A practical home observatory

This account shows how a small outbuilding can be easily converted into an observatory, greatly improving the comfort and performance of observing sessions. By Keith Venables.

I have recently got back into practical astronomy as my career and family circumstances finally gave me some time to spare. I had been a keen observer while at school and took a degree in Astrophysics, but I subsequently took up employment as an engineer and settled in a light polluted area.

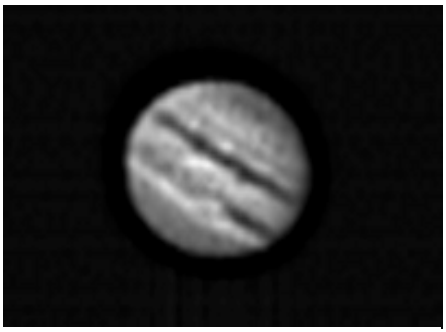
In the last few years my interest returned, fuelled only by appropriate TV, magazines and books. I dreamt of acquiring a telescope and getting stuck into some serious observing, but it looked as if I was going to have to retire first! Then I moved to Somerset. The night sky was quite dark, and with some spare time, it didn't take long for me to start thinking about finding a telescope.

Telescope to be housed

My first buy was a 150mm TAL Newtonian. It gave fair performance, but was let down by poor eyepieces and a cumbersome mount. At school and university I had been spoiled by a permanent installation in an observatory. Now it was taking half an hour to get set-up, and as I added a CCD camera and needed to align more accurately, setting up (and packing up) took even longer and became so much of a chore that I would often find excuses not to observe.

A year ago I swapped the TAL for a Celestron C8 with digital setting circles. This was done partly because the opportunity arose, but I also thought it would be easier to use. It wasn't much quicker to set up, but finding objects and taking CCD images was much better. I was beginning to get some good observing in, and so the setting up problem became even more frustrating. There was nothing else to do but to build an observatory!

My garden is very small but has two outhouses, originally built as washhouses around the turn of the century. They are brick built with a tiled roof. The roofs leaked, and the brickwork was decaying, but overall they were the best starting point. One was smaller



CCD image of Jupiter showing GRS, taken by the author with his Celestron C8 and a Starlight Xpress M5 camera. A sequence of images over 2 hours led to a measurement of 9h 55m for the rotation period at the GRS.

Despite a number of fairly close buildings and trees, a good coverage of the sky is seen from the top of the outhouse roof. The roll-off roof can be pulled towards the telescope to shield the observer from stray lights. This view is approximately due North. Photograph Keith Venables.

(2m x 2.2m) but was furthest from obstructions and lights. Sitting on the roof one night I could see that the field of regard would be quite adequate, but that some lights to the North would need to be screened out.

The Planning Stage

Now the project turned into the planning stage. As an engineer I knew the value of thoroughly considering all aspects of the job, with trade-offs at each stage where a major decision was needed. The key design questions soon became clear,

a) Where did the telescope mount need to be with respect to the roof.
b) What size of opening would be required in the roof.
c) What type of dome or roof over the opening would be best.
d) How to mount the telescope.

Problems a) and b) were first tackled by a scale drawing of the telescope superimposed on a sketch of the roof line. The object was to get the telescope as low as possible, while giving maximum coverage of the night sky. The tiled roof fell away to the North, which was exactly the opposite of what might have been best, but I was not about to change it! I also at this point worked out how low the telescope could be stowed, thereby defining the minimum size for the new roof. The building being small meant that I couldn't consider a large opening, but with an SCT the rotating diagonal means that the eyepiece can be readily adjusted to assist, and my prime interest is CCD imaging so comfortable access to the eyepiece is not critical. I decided to leave the exact final size of the opening to a practical test once the project was underway.

I fancied a proper dome, but this was soon rule out on three grounds, proprietary domes are very expensive, making one would be difficult and too time consuming, and importantly it would be fairly obtrusive to my neighbours.

