Appendix A
Recommended Equipment Manufacturers for Amateur Astronomers

There are numerous manufacturers of outstanding astronomical equipment today, too many to list. The following represent the author's own preferred companies, carefully considered to be sure, but by no means meant to imply that other outstanding manufacturers do not exist. Whenever possible, I have listed some European distributors of American companies. In other instances, I have indicated whether a particular company handles exports if they do not have an overseas distributor.

Telescopes

1. JMI (Superior split-ring equatorial Newtonian truss telescopes; accessories for all makes, including motorized focus units)
   810 Quail St., Unit E
   Lakewood, Colorado 80215
   (303) 233-5353
   www.jimsmobile.com

   In Europe, JMI products are available through:

   Broadhurst, Clarkson & Fuller
   6, Tunbridge Wells Trade Park
   Lonfield Road
   Tunbridge Wells, Kent
   England TN2 3QF

(44) 2074-052156
www.telescopehouse.co.uk

Intercon Spacetec
Gablinger Weg 9
D-86154 Augsburg 1
Germany
(49) 8214-14081
www.intercon-spacetec.com

La Maison de l'Astronomie
Devaux-Chevet
33-35, rue de Rivoli
Paris, France 75004
(31)1427-79955
www.maison-astronomie.com

2. Obsession Telescopes (Superior Dobsonians)
   PO Box 804s
   Lake Mills, Wisconsin 53551
   (920) 648-2328
   www.obsessiontelescopes.com

   Obsession sells and exports direct worldwide, but has no distributors.

3. Astro-Physics (Superior apochromatic refractors)
   11250 Forest Hills Rd. Rockford, Illinois 61115
   (815) 282-1513
   www.astro-physics.com

   Astro-Physics exports direct to Europe and many other countries, but does not export to countries where there is a distributor. Distributors include:

   Baader Planetarium KG
   Thomas Baader
   zur Sternwarte
   82291 Mammendorf
   Germany
   (081) 458802

   Medas SA
   57, Avenue P. Doumer
   BP 2658
   03206 Vichy Cedex
   France
   (04) 70-30-19-30
   www.medas.fr

   Unitron Italia Srl.
   Giovanni Quarra
   via Agostino Lapini, 1
   50136 Firenze
   Italy
   (055) 667065
   http://www.untronitalia.it

4. Parks Optical (Superior traditional Newtonians and other types)
   PO Box 716
   Simi Valley, California 93062
   (805) 522-6722
   www.parksoptical.com

   Parks telescopes are available in England through:

   Venturescope
   The Wren Centre
   Westbourne Road
   Emsworth, on the Hampshire–Sussex border
   England PO10 7RW
   www.telescopes.co.uk/parks.htm

5. Orion (Maksutov–Newtonians, achromatic & apochromatic refractors, and low-cost, high quality Dobsonian telescopes up to 10-inch aperture, eyepieces, filters and accessories)
   PO Box 1815-S
   Santa Cruz, California 95061
   (800) 676-1343
   www.telescope.com

   Orion does not directly export its products internationally, but does have two distributors in England:

   SCS Astro
   The Astronomy Shop
   1 Tone Hill
   Wellington, Somerset
   England TA21 OAU
   (44) 1823-665510
   www.scsastro.co.uk

   Broadhurst, Clarkson & Fuller (see JMI)

6. Astro Works Corporation (sophisticated observatory instruments)
   PO Box 699
   Agulia, Arizona 85320
   (520) 685-5000
   www.astroworks.com

   Astro Works is a small company, that has no e-mail contact. Contact them by phone for possible export arrangements

7. Takahashi (premium apochromatic refractors; reflectors, catadioptrics)
   Texas Nautical Repair, Inc.
   3110 S. Shepherd St.
   Houston, Texas 77098
   (713) 529-3551
   www.LSSTNR.com

Takahashi products are available at dealers throughout the world, and in England from:

