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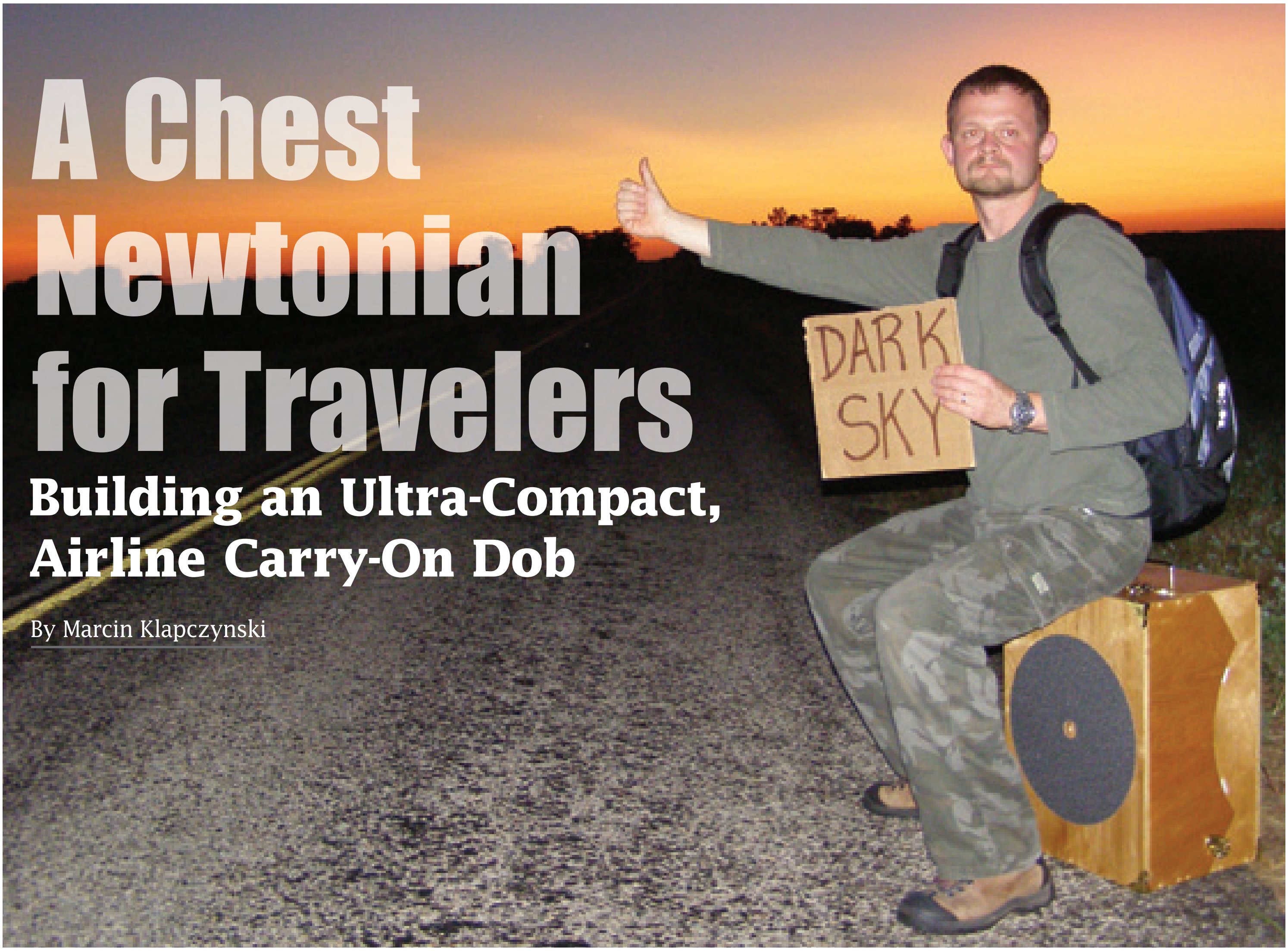
A Chest Newtonian for Travelers

Building an Ultra-Compact, Airline Carry-On Dob

By Marcin Klapczynski



I am one of those hard core ATMers who daydream every time they pass some stacked Sonotubes at a local hardware store and treat the plumbing isle as a source of parts for a homemade focuser. I have an unstoppable urge to build things out of simple parts, which when combined create a functional and, hopefully, "simply beautiful" device.

