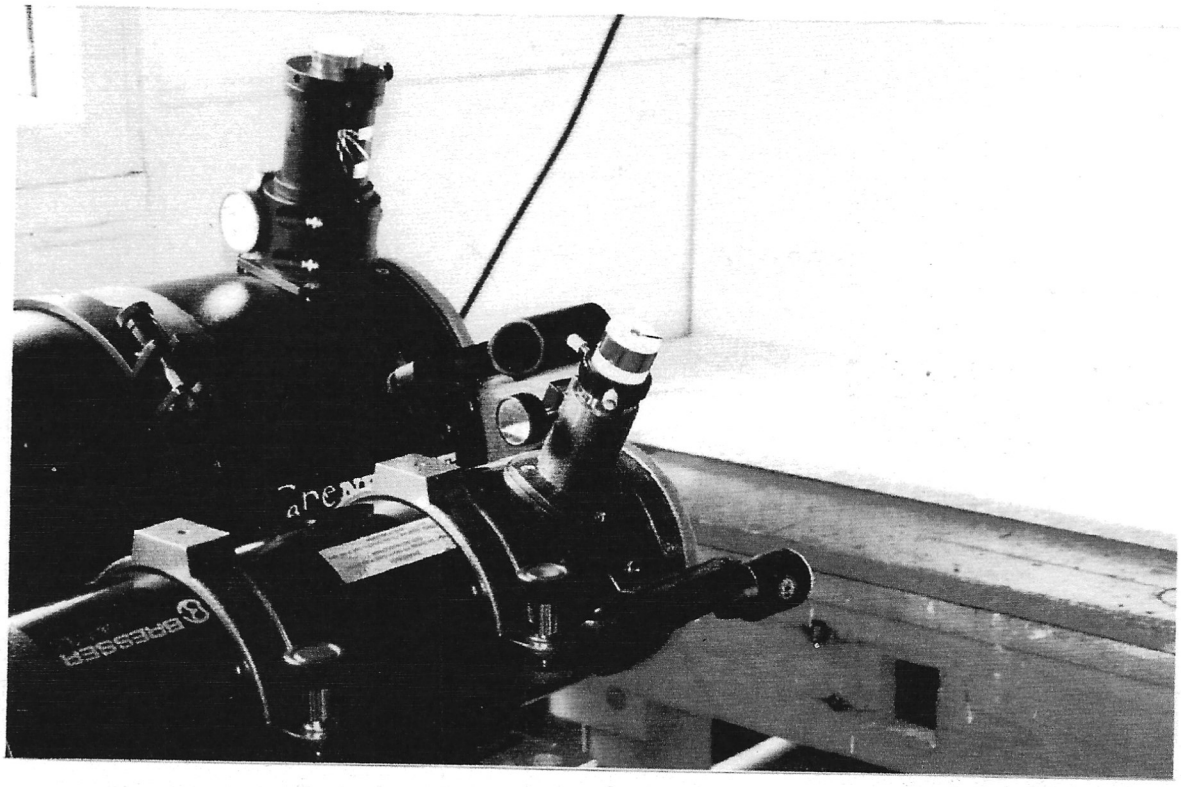
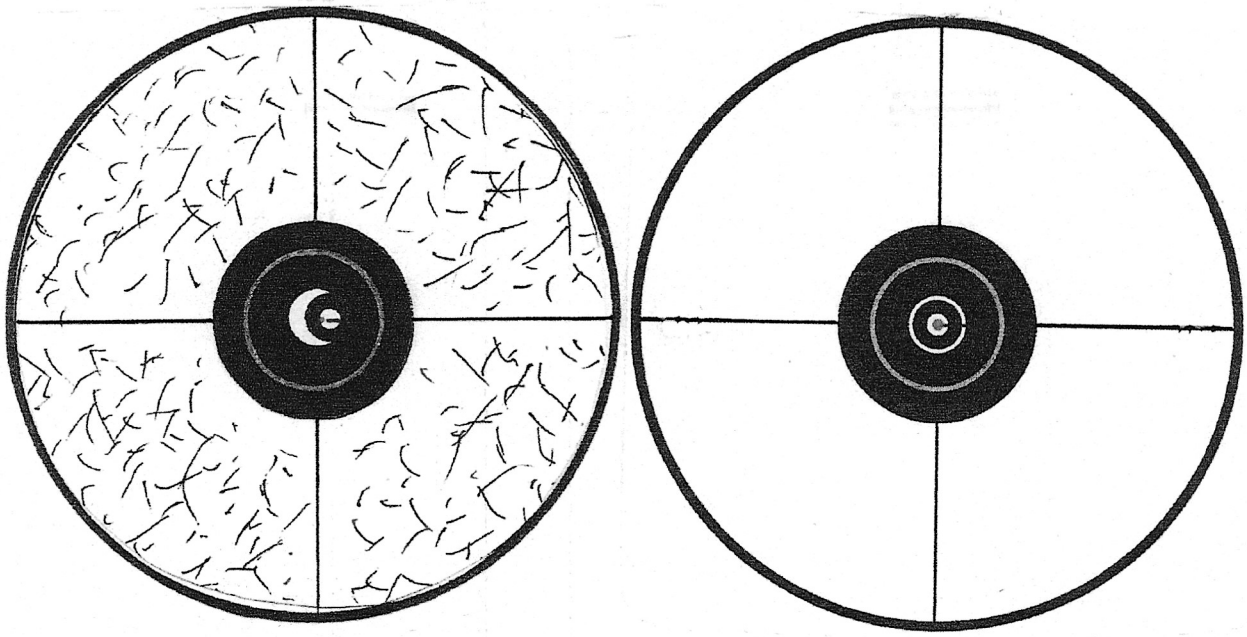