True Technology Ltd.
c/o Nick Hudson
Woodpecker Cottage
Red Lane
Aldermaston, Berks
England RG7 4PA
(44) 01189-700-777
www.trutek-uk.com

8. Internet Telescope Exchange (custom Maksutov–Newtonians; apertures to 16 inches)

   3555 Singing Pines Road
   Darby, Massachusetts 59829
   (406) 821-1980
   www.burnettweb.com/ite

   ITE ships worldwide; its products are also available in England through:

   SCS Astro (see Orion)

Typical Approximate Costs in US (US$) for New Equipment

Dobsonian reflectors
6–10 inch: $500–$2,000
12–30 inch: $1000–$10,000

Equatorial Newtonians
6–10 inch: $500–$3000
12–18 inch: $1250–$13,000

Other types of equatorial reflector (i.e. classical Cassegrain)
18–30 inch: $20,000–$75,000 + up

Equatorial achromatic refractors
3–6 inch: $400–$3000

Equatorial apochromatic refractors
3–5 inch: $1500–$5000
6–7 inch: $5000–$12,000
8–10 inch: $20,000–$40,000

Equatorial Maksutov–Newtonian
6 inch: $2500
8 inch: $5000
10 inch: $10,000

Schmidt–Cassegrain
8–12 inch: $1000–$4000
16 inch: $15,000

Light Pollution Filters, Eyepieces and Accessories

1. Lumicon
   6242 Preston Avenue
   Livermore, CA 94550
   (925) 447-9570
   www.lumicon.com

   Lumicon exports its products throughout Europe, but also has dealers in the UK and most European countries. In Europe, contact:

   Broadhurst, Clarkson & Fuller (see Telescopes: JMI)
2. Orion (see Telescopes)
3. Televue Optics (Eyepieces, superlative small refractors, other accessories)
   100 Route 59
   Suffern, NY 10901
   (845) 357-9522
   www.televue.com

   Televue products are available widely in Europe. Contact:

   SCS Astro (see Telescopes: Orion)
   Broadhurst, Clarkson & Fuller (see Telescopes: JMI)
   Venturescopes (see Telescopes: Parks)
4. Collins Electro Optics (Specialized light pollution filters for intensifiers, video cameras, frame averagers etc. See image intensifiers)

Typical Approximate Costs in US (US$) for New Equipment

Eyepieces:
$25–$400 (depending on type: traditional versus modern multi-element, highly corrected types)

Light pollution filters:
$70–$250 (depending on size: 1_-inch or 2-inch, and type)

Digital setting circles (including encoders):
$350–$500 (depending on presets/functions)

Image Intensifiers

Specialized, ready for astronomical use:

1. Collins Electro Optics (Complete systems for astronomy – no adaptation necessary)
   9025 East Kenyon Avenue
   Denver, CO 80237
   (303) 889-5910
   www.ceoptics.com

   Unfortunately, Collins has no distributors overseas. Presently, certain export restrictions apply; contact Collins Electro Optics for export information for your situation.

Other Image Intensifier Products

The following products will need adaptation.

2. Electrophysics Corporation (Generation II, III, IV units)
   373 Route 46 West
   Fairfield, New Jersey 07004-2442
   (973) 882-0211
   www.electrophysics.com

   Electrophysics exports to many countries; some European distributors include:

   AM Vision
   The Old Schoolhouse
   Wilberfoss, York
   England YO41 5NA
   (0044) 0 1759 388235

   Jabsco
   Ostsrabe 2B
   D022844 Norderstedt
   Germany
   (040) 53533730

   Jenoptec
   12, rue J-B Huet
   Les Metz
   78350 Jouy en Josas
   France
   (33) 01 34659102

3. D & VP Corporation
   PO Box 54074 N. Salt Lake
   Utah 84054-0274
   (801) 299-8548
   www.dandvp.com
   or: www.nightvisionweb.com

D & VP has no European distributors, but exports most of their products.