The simpler the solution is, the more satisfaction I feel. I have this weird habit of flicking through telescope catalogues and thinking, "Hmmm, this part could be actually made of three metal brackets and a couple of compression springs." I pride myself on being able to manufacture almost anything using wood, sheet metal, a jigsaw, and a drill. Actually, the more I write about it, the more I am convinced that it is some kind of mental condition – the same condition that causes many of us to spend most of our time looking at telescope advertising pages when we "read" astronomy magazines.

My condition developed not that long ago – in 2006 I was translating and editing some astronomy news for an Internet portal and I stumbled upon an article of Ray Cash-Le Pennec about building a simple Dobsonian. I was surprised to learn that such a sophisticated instrument as a Newtonian telescope could be built by any skilled DIYer.

Following Ray's guidelines, Jean Texerau's "ATM bible," and getting lots of advice from Internet forums, I successfully ground, polished, and figured a perfectly performing 8-inch mirror, then built a telescope out of plywood and a Sonotube. And I didn't get divorced in the process!

Visual astronomy became my passion, which was kind of problematic for someone living in Chicago, not quite a fairyland for stargazers. After a few months of star sight deprivation I was getting cranky and grumpy about it all, but at least those cloudy nights and snow up to elbows (or muggy air in the summer) forced me to spend time improving my telescope in many ways. I added light baffling, cooling fans, balance improving springs, and finally made a split tube for portability.

A Split Tube Was Still Too Large!

Well, at least I thought that the split tube will solve the last problem. Nope. For someone who owns a Corolla, even a breakable 8-inch scope is a monstrous fit. And, arguments like, "Honey, do we really need a tent and foldable chairs for camping?" don't work either. So under those darkest sky sites I was looking through my binoculars at M13 and thinking, "Oh boy, this thing would look awesome through my scope." So I kept thinking I should buy a travel size telescope, maybe one from those fancy catalogues. But one day my loony mind shivered in disgust and declared, "No, you shall make one!"

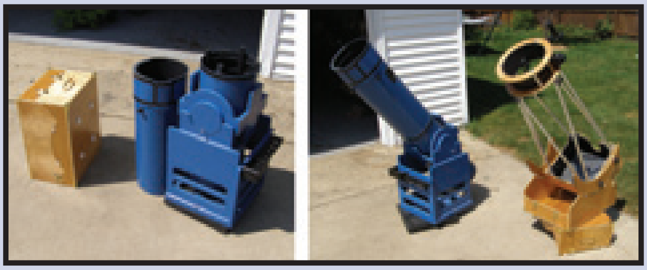


Figure 1. Splitting the Sonotube is not enough for a small car owner. The "chest design" saves the day!

Figure 2. Front collimation is quick and convenient. The folded chest is quite heavy, but it can be carried by a fit individual without problem.

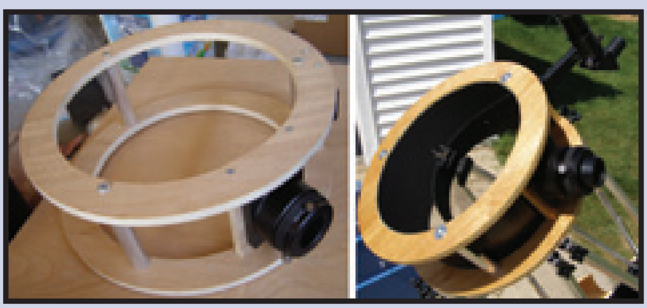


Figure 3. The secondary cage takes shape. Kydex was used for baffling.

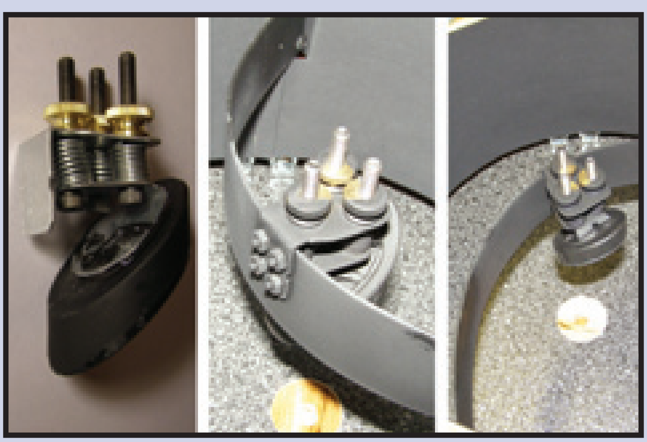


Figure 4. The low profile spider can fit into a short secondary cage.