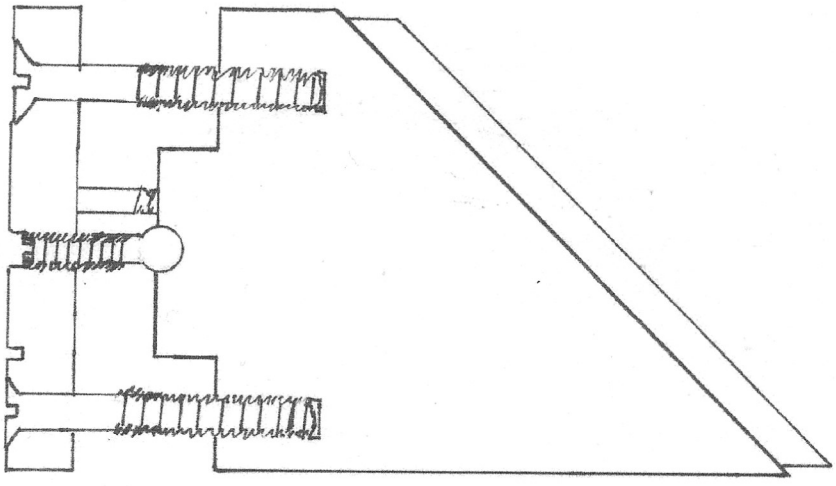
INSTRUCTIONS

in the successful use of the

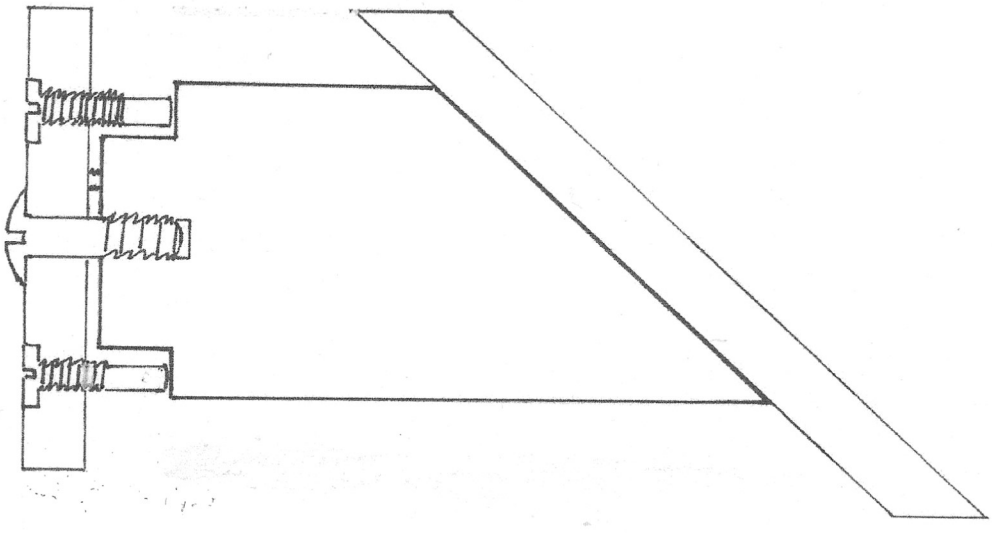
CAVE

TELESCOPE COLLIMATOR

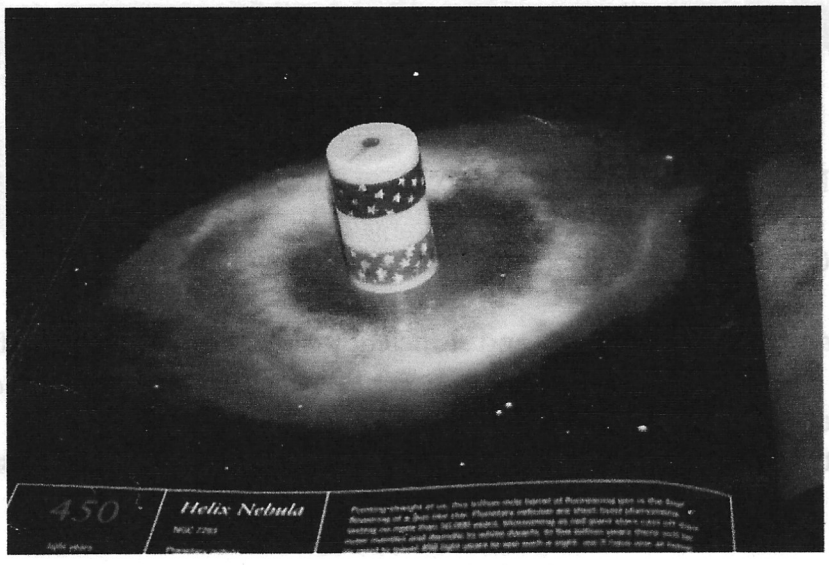
Peter R. Clark



TWO WAYS OF MOUNTING THE SECONDARY MIRROR.
The upper one is for heavier units. Being hung off such long bolts would be less stable. The lower drawing shows lighter weight possibilities and a type of off-setting in which the mirror may not reflect circular.
The methods of rotation are clearly different. These drawings may be useful in blending probably Newton's first moves, Stage [1], with the New Method.



First Edition 2012
Second Edition 01. 09. 2012



"The Cave Collimator was excellent for my Maksutov-Newtonian telescope and very good for my Rumak - Cassegrain."

– PROFESSOR IAN MORISON, JODRELL BANK

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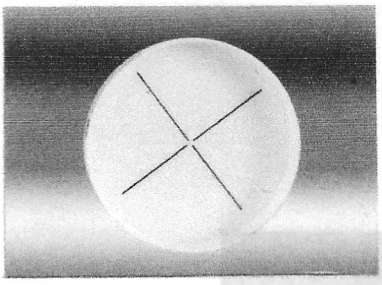

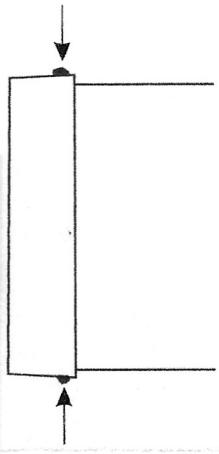

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Details of any partial obstructions:

Laying the telescope lengthways for car journeys and with the focus tube vertical, guards against secondary mirror rotation by gravity. Adjusters of spring wire spiders can loosen causing difficulties when collimating with a star.