4. Stano Components, inc.
   PO Box STANO
   Silver City, Nevada 89428
   (775) 246-5281/5283
   www.stano.night-vision.com

   Stano does not export to countries outside USA.

5. Aspect Technology and Equipment, inc.
   811 East Plano Parkway, Suite 110
   Plano, Texas 75074
   (800) 749-3802 / (972) 423- 6008/7717
   www.aspecttechnology.com

   Contact Aspect directly for possible exports and dealers in Europe.

A Sampling of European Companies Supplying High Quality Image Intensifiers

6. Optex (Gen III-equivalent miniature systems, probably ideal for astronomy)
   20–26 Victoria Road
   East Barnet
   Hertfordshire
   England EN4 9PF
   contact: simon@optexint.com

7. The House Of Optics (Russian intensifier units including Gen III)
   Hunstanton
   Norfolk
   England
   07879-214651
   www.houseofoptics.ltd.uk

8. Delft Instruments NV
   Röntgenweg 1, 2624 BD
   PO Box 103, 2600 AC Delft
   The Netherlands
   +31-15-2-601-200
   www.delftinstruments.com

9. Eureca
   Messtechnik Gmbh
   Am Feldgarten 3
   50769 Köln
   Germany
   www.eureca.de

Typical Approximate Costs in US (US$) for New Equipment

Fully dedicated Generation III systems, ready to use (i.e. Collins):
$2000

Generation 2 (intensifier only – will require eye lens and adapters):
$500–$850: more advanced Generation 2 products up to $2000.

Video Cameras For Astronomy and Accessories

1. Adirondack Video Astronomy (also sells image intensifiers)
   26 Graves St.
   Glen Falls, NY 12801
   (518) 812-0025
   www.astrovid.com

   Adirondack's distributor in the UK is:

   True Technology Ltd. (see Telescopes: Takahashi)
2. Santa Barbara Instrument Group
   147-A Castilian Drive
   Santa Barbara, CA 93117
   (805) 571-7244
   www.sbig.com
3. Internet Telescope Exchange (see Telescopes)

Typical Approximate Costs in US (US$) for New Intensifier Accessories

Camera and attachments for intensifier:
$850

Media converters and software for interfacing with computers:
$400

Infrared band-pass filters (for light-polluted areas):
$250

Recursive frame averager:
under $1,000

Appendix B

Resources

Prominent Amateur Astronomical Associations and Links

ALPO – Association of Lunar and Planetary Observers
www.lpl.arizona.edu/alpo.com

British Astronomical Association
www.ast.cam.ac.uk/~baa.com

Astronomical Society of the Pacific
www.astrosociety.org
(Website supplies worldwide listing of astronomical organizations, etc.)

International Supernovae Network
www.supernovae.net

American Association of Variable Star Observers
www.aavso.org

International Dark Sky Association
www.darksky.org

Astronomical League
www.astroleague.org

International Meteor Organization
www.imo.net

International Occultations Timing Association
www.lunar-occultations.com

NASA Photographic/Information Reference Website
www. images.jsc.nasa.gov
(A comprehensive catalog of NASA's photographic records of lunar, planetary and deep space subjects, together with links to many other relevant sites, including amateur images, groups, etc.)

Figure B.1. The planet and satellites (and shadow), with Great Red Spot 11/12/2001, recorded in real time by Astrovid 2000 camera in conjunction with 18″ JMI reflector and Televue 2× Barlow lens

Appendix C

Real Time Observation of Stellar and Galactic Sources using a Third Generation Image Intensified Optical System

W.J. Collins

August 4, 1998
(Reprinted with his kind permission)

Introduction

This report will familiarize the reader with the optical frequency spectrum of astronomical objects for observation using the I_3 intensified optical system, and the system's performance as it relates to the objects' spectrum.