Second best choice would be a roll-off or fold back roof. After a couple of hours sketching every possible option, the idea of a roof rolling-off to the North seemed like the perfect solution. It had a number of key features that I needed to maintain as I moved forward to detail planning and then construction. These features were,

- As the roof rolled to the North it moved down the tiled roof, giving better views of the polar region.
- The roll-off roof would double as a light screen for those troublesome lights that I mentioned were to the North.
- Views of the important South would be obtained by folding down part of the roof.
- I hoped that the roll-off roof could be drawn up as far as possible to act as a wind-break while looking overhead or to the southerly directions.
- A raised floor would be needed to make observing comfortable.

- This floor would need to be isolated from the telescope mount. In fact as the building did not seem to be too sturdy, I decided to isolate the telescope from the building as well.
- Making the whole building weatherproof was a must!

A bit more detailed planning was needed before I could start. Designing a weatherproof cover was important. To seal the opening I adopted a principle similar to a roof light. Water runs off the roof tiles and the roll-off roof into a gutter around the top and sides of the opening. The roll-off roof was designed to overhang the opening and therefore drain well away from the telescope. Furthermore the roll-off roof was arranged to be sealed except for the fold down flap, which has large wings on three sides to overlap the roll-off roof. Material for the roll-off roof was chosen as external grade 12mm ply.

The plans showed that the telescope mount would need to be 2.2 metres above floor level. A stable pillar would be needed, but one that did not intrude too much into the already small building. The washhouse floor was brick laid on soil, so adding foundations for a pillar would not be difficult. I searched around and came up with a 3m length of 150mm diameter galvanized air ducting. This presented a good starting point, but some experiments showed that it would probably not be stable enough on its own. Although I could not prove it, I thought that filling the tube with concrete would provide a stiff enough pillar.

Getting down to business

Enough with the theory, and I was anxious to get on and start the project. First I used scaffolding to erect a raised floor 1.2m above floor level. The scaffolding rested on the brick floor, and vibrations would be unlikely to reach the telescope pillar. Assisted by the new floor, I started removing tiles. Following my first plans, I found that an opening 1.1m by 1m worked well with the rafter and tile spacing. Next, in daylight, I set-up the telescope on its heavy duty tripod on the raised floor. Moving the tripod about, and adding blocks under its legs, I could fine tune the best position for the telescope mount, and check that the field of coverage and access to eyepiece would be adequate.

Now that I knew that the opening was correct, and where the mount should be, I made good the opening surrounds, constructed the roll-off roof, and generally attended to making the roof watertight. The roll-off roof has four 4" nylon wheels running in aluminium tracks. The weight of the moving roof was counterbalanced by two 5kg weights on wires running over pulleys on the South wall.

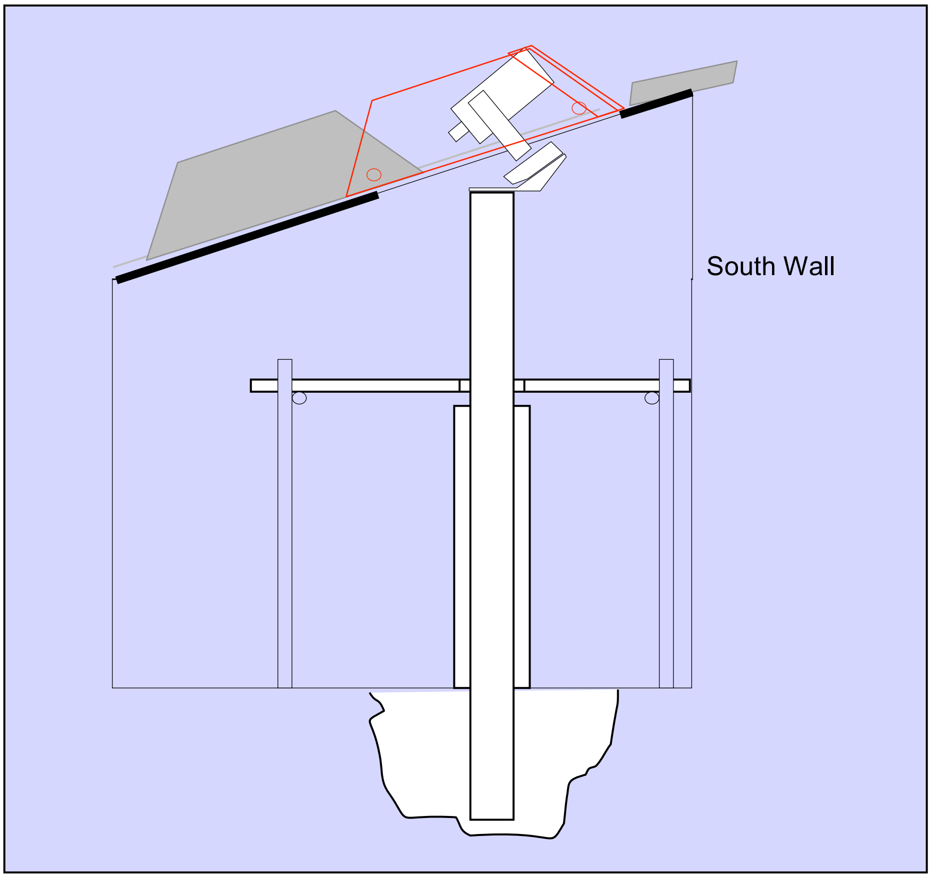
When the roof was done I turned to the pillar. I dug out a hole about 90cm cubed, cut an oversized hole in the raised floor, and positioned the steel tube correctly. The most physical work now had to be done, mixing some 350kg of concrete! I filled the hole and the pillar with concrete mix, and just to make sure, put some iron bars in the pillar to reinforce the concrete.