The hexagonal mask for telescopes is useful for viewing difficult double stars especially with good optics when one of the components is brighter than magnitude 6. Magnitude and colour differences will be clear, but separation may be masked by faint Airey rings which good optics reveal. Cardboard masks need a minimum width of 25mm, plywood 12mm. Lesser optics can pass these tests by stars being sharper than unaided vision or hard outlined blobs, but colour and magnitude differences may suffer.

Please see www. The Guide to Amateur Astronomy, and 'Hexagonal masks for double stars'. Webb Deep-Sky'.

Twist Lock / Precision Centring Adaptors do just that by gripping eyepieces and collimating tools. They are appreciated even more by people who come to dislike grooved eyepiece barrels.

Mainly for beginners to portable equatorial mounted telescopes

So as to be speedily set up and to on a star within 15 minutes every time, paint 3 white blobs or bed in 3 tripod anti -vibration pads for tripod feet. True north alignment may be derived from the Sun's shadow of a vertical stick when at its minimum length time , or use the exact meridian passage time by applying the Equation of Time correction. Longitude is 4′ of time per degree of hour angle, 15′ of R.A. Then, with the counterweights pointing approximately at Kochab and ideally having crafted a 1° true FOV for your telescope with..... FOV= FSD x 57.3 / Focal Length, Polaris should become easier to find and work with. Another good tool for star collimating is a Planisphere's indication of the altitude of any useful star near to the meridian just before you can see it with the naked eye. It has a faint zenith mark from which you can interpolate altitude on the declination scale, or use a builder's or satellite dish installer's elevation protractor. Field Stop Diameter, the clear measurement across the back of an eyepiece, is easily obtainable from stockists.

References www. The 'Difficulty Index List' of double stars. Louis Arguelle. Sky & Telescope Jan. 2002.
Norton's Star Atlas 2004, p.38, *is very clear on displacing the secondary at high f ratios.*
www. 'Testing Optics'. P.J. Violin Cloudy Nights, *for determination and descriptions and the final image.*
'Setting-up a Small Observatory', David Arditti, *esp. p.197 on cleaning perfectionists.*
www. 'Ninian Boyle *for the 45° nature of slew error, see also Astronomyknowhow.com.*
'New Perspectives on Newtonian Collimation.' Vic Menard 5th Edition, for the *Step [8] drawing on p.14, the several ways of collimating and a good read with answers to the important questions.*

Occasional Cleaning of mirrors and glass plates.

The door to confidence is opened by a documentary in which a segmented VLT is seen being hosed down, so:

1. Remove loose particles with a squeeze action blower. Fine brush removal needs a guarantee of no grease.
2. With the mirror removed, angle it downwards slightly so water doesn't drain in and bottle pump spray filtered tap water all over the face. Www. *Andysschotglass* has good illustrations of this stage.
3. Put a couple of drops of smear less wu liquid, ' Fairy Liquid only', says the window cleaner, or delicate fabric liquid soap in distilled water then swab using cotton wool, working from the centre outwards in strokes.
4. Pump spray plenty of fresh distilled water over the face, then dry mostly naturally. Baby cotton buds and unscented paper handkerchiefs may be used to blot only, no wiping now. Do not use toilet paper.

Eyepieces

1. As above then soak a fresh ball of cotton wool in Isopropyl Alcohol and distilled water, then dab, angled slightly downwards. If you attempt more than 2 a day this care in keeping water out may desert you
2. When it looks clean, angle downwards and drench spray with distilled water.
3. Blot surrounds on paper hankies. Dry naturally. Baby cotton buds and lens cleaning aids useful with care.