Galaxy Spectra

It is generally agreed that the spectral range of human vision is between ~ 380 and ~760 nanometers (nm = billionths of a meter). Referring to Figure C.1, the A curve represents the spectral response of a typical Generation 3 intensifier (as used in the I_3 Piece). One can immediately see that the tube response extends to 900 nm, with the peak at ~ 775 nm. This region of the spectrum between 760 and 900 nm is included

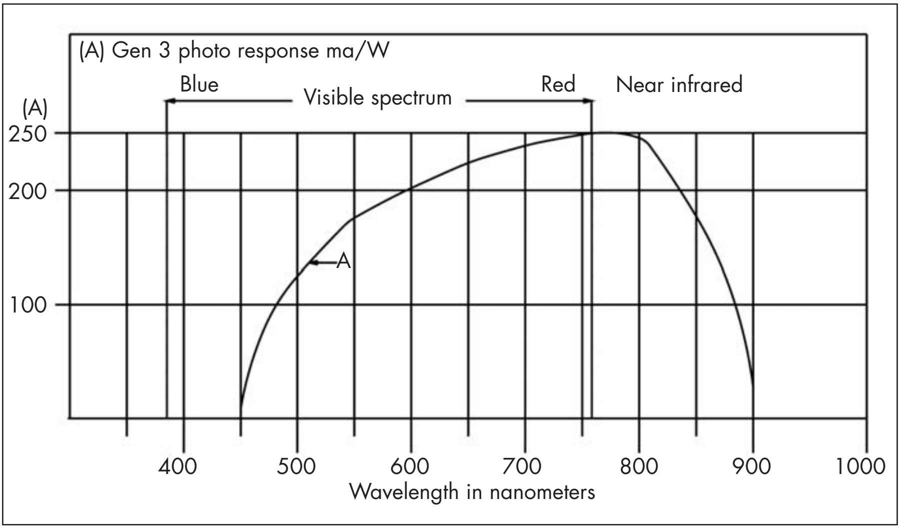

Figure C.1. Collins Electro Optics spectral response curves of Generation 3 intensifier.

in the near infrared portion of the electromagnetic spectrum and is not visible to the eye in real time without the assistance of a device such as an image intensifier. Now referring to Figure C.2, curve B, this is a curve-fitted plot of galaxy types (spiral, elliptical, irregular). The slope of curve B is a good fit to the tube response of curve A, particularly between 550 and 800 nm. Also note that the majority of spectral output falls above 700 nm and extends to 900 nm with good uniformity. (Galactic spectra extend well beyond 900 nm; however, this report concerns itself with the spectrum of tube operation ≤ 900nm.) Also note that the spectrum of curve B actually begins below the threshold of sensitivity of curve A. Generation 3 devices are essentially blind to this (violet) portion of the visible spectrum. Fortunately, this narrow band between 400 and 450 nm represents a small percentage of the entire galactic spectrum that is visible.

Ellipticals

Curve B represents the average spectrum of the entire galactic mass for the three galaxy types. Within individual galactic types, the spectrum (and hence the intensifier response) can be further quantified. Ellipticals, which are classified by Hubble category EO to E7, depending on how round (EO) or elliptical (E7) they appear, are symmetrical in shape. M87 is an example of an elliptical. The stellar population of ellipticals is called Population 1 from the work of Walter Baade at the 100-inch Mount Wilson telescope. Ellipticals are in fact comprised of “old” Population 1 stars. These are “metal rich”