I was browsing for ideas on the Internet and stumbled upon a design by Serge Vieillard and Pierre Strock, French amateur telescope makers. I adapted the base, rocker and mirror box from their project, enlarging them a little bit. I didn't like their secondary cage and truss mounting solutions, finding them not sturdy enough. I decided to make the chest a little bit bigger to accommodate truss tubes and additional equipment. I prefer and recommend my, more beefy version although it should be noted that the telescope I present here is still accepted as carry-on luggage by most US airlines.

Designing the Chest Scope

How do you attempt to design such a telescope? Things you cannot change obviously are optics parameters – the primary mirror aperture and its focal length. First thing that should be designed and built is a secondary mirror cage, or upper tube assembly (UTA). I like an oversized UTA in order to eliminate possibility of vignetting and have shorter length tubes. That is why I have used the secondary cage of inside diameter 10 inches and a low profile focuser. I have made the rings pretty wide - 1.5 inch - which is not really necessary; I just like the look. They were connected by using threaded tube connectors tapped inside the truss tubes. Total height of the secondary mirror cage is 5 inches, which comfortably accommodates any type of focuser and a low profile spider. With some effort, the height could be further reduced, if needed.

I used a one-vane curved spider and a very simple, low-profile secondary mirror holder. The holder is made of two angle brackets, one of which is bent at 45 degrees (see **Figure 4**). To collimate it, one uses the three knurled knobs, which compress springs between the holder's elements. It is tricky to position and center this kind of a spider. I had adjusted it after putting together the complete optical tube assembly (OTA), so I could actually see the alignment and pre-collimate the optics. I had planned to use two thumb screws on each side of the vane, but instead I have attached it directly to the truss tubes using metal screws. The spider is very rigid and vibration free. The secondary mirror cage defines the size of the rest of elements.

I always preassemble everything using wood screws. One should always predrill holes for even fine screws to prevent the plywood from splitting. I permanently glue all the parts only after testing the final setup in the field. Wood is graceful and forgiving material to work with, but it also contracts and expands under temperature, which is why I apply all the extra clearances.

The Mirror Box and Cell

The mirror box must accommodate a mirror cell, the mirror itself, a protecting cover, and the secondary mirror cage. So the walls of the mirror box form a square with a side length equal to the outer diameter of the UTA plus 0.5 inch. The mirror box bottom and front sides are shorter, forming a frontal notch that will help to make the rocker box lower (see **Figure 5**). The back wall has to have an opening for the focuser that will stick out from the secondary cage while packed up. In order to easily pull the secondary cage out of the mirror box, all its walls should be 0.5 inch lower in the middle than at corners. Height of the mirror box is summary of: height of the primary mirror cell plus 1.0 inch, the primary mirror thickness plus 0.5 inch, and height of the secondary mirror cage.

The mirror cell is a flotation system with 9 points of support and a sling. Because the mirror box must fit into the chest for transport, one cannot use typ-

Figure 5. The front wall and the bottom of the mirror box are smaller in order to create an open notch. This allows to design a lower rocker box and let the air circulate and accelerate the primary mirror cooling. For storage, the mirror box must accommodate the secondary cage with the focuser.

Figure 6. The mirror cell detail. The front protective screws were later moved to the sides, the sling was installed on them (not shown).

Figure 7. Attachment of the upper part of the truss tubes.

Figure 8. Attachment of the lower part of the truss tubes.

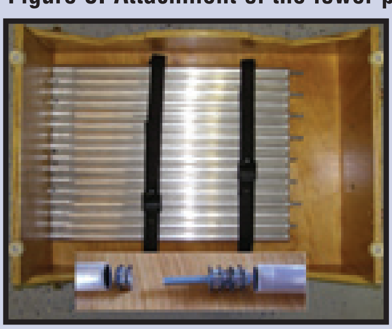


Figure 9. The truss tubes storage and tube parts connection (inset).

ical collimation bolts. Instead, there are only two adjustable shoulder bolts that can regulate the height of the two back-side triangles floating on the hinged metal bars (see **Figure 6**). Back-side triangles can be positioned above or below the third, front triangle which position is fixed on an angle bracket. The collimation bolts go into threaded inserts that are installed through the plywood. The convenience of frontal collimation is exceptional – one can look through the focuser and turn the knob at the same time. To support the mirror while in transport, I placed four 3-inch screws around it. They have no heads and are wrapped in soft plastic tubing. The protecting mirror cover rests on them during transport, while the telescope is set up, and folded down. The cover is a piece of laminate with a thin foam ring attached to it that protects mirror edges from damage. An old backpack strap serves as a sling to hold the mirror in place and prevent tension.