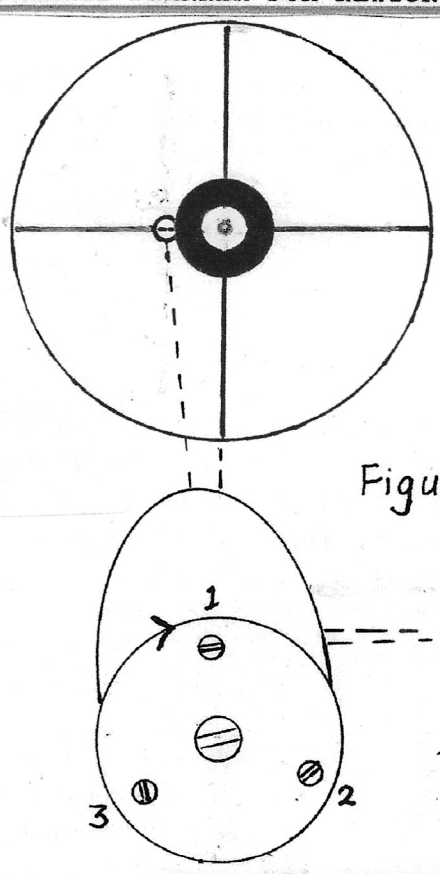

Figure 2A


(5)


(6)

These become more circular as alignment is improved. Any remaining high spots start coming in to line with or opposite one of the adjusters, making final fine correction easier.

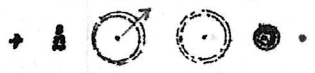
(8)

Figure 2. Primary central doughnut at *f6* and 1,200 mm.

Figure 3. View of alignment after rotation, possibly with just one adjustment to finish.

Figure 2a. Shows reason for sideways displacement and arrow showing correction.

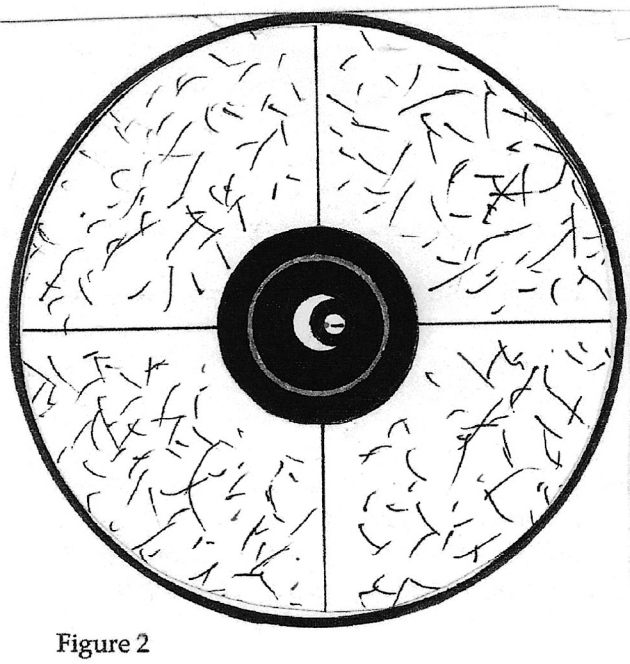

Figure 2

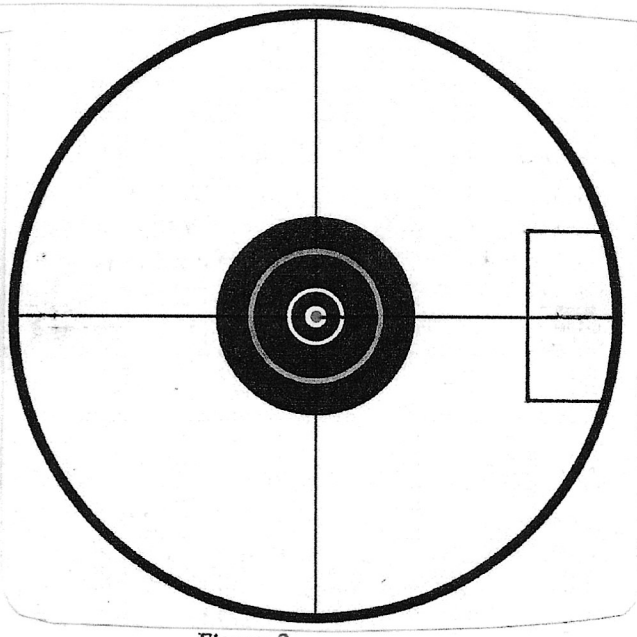

Figure 3

55cm between mirrors

tilt adjuster 1 to swing the flat towards the focus tube. Experiment a little then tighten the centre bolt, re-check for rotation and you should definitely be **ready for use** with classic observing Newtonians. If the doughnut has gone slightly down tube again go to stage [8].