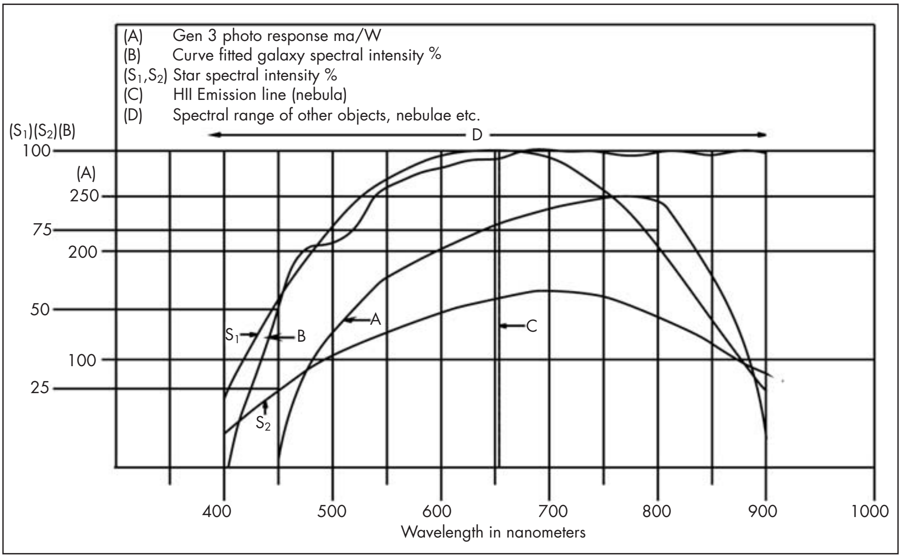

Figure C.2. Collins Electro Optics spectral response curves compared with galactic and stellar radiation.

and predominantly M class, including red giants, most of which exceed 10 billion years in age. From a spectral standpoint, ellipticals are very energetic sources in the red and infrared portions. Ellipticals display a uniform spectral curve across their entirety and, when taken individually, their spectra are similar to the S2 curve of Figure C.2 (an M class star). This far red/infrared spectrum makes ellipticals an excellent match to the image intensifier response (curve A).

Spirals

Spiral galaxies can be normal (Hubble type S) or barred (Hubble type SB). Both types are also classified A, B or C, as to the tightness of spiral structure that they display, with A being the tightest and C being most open. Also, the size of the nucleus relative to the spiral structure is A, the largest, and C, the smallest; some galaxies show disk-like structure without spiral structure and are termed SO. Within the nucleus of spiral types, old population stars predominate as in ellipticals. The nuclear bulge is therefore also an excellent match for the intensifier spectral response. As we look into the spiral structure, gas, dust, and young (Population 2) stars are most prominent. This makes the spiral structure more skewed towards the blue portion of the spectrum, making the spiral structure less visible using image intensification than the nuclear central bulge. This can be confirmed observationally by noting the increase in luminosity between the nuclear and the spiral structure. The image intensifier response to the spiral structure, independent of the nuclear bulge, is very dependent on the averaged spectrum that comprises the entire spiral structure. To clarify this important point, spiral galaxies that present their structure to us without oblique perspective, such as M101, will appear highly intensified in the nucleus and will show little difference in visual observation to their spiral structure, due to the predominantly blue response in the spiral arm region. As the observer's plane of view to the galaxy becomes more oblique, the dust lanes become more prominent. Galaxies such as M107 and NGC 4565 present an "edge-on" appearance; the dust lanes have a strong infrared signature, making these types ideal for image intensified observation.

Irregulars

These have Hubble classification IRR1 (mostly O and B type stars and H II regions) with a general lack of dust clouds, and IRR2 (not resolvable into stars, no H II regions) with prominent dust lanes. Of these two, IRR2 types have a more red/infrared spectrum (dust lane infrared signature) and may be a better match to the intensifier spectral sensitivity.

Two additional galaxy types not easily classified are Seyfert (1 and 2) and BL Lacertae objects. Both Seyfert types have unusually small and optically intense (star-like) nuclei. Of the two types, Seyfert objects have a more energetic infrared spectrum. BL Lacertae objects have rapid intensity variations in visible and infrared wavelengths and may be good candidates for image intensified observation.