Designing the OTA

Before building the rocker box, one should have the complete OTA made first. In order to do that, the length of truss tubes must be known. First one needs to figure out the distance from the mirror face to the center of the focuser hole using the following formula: D = FL – (ID / 2) – FPT – FH – AFT [Where: FL = focal length, ID = inside diameter of secondary cage, FPT = focuser plate thickness, FH = focuser height, fully racked in, and AFT = additional focuser travel of 0.5 inch to 0.75 inch].

Then half of the UTA height (but only if one puts the focuser exactly in the middle between the rings!) and the distance from mirror face to the top edge of the mirror box at corners are subtracted from D. One needs also the distance from the middle of the wall top edge to a truss tube mounting strap on the same wall. Once the two sides of a right triangle are known, the length of the third one can be calculated. This is the truss tube length.

Truss tubes are connected to the secondary cage by simply stringing them onto 1.25-20 bolts, which are mounted on a 0.5-inch wide, 1-inch by 1-inch angle bracket with two nuts and a washer (see **Figure 7**). The tubes have holes drilled through their upper ends. Once in place, the tubes are fastened with threaded hole knobs. The two mounting screws on each side are parallel to each other. The washer and two nuts are used not only to hold the bolt in place but also to position the truss tubes properly, so they stick out 0.25-inch beyond the UTA edge. This solution is not the most elegant, but it makes mounting the tubes' lower ends much easier, because the tubes do not have to be tilted towards the optical axis. The knobs sit on the bolts while in storage and they fit into the mirror box nicely.

Truss tubes are connected to the mirror box by simple pipe straps (**Figure 8**). One part of each strap is permanently fixed with a screw. The other part is fixed with a threaded stud knob that goes into a surface threaded insert. There is an additional nut raising the knob slightly, which prevents its arms from bumping onto the strap bend. It is crucial that the inserts are tapped in well and enforced with epoxy, otherwise they will be pulled out while tensioning the clamp. To hold tubes at the same position, there is a sturdy angle bracket installed in each corner of the mirror box. Position of threaded inserts is determined and marked after assembling and adjusting truss tubes in complete OTA.

In order to fit truss tubes into a chest, they were cut in half and connected using the tube connectors (**Figure 9**). It's essential to make a precise, clean and square cut – a tube cutter is a right tool for the job. To prevent tube ends from crushing and to make stable connection, a couple of washers can be used between the parts. It takes some time to assemble them, so it is not the most convenient solution. One could consider some kind of telescopic tubes, like fishing poles or wheeled luggage handle bars, which can be extended and collapsed in no time.

I like physically balancing the OTA to find the balance point. In order to do it, I place a completely assembled OTA (including a finder and an eyepiece) on a sturdy dowel, like a seesaw. After the balance point is determined, one can figure out the diameter of altitude (alt) bearings and plan the height of the rocker box and the base. One way to do it is to cut bearing dummies out of cardboard or Styrofoam and try them on. The alt bearings do not have to be half circles in order to observe at horizon and slightly beyond zenith, since Teflon pads are usually spaced around 70 degrees apart. On one of the alt bearings, an extension spring can be mounted, in case of balance problem. The bearings are attached to the mirror box by two threaded stud knobs and strong threaded inserts that go all the way through the walls (**Figure 10**). The laminate strips are attached with some contact cement.

The Rocker Box and Base

One needs to take some time to design the rocker box and the base. The bearing size will only partially determine their dimensions. Both these elements will form a chest that has to accommodate all the elements of the telescope. Besides the mirror box with the secondary cage in it, you need space for alt bearings on one side and truss tubes on the other (**Figures 11 & 9**). The front and end walls of a rocker box cannot be too high, because the mirror box will bump into them or/and placement of the bearings will be awkward. These walls should not be too low either, because the rocker box will lose its rigidity and the base walls will be consequently too high and possibly unstable. The rocker box should be the internal width of the mirror box, plus 0.25 inch to allow smooth motion and prevent mirror box and rocker box walls from rubbing onto each other. The elements' length is determined by the alt bearing diameter, so they can fit in for storage.

An azimuth bearing is made of a 14-inch diameter circular piece of Ebony Star laminate on the rocker box and four PTFE pads on the base (**Figure 12**). The laminate is attached using contact cement and the PTFE pads are fastened with screws in predrilled holes, so their heads are well hidden. The base contains a threaded insert in the center; the rocker box has just a rough opening of bigger diameter. The bearing bolt is actually a shoulder bolt of the same type as used in the mirror cell collimation system (**Figure 6**) – it is slightly thicker in its upper, unthreaded part. This upper part goes snugly through the rocker box opening. The bolt is then tightly driven all the way in the insert in the base so it will not move while in use. This solution performs very well.

