car wax on the Formica. If I build another telescope, I'm tempted to forget about Teflon completely and just use high efficiency bearings with adjustable polyethylene-aluminum friction.

Portability, usability: As it turns out, in my case the equatorial mount may actually be more portable than an altazimuth Dob. Because of its height, I would have trouble getting a 20" Obsession mirror box - rocker combination into my vehicle, a Passat wagon. I might have to separate the mirror box from the rocker, or else remove the altitude bearings. By contrast, my equatorial scope fits in with no problem. The mirror box goes in first, then I slide the fork in behind and partially around the mirror box. With the rear seats folded down, there's plenty of room left over for the remaining components.

The heaviest component that I have to lift is the 50-lb fork, which is easily manageable and balances well when I carry it with the fork arms on either side of my body. Assembling the scope takes about 10 minutes and is not tiring at this point in my life.

Actually, the thing I dislike most about the scope is the fact that I have to stand on a ladder to use it! The eyepiece height is several inches higher than it would be on an altazimuth mount, which is a disadvantage.

With any fork mount, there is a limit to how far below the equator you can point until the tube hits the base of the fork. I designed my 10" and 14" mounts to reach -50 degrees. On the 20-inch, I decided not to worry about the southern limit and just made the mount as compact as possible. As it turned out, it reaches to -37 degrees, which is far enough south to track the southernmost Messier object, M7 (-35 degrees). I can observe almost down to the southern horizon by cranking the turnbuckle down, but cannot track accurately in this area. I don't regard this as a serious problem.

Alternatives

You may ask, "Why bother with an equatorial mount? The problem of equatorial motion has already been solved with dob drivers and platforms." A perfectly legitimate question. As I see it, each approach has its own benefits and drawbacks.

Dob drivers are computer-controlled motors that drive the altitude and azimuth axes to track the stars. We have the ServoCat system installed on the club's 24" Starmaster and new 30" Obsession scopes, and it works superbly. Coupled with digital setting circles, it provides go-to functionality and spiral searches in addition to star tracking. If you just want to get to your objects as fast as possible and don't mind being dependent on electronics to get you there, it's a natural choice. Since it adds nothing to height and little to weight, I think it will remain the system of choice for telescopes 30" and larger. On the other hand, you need to use the control pad to move the telescope unless you disconnect the drive, in which case you lose tracking. I'm not a big fan of electrical telescope controls. I own a 6" Maksutov-Newtonian on a very fine Vixen GP-DX mount. This mount has electric slow motion controls on the polar axis and a mechanical worm gear on the declination axis. I have always found the mechanical control to be much faster and more accurate. With a dob driver, the image rotates which complicates long-exposure imaging. There is the "Dobson's hole" problem where objects near the zenith are hard to track. To a certain extent, a system with a cable-driven altitude axis like ServoCat ties the mirror box to the rocker box, since re-installing the drive cable is a somewhat delicate and time consuming operation. Installing ServoCat on an existing telescope is not a trivial task and may be too difficult for some people.

Equatorial platforms employ an ingenious mechanical system to turn a horizontal platform in sync with the earth's rotation. You just set your Dobsonian scope on top of it and voila, you've got equatorial tracking. Its big advantage is that it's easy to install under just about any Dob. But it has to be reset about once an hour when the platform reaches its limit of rotation, and you have to find the object you were tracking again. If you're using digital setting circles, they need to be re-aligned. Platforms have a limited range of latitude adjustment. While they track through the zenith with no problem, you still have the problem of moving from one object to another in that area.

My equatorial base most closely resembles a platform in capabilities. You could think of it as a high-performance platform. It tracks for about three hours, compared with one hour for a platform. After resetting the drive on my scope, it's easy to find the object you were looking at - just push the scope west a little to compensate for the time the drive was off. If you're using digital setting circles, there's no need to reset them. My platform has a much wider range of latitude adjustability. Of course, the downside is that it only works for one telescope.