With *f* 2 to *f* 4 imaging Newtonians and handy spherical mirror types modulated *f*6 to *9*, you may need to correct for the:-

3 remaining errors of the Secondary Mirror.

(nb. If 'fuzz', or soft blobs now describe focussed stars, making a simple Hartman mask for analysing will show spherical aberration clearly. Return to seller. There is more risk in not keeping to amateur telescope brands advertised in astronomy magazines.

[5]. Check and correct for rotation then bring any lop-sided de-focussed star into shape by tightening or easing away or towards the centre with adjuster 2 or 3, centre bolt eased slightly. 1/16thturn ease-tighten stages can be sufficient. The precision of Allen keys can now be appreciated. Marking knobs and screwdrivers enhances their accuracy. Secondary mirror adjustments using a star are best accomplished by pre-planned 'military drill', inspecting only after re-tightening. When making these adjustments it is safer to put the telescope level then elevate back on to the star.

[6]. If a pronounced **vertical oval** is seen at any stage, screw the secondary mirror outwards in equal half turns on all adjusters. It is caused by the converging cone of light from the primary being wider were it strikes the lower part of the secondary mirror when reflected at 90°. Then for more rounded vertical ovals try 1/8th secondary tilt turns again to swing the flat towards the focus tube.

[7]. To discover any **fine tilt error,** check a suitable double star, say ε Bootes or ι Cass. for an 8 inch instrument or α Hercules for a 4½". Then with their B stars many times fainter than their primaries, slight secondary mirror tilt adjustment may be needed for them to be resolved and colour corrected. As a guide, choose a separation of around 4.5 x your Dawes Limit for stars brighter than mag. 5.

[8] checks coincidence of depiction (6) and Figure2 by repeats of rotation until a defocussed star rounds up or shows a small triangle at near focus (8) which means need of 45° primary slew to finally round up the tiny image. Hurray! Birdies have vanished. Should a Figure2 like depiction remain, leave it, even if the doughnut has now gone to 45°. Off-setting has occurred so as to adjust from 90° reflection angle to that which rounds up the star perfectly. The peep-hole and its reflection and cross hair sights will be aligned, now at the expense of the doughnut and laser reflections.

Good observing and imaging.

A telescope that's gone off in use can be made worse with a wrong correction, e.g. if the doughnut has gone 90° to one side it is still tempting to correct with primary mirror slew adjusters. But how can they show displacement in any direction other than 45° in line from a slew adjuster through to the centre bolt? Only by coincidence and difficulty. Rotation is the more likely error. Determine the adjuster that does the business rather than steering with two.

Back on to the bright side of collimating instructions, the **New Method** is more about aligning the peep-hole, doughnut and cross-hairs and the cursor on the focus tube axis, but mirrors are not constrained into perfect array. Moreover, the symmetry shown in Fig.3 is not an aim and may be final only through *f* 6 and slower, but is obligatory with Cassegrain optics.

Collimating a Newtonian telescope with the Cave Collimator

Preparation. Screwdrivers and Allen keys really need to be new and fit exactly to prevent damage. Bench collimation is carried out mostly with the tube horizontal. Ensure tightness of all assembly bolts and operation of the focuser. A focus tube base which doesn't look square must be checked mechanically with a plumb line and correction refined further with a spirit level, ruler and then with the peep-hole cursor, cross-hair sights and the focus tube. You will then be making optical adjustments known nowadays as collimating, to place the image concentric on to the eyepiece as is.