While the concrete hardened I ran power out to the building and installed lights and sockets. Two lighting circuits were added, a working light with an ordinary 60W lamp, and a night light with a 15W red lamp. Later I found that even the 15W red lamp was too bright while observing, so I rigged some high brightness red LEDs. Mains was fed to the Observatory via a sensitive RCD for personal protection.

With some black paint on the inside walls, the observatory was starting to look the part. However the pillar was giving some concern. When nudged at the top, it swayed perceptively for a couple of seconds. I decided this must be due to two factors, a) the pillar was not as rigid as I had hoped and b), the heavy weight of the pillar was helping to turn any movement into a slowly decaying oscillation. I considered many options for overcoming the problem, and came down to either supporting the pillar with a tripod of scaffolding poles anchored in the ground, or to thicken the pillar with a larger diameter sleeve of concrete. The former would have been easier but the poles would have encroached into storage space and would have been vulnerable to getting disturbed. Some elementary calculations showed that I did not need to thicken the pillar all the way to the top, indeed this would add further weight at the top and could still leave me with a top heavy pendulum. The perfect shape is in fact a pyramid with all the weight and strength at the bottom. I found some 300mm diameter tubing and cut a length to fit from the floor to just under the raised floor, some 1.2m. This was installed and duly filled with yet more concrete! My plan if this still didn't work was to put another shorter but wider concrete filled sleeve at the bottom of the pillar, thus creating a "pyramid". I need not have worried though, as the pillar became really stable once the concrete had set in the 300mm tube. Knocking the pillar now result in a oscillation of around 3-5 arcsec, which decay away very quickly in about one second. The movement in the pillar is now far less than the play in the Celestron fork mount.

Installing the Telescope

At last I was ready to install the wedge mount and telescope. Fortunately the wedge was a deluxe model and was easy to adjust. After a quick and rough alignment, three hours were spent applying the declination drift method to achieve a precise polar alignment. This method is well documented and with the adjusters on the mount it was easy to achieve. Without the adjusters I could imagine however that applying fine corrections to the polar axis could be very difficult. Towards the final stages one needs to apply adjustments of the order of arc minutes, and if you don't have adjusters I strongly suggest you improvising with some screw threads or similar. However its done, the rewards are well worthwhile. After alignment I did a simple one star alignment for my digital setting circles using Sirius, and then punched in M82 as a new target. I swung the scope around as guided by the computer, and there



Schematic of the observatory shows the concrete pillar and foundations, raised floor, telescope position, and the roll-off roof in both closed and open positions.