A traditional equatorial mount (one with actual mechanical polar and declination axes) can track the stars with nothing more than a simple motor. If the motor or battery fails, you've still got the benefit of equatorial motion (manually operated). This reliability is an important plus when you're taking advantage of a rare opportunity observing in a remote location with little or no repair capabilities. There's almost nothing that can go wrong with a mechanical mount and it should continue working fine for decades. Equatorial mounts can track and move through the zenith, the highest quality part of the sky, with no problem. If you enjoy star hopping with atlas in hand, an equatorial mount is helpful since it naturally moves along lines of declination and right ascension. It's easy to hop two degrees west and one degree north to the next object. On my truss tube scope, it's especially easy since there is always a north truss, south truss, east truss, and west truss. If you want to move west, just pull on the top of the west truss or push on the east truss. Personally, I just like the fact that the mount moves the way the sky moves. On the other hand, most equatorial mounts (except for mine) are substantially larger, heavier and more expensive than altazimuth mounts.

So the type of drive you choose is a personal one, depending on how you want to use the telescope. I think my 20" has proven that there is a realistic, build-it-yourself alternative if you don't like Dob drivers and don't like platforms (and also don't like the pure Dobsonian nudge-nudge system.)

As far as I know, there is no telescope similar to this one currently on the market, so you'll have to build it yourself. Once I got started working seriously on it, it took about eight months to complete. I tend to be a slow and meticulous worker so I'm sure a lot of you could get it done quicker. I didn't keep track of the money I spent, but estimate that the materials cost a little under $1000, excluding the optics and Feathertouch focusser. It's a fairly challenging project and maybe not the right one for you if you're looking for guaranteed success. But if you enjoy sitting down with some graph paper or a CAD program and working out the details of a design, I think it would make a fascinating ATM project. I'll be glad to offer advice.

I did a quick search for commercially available equatorial Newtonians larger than 10" and could only turn up four. Parks offers 12.5" and 16" scopes on German equatorial mounts. And JMI has the NGT split-ring scopes in 12.5" and 18" sizes. The JMI 18" is probably the closest to mine in overall performance. I've never had the pleasure of trying one out, but it appears to be beautifully engineered. I would expect the split ring design to be more solid than mine, possibly equal to a good Dob. On the other hand, it's not as compact. In the JMI scopes, the ring is twice as wide as the mirror and it's hard to see how it could be made much smaller. In contrast, my fork is just 28" wide for a 20" scope. The split ring can only turn about 180 degrees about the polar axis while my narrow-fork can turn a complete circle. I expect that a split ring would be more difficult for an amateur to build than my fork mount.

Future trends

So, will my Narrow-Fork (or Dob-Quatorial) mount be the next big thing in telescopes? I rather doubt it. Although I think it has a lot of merit, somebody with more time, energy, and money than I have would need to promote it.

At last August's Northwoods Starfest, renowned telescope builder Mel Bartels was the featured speaker. He spoke about current trends in telescope making. One big trend is ultra-light telescopes. In these scopes, the mirror box and rocker are reduced to almost nothing and a sturdy ring on the ground provides stiffness. The secondary cage and truss are also made as light as possible, sometimes by using "strings" in place of some of the truss tubes. Dave Kriege at Obsession has more or less thrown away his own book on telescope making with his new line of ultra-lights. My personal opinion is that people are going a little overboard in this direction.

What I would like to see is an ultra-fat telescope. Something like a 36” f/2 about 6 feet high, maybe with a negative coma-correcting lens just in front of the diagonal. I don’t know if such a thing is even possible optically. Al Nagler, are you listening?

Mel Bartels also said, “Telescope technology is limited by ladder technology.” Or as Kriege and Berry said, in my favorite sentence from their book, “Before you become fully conscious of the tendency, you’re choosing the next object near where the telescope is already pointing so you won’t have to move the ladder again.” Maybe we need to get rid of the ladder. At about 28 or 30 inches, the mirror box weighs about as much as the observer. This suggests a telescope modeled after bicycle pedals. The mirror is on one pedal, the observer on the other, with a single huge altitude bearing in between. I’m sure this could be made to work in a permanent observatory where weight was no object. Could it be made portable without vibration from the observer killing the view? The only way to find out is to build it and see if it works.