Making the Peep-hole Eyepiece. *Beginning with a pricker, a 3mm hole drilled accurately with a new drill bit in the central depression of a white 35mm-film canister bottom is about the largest needed. Finish with a model maker's file. If the reflection of the peep-hole outline isn't too clear, paint its surround red with glass paint from an art shop, then inscribe a black cursor line on the inside face line iwith a China graph pencil or permanent ink pen. Four to to six turns of 12mm wide holographic fun tape wound around the top and bottom halves aligns the eyepiece in the focus tube and stops it dropping down.*

Primary Mirror Centre Doughnut. *For the greatest clarity it is best to remove any blob type centre mark with a plastic scraper and an air blower, possibly aided by chilling; last resort water rinse-able solvent on a baby cotton bud. Paint a paper ring reinforcement with Tipp-Ex then stick it on centrally. A good method is to cut a hole in the exact centre of a paper disk the diameter of the mirror with a circle cutter set to the radius of the doughnut.*

Method of use. Read a stage only after completion of a stage. **Cross bridges only when** you come to them. Starting at Stage [2] when nearly aligned anyway risks being haunted for ever.

[1]. Screw the mirrors fully out then back equally to 2 turns on primary adjusters, secondary 0 to 2 turns. Sense the secondary adjusters' contact and firm them lightly to begin from **mechanically square** with scope for optical adjustments. Don't fall for everything looking concentric down the focus tube with the secondary adjusters just because you find the fumbling process easier than counting turns. It works, but is said to dim one side of the FOV slightly and any secondary mirrors mounted in cylinders can 'ding', flaking the edges. Equal turns on adjusters are more important as are alignment of peep-hole, doughnut and cross hairs, especially with the off-set mounted ones. *This stage often results in you being able to remove primary mirror locking bolts if they are a nuisance.*

[2]. Fit the collimating cover and **a**lign the peep-hole eyepiece so that its cursor lines up with the focus tube axis. Then if the doughnut is to one side, **rotate the secondary mirror** on its centre bolt to bring it over the focus tube axis. Some manufacturers make rotation easy by providing a spindle or the tube bolt holes are oval. With others you make keys from old drill bits in a strip of hardwood or ease the centre bolt or adjuster 1 slightly, then with Cave Collimator off, grab gingerly and turn.

Correction **[3]. Tilt the Primary Mirror** to bring the doughnut over the centre, and so achieving what is shown in Fig.3. The cursor may have needed turning off-axis to locate the peep-hole reflection if the larger doughnut has covered it (see Fig. 2) and one or two makes hold the secondary mirror on ridiculously more than 0-2 turns off the mounting plate.

This is about the limit of collimating tools. Star testing now takes you into fine adjustments for the best results.

[4]. Using a magnified star. De-focus a 2nd or 3rd magnitude star at 120 to 450 x and bring it's centre spot central with the effective primary adjuster. Classic Newtonians are now likely to be fully collimated, but if a slightly de-focussed star is still not concentric, displace the secondary mirror inwards in ½ turns then ¼'s and strictly equally until it almost rounds up. Then ¼ turn on its

Without having had to get familiar with short focus/low *f* ratio, the instructions could have been nothing special like one manufacturer says at the large concentric de-focussed star stage, '...and that should suffice.' Not nowadays. However, modulated and 'fast' 'scopes have proved to need just four more stages you simply must be chronological with. An embroilment no longer. Not at all like what you are reading right now! Placing the stages in a circle, starting anywhere and being lucky can work well enough at longer than classic *f*6 ratios, but more adjustments are likely.

As with most things worthwhile it takes practice, but 10 minutes for *f* 5 and longer is achievable. In the instructions you will see it is recommended that bridges are crossed only when you come to them. Lives are not in danger, damage to mirrors and receiving eyefuls of laser beam are fully prevented by carrying out Stage 1 only, surely Isaac Newton's and any assembler's first moves.

On the first night after you thought you'd got it right you may see just a little more to do, but no longer will it be collimating all night, night after night and then trawling for actual instructions in between the causes and whys of the otherwise good armchair reads listed under 'references.'

Successful collimating soon, then clear skies and good observing.

 (Basic and Cheshired Laser Collimators, Sight Tube and Easy Tester.
8" Wise-Newtonian *f*3 modulated to 6, 4 ½" Bresser *f*4.4 and 6" Sky-Watcher *f* 5 owned.
8" Sky-Watcher *f* 6 available).