With all these add-ons it looks a bit top heavy, but a large counterweight keeps satisfactory balance. The 2" flip box holds the Starlight-Xpress M5 CCD and a Meade 10mm reticule eyepiece, just visible is a 5 filter slide in-front of the CCD camera. The Televue on top has a x5 Powermate and a b/w tv camera, this gives about 2 arcsec resolution on the tv monitor. Just visible behind the mount is the 17" PC monitor, used for displaying CCD images and Sky Map Pro 6. The C8 electric focuser is nearly essential in achieving best focus.

it was, right in the middle of the eyepiece field of view. Much of what I had wanted I had now achieved. I can leave the house and start observing within about 10 minutes.

Finishing Touches

With the basics installed and set-up, I spent a few hours adding some final touches. First I installed a heavy duty regulated DC power supply and ran 12V and 9V DC up the pillar to the telescope. The telescope and all my accessories needed one or other of these and having a common supply removed the inevitable spaghetti junction of transformers and cables. This supply also allowed me to add some red LEDs around the observatory to guide me to controls etc.

The cabling for my CCD camera was also run under the raised floor and up the pillar, removing another hazard in the dark. A set of shelves on the South wall carry my PC, clock radio, and tv monitor. The clock radio has two functions, the radio keeps me company during long sessions, and the clock is of course a vital necessity for serious observations. The clock is of the radio controlled type, made by Sony it has an illuminated time display including seconds. Comparisons with the BBC time signals have shown that it is very accurate.

Personal Comments on Equipment

I have already stated my main telescope is a Celestron C8. The original finder has been replaced with an Intes 8 x 50 with illuminated reticule. An additional EZ-finder makes short work of manual slewing to more visible targets. Piggybacked on the C8 is a Televue Ranger.

A 2" flip box and 5 filter carousel are used with my Starlight-Xpress M5 CCD camera. A 10mm illuminated reticule eyepiece is used for alignment.

As for eyepieces, I was originally content to use the 25mm SMA included with the C8, plus 9.7mm and 26mm super Plossls and a short barlow that I use with my Meade ETX90/EC. I added a 50mm for wide angle work, and a Televue x5 Powermate barlow for planetary and lunar viewing.

Use of the barlows always left a feeling of disappointment. Even when I was well below the theoretical magnification limit of the telescopes, the image seemed almost worse with the barlow than without. One night I had the chance to use a friends Televue Panoptic eyepiece and immediately realised the full potential of the telescope.

I then added a 7mm type 2 Nagler and a 17mm type 4 Nagler from Televue. The later is particularly expensive, large and heavy, but has almost made every other eyepiece I own redundant! It has a clarity that is superb for planetary imaging, yet a field of view that is great enough for nebulas and galaxies. The old adage that you only get what you pay for has never been better illustrated for me. I have the advantage of travelling to the States frequently, so I can buy accessories at about two-thirds the cost in the UK.

My final eyepiece is unusual. It is a home made assembly based around an image intensifier tube of the type used in night vision sights. The tube has a light amplification factor of many thousands, and it includes an automatic gain control that maintains an optimum output brightness. In practice it is the brightness of background sky that causes the gain to reduce to the point where the background is just visible as noise. An eyepiece is normally used to view the output face of the image intensifier tube. Using this arrangement I can usually see stars 2 magnitudes fainter, and some detail in nebulas and galaxies. An example is the central dark lane across M82, which is stunningly clear using the eyepiece.

The full potential of the intensifier tube is achieved by using a sensitive tv camera to capture the image, the camera output is then integrated over a number of tv frames, bringing back some of the gain of the tube.

Closing Comments

It is not long since I finished building and setting up the Observatory, but I can already see that it is achieving everything I wanted.

Not only is getting set-up faster, but also so is moving between objects during a session. I'm much more likely to "have a go" at finding a difficult subject. Much of this comes from being able to sit in relative comfort, surrounded by charts, and spend time at the eyepiece or pc screen.

Sitting at the telescope, surrounded by all ones favourite equipment neatly arranged and ready to use, it can be difficult to finish an observing session. But when it is time to stop, the satisfaction of shutting down and closing up within a few minutes is bliss.

The whole project took around 40 hours to complete, and has cost less than £400. This seems very affordable when compared with the cost of telescopes and accessories.

The roll-off roof blends in well with the surroundings, and even when in use the observatory does not intrude into the neighbourhood. Photograph by Keith Venables.