To be able to set up the telescope on uneven terrain, four soft-rubber legs are attached and they passed the in-field test on a gravel road and my lawn. The front and back walls of the rocker box must be cut to fit those legs. Also, the side walls of the base must be cut to fit the PTFE pads of altitude bearings installed on the rocker box (**Figure 13**). They should be cut at the end, once you're sure the pads are spaced properly. To protect the telescope from damage, corner protectors should be used. To keep the telescope closed and its contents safe during

Figure 10. Altitude bearings. One of them can accept an extension spring mount as a virtual counterweight.

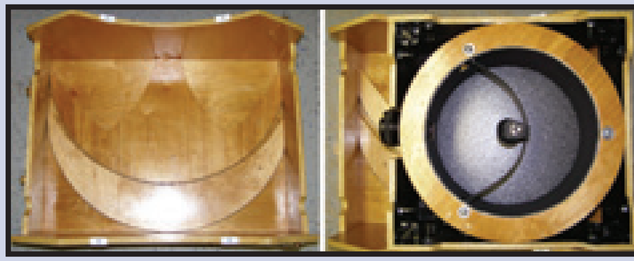


Figure 11. Rocker box will accommodate alt bearings and the mirror box with the secondary mirror cage in it. There is still some space left for a shroud and other equipment.

Figure 12. The azimuth bearing parts are the outer walls of the chest

Figure 13. The legs and the Teflon pads should fit into notches. The latches are used to secure the chest contents.

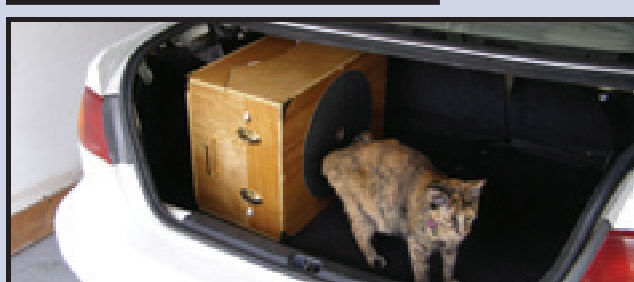


Figure 14. Xena approves the chest size.

transport and carriage, I used four latches – two on the top, and two on both sides – to allow the chest stand in vertical position. Wood needs to be stained to protect it from moisture. I used three coats of polyurethane, then I also blackened the inside of the mirror box with spray can paint. A hard lesson to learn was to figure out that wood filled holes look really bad after staining. I guess it's better to leave these shiny screw heads alone, or maybe use some kind of plug later.

The telescope performs exceptionally well – it is sturdy, it operates without effort, and stays at set position, no matter what is in the focuser. I don't own any of those very heavy eyepieces, but I suppose I would use an extension spring as a virtual counterweight, as mentioned earlier. I like the advantage of open OTA and no air currents crawling in the tube. I already tried the telescope under dark skies of Green River Wildlife Area, near Dixon, Illinois, and was very happy about the outcome. My secondary mirror dewed up though, so I guess it's time to get 12-volt hairdryer and a shroud. Somehow, the primary mirror stayed dry all night, despite heavy moisture in the air that had others fighting dew and wiping corrector plates every five minutes. Best of all, I am still amazed how much space I have left after packing the scope into trunk of my Corolla.

What don't I like? Becoming a master of nightly collimation is one thing – it's quite annoying. My previous, split-tube Dobsonian didn't have to be collimated for months. I believe it's an issue for any truss tube telescope. The telescope weight could be a problem too. The height of the secondary cage and width of its rings could be further decreased to reduce dimensions of the rest of the elements and overall chest size and weight. The solid construction makes the scope very sturdy, but the chest is quite heavy if it has to be carried very far. This problem could be partially solved by cutting some wood pieces out of walls, which would be good opportunity to show off some artistic skills. I have considered it for a while, but I store my telescope in a garage and don't want dust, moisture and insects to get in, although now that it's a scope chest, I could easily fit it in my bedroom closet. ATT

CHEST NEWTONIAN FEATURES

Primary mirror
Handmade 8-inch(208mm) f/5.8, Beral coated.

Secondary mirror
1.54-inch (minor axis).

Mount and truss-tube materials
1/2-inch Baltic birch plywood, 3/4-inch OD aluminum poles, Kydex

Bearings
Virgin PTFE on Ebony Star laminate.

Dimensions after folding
20.5 inches x 15.5 inches x 11.5 inches (cm: ~ 52 x 39 x 29).

Weight
35 lbs (16 kg).