It can also be used for other types of telescope and light sensing of CCD cameras.

Cavecollimators.co.uk for ordering complete or just, 'INSTRUCTIONS in the successful use of the **CAVE *TELESCOPE COLLIMATOR.***'

About the only other collimating tool that may be useful is the Easy Tester Eyepiece. For although it and the laser collimator may be the least accurate, I find it to be the only one which still doesn't reflect it's parts truly back on itself when two wrong adjustments or fluky atmospherics have tricked you towards the end of a night of observing and so apparently all set for the next clear night. When you are truly star test ready an Easy Tester confirms that you are.

For anyone DIY ing who hasn't worked with fibreglass, practice first on what doesn't matter, wear old clothes and latex gloves. Don't answer the phone. The wetted material has to hang down to at least 3 x the flange finished depth, so the telescope tube may be its own best mould. Resin and hardener should not be mixed until you've done 2 hours preparing and thinking about it. Those who can call on their experiences in car body or boat repairs and model aircraft canopy moulding before plastic kits, or who can wallpaper badly should have little difficulty with this accurate endeavour. Always given that you have a place to work on your telescope as well as store outside and use it. Telescopes don't like sudden increases in temperature.

the Cave Collimator

Ardath, Ellerker Lane, South Cave, Brough, East Yorkshire HU15 2DZ, England.
Ph/Fax 01430-422460 **www. cavecollimators.co.uk** **e-mail: prcclassicff@gmail.com**

AN EASIER WAY TO COLLIMATE A NEWTONIAN TELESCOPE

This invention is a translucent front cover inscribed with cross-hair sights and is used in conjunction with a white 35mm peep-hole canister and doughnut centre mark on the primary mirror. They ensue from Professor Cheshire's 1903 adaptation of the periscope for illumination via the metal peep-hole eyepiece and then combined with the Sight Tube which has cross-wire sights at pistol length only and other disadvantages occurred in use. The Cave Collimator is attributed to a black plastic cover that cracked in 2006 resulting in a new one being made from translucent fibreglass over the front. It's use for aligning mirrors was noticed in May 2009 after 3 years of limited success with various instructions and a laser collimator. The whole telescope becomes an impressive sight tube of almost focal length accuracy. It has even more usefulness when the secondary mirror is mounted in glass or when the spider is not set square to the focus tube.

The tool is triple purpose, gathering and filtering light to an even tone without reflections. Cave Collimator ® with its instructions,' becomes even more useful for classic Newtonians as adjustments become finer with faster low *f* ratios, and for any ratio where additional optics for handiness and aberration correction are a feature of the telescope. Indeed, it hard to imagine any alignment tool needing instructions other than these for the owner who quickly wants to get the best from any reflector telescope and you will find that you relegate them somewhat.

It works well in ordinary mixed lighting, often without moving the telescope off a bed even. The results is an apparently greater clarity of the central area by bringing the remainder below distraction level. Dust, dirt, and anti-dazzle are other considerations controlled easily. Except for modulated and fast 'scopes the system is quite capable at the first de-focussed star test of showing the telescope is ready for use.' Felt backed tape is supplied to give a good smooth fit.

In December 2005 and one year into telescopes, the demanding optics of the new and handy 8" Wise-Newtonian were taken on unwittingly. A second new telescope with no instructions. 'This must be normal get on with it!' Sextant correction was by just one formal method for the same number of reflections. So after having been hit in the 1980's by Tippy D'Auria, 'There wasn't much to go on,' (*New Perspectives on Newtonian Collimation 1987-2008),* with his foundation in WW2 submarines, telescopes are now being sorted from above the waves!

The Achilles heel of tools to aid the aligning of telescope mirrors is the instructions. By keeping them to the point, the details have needed just a page and a half plus an illustrations and a useful page of tips that includes a recommended reading list. The worst reaction is being intimidated into paying experts to do the age 7 to 12 year old Meccano. It is surprisingly easy, spreads the skills and keeps them alive. Almost forgotten basics has been the key, with no swanning around.