Stellar Spectra

Referring to Figure C.2, curves S1 and S2, curve S1 is a star with spectral class G, such as our Sun or Capella. Notice the distribution of spectral energy, with the majority in the visible spectrum and decreasing (although still significant) in the infrared. These "main sequence" stars have surface temperatures of ~ 5000 kelvin, producing the spectral distribution curve of S1. Looking at curve S2 in Figure C.1, we see a spectral distribution shifted more towards the red/infrared portion of the spectrum. This falls into spectral class M and includes red supergiant stars such as Betelgeuse in Orion, or Antares. M stars such as these are a fine match to the spectral response of the imaging tube. M stars have surface temperatures in the 3000 kelvin range, causing their red shifted spectrum. Spectral class types B, A and F are not shown. These hotter, bluer stars have spectra shifted towards blue and ultraviolet (the spectral region at the 400 nm end of the chart) and may show modest or no intensity increase when viewed with a Generation 3 intensifier, due to their spectrum falling in the region near the tube's minimum response. K types fall between G and M and are also not shown. Understanding where a star's spectral class falls within the intensifier's effective spectral range (curve A) will allow the user to predict the effectiveness from an image intensification standpoint. M giants and supergiants give the greatest potential for image intensified observability.

Nebulae

Emission Nebulae

Refer to Figure C.2, (D) nebulae along the top section. Notice that the spectral distribution ranges across the entire spectrum shown. The most predominant frequency for the nebulae is centered at the H II line in Figure C.2. This is the H alpha line at 656.32 nm and is the result of spontaneous photon emission from the ionized hydrogen gas present in the nebula as the electrons decay from the third to second energy level. Other gases present within the nebula may also be ionized, as is the case with the Great Nebula in Orion, in which ionized helium and oxygen are also present. These optical recombination lines give rise to other characteristic spectra causing emission lines at other wavelengths. In the case of M42, ionized oxygen (at 500.7 and 495.9 nm) produces the green light present, with H II emission producing the greater part of the red emission.

Emission nebulae will show greatly enhanced observability using Generation 3 intensification when most of their emission spectra occur within the H II region. This is the first emission line in the Balmer series of hydrogen emission lines. As electrons decay from higher valence levels within the hydrogen atom, they emit photons at higher frequencies. This gives rise to the Balmer series of visible emission spectra with the first line (known as hydrogen alpha or H II). There are five emission lines in the Balmer series that are present in the visible spectrum at 656, 486, 434, 410 and 397 nm. As previously stated, the H II line is most observable with Generation 3 intensification, with hydrogen beta (486 nm) also visible. We may therefore predict the image intensified observability of emission nebulae by first knowing what ionized gases constitute their observable spectra and their corresponding emission line frequencies. These emission lines can then be plotted in relation to the tube response curve and their potential for amplification predicted.

Planetary Nebulae

As with emission nebulae, the ionized spectra present are due to their proximity to a star(s), and in the case of planetary types, their surrounding of a hot star (30,000–100,000 kelvin). The Ring Nebula in Lyra is a good example with a characteristic circular shell (hence "planetary", termed by Herschel) surrounding the central star with a temperature of 70,000 kelvin. The strong ionizing radiation gives rise to hydrogen (Balmer series) and oxygen lines at 500.7 and 495.9 nm. The shell of expanding gas in M57 is an excellent choice for Generation 3 intensification because of its H II abundance, and to a lesser extent, its oxygen lines. The central star, although observable with intensification, is nevertheless very blue in color and at the low end of the intensifier response. The observability of planetary nebulae is based on the identical criteria previously stated for emission nebulae.

Reflection Nebulae

Certain nebulae are simply clouds of dust that are illuminated by nearby stars and reflect the stellar spectra present. The Pleiades are a good example of a reflection nebula in the presence of young (hot, blue) stars. The nebulosity present in the cluster reflects the blue spectrum present in these stars. The potential for intensified observability can be determined by the characteristic spectrum of the stars that illuminate reflection nebulae.

Visual versus Silicon-Based Spectral Sensitivity

When used for visual astronomy purposes, image intensified devices are often met with questions such as "why is the image green?". The logical reasoning behind this is as follows:

Color	Red	Orange	Yellow	Green	Blue	Violet
Wavelength, nm	670	605	575	505	470	430
Relative radiant power	10,000	1000	100	1	2	20

Therefore, at 505 nm, the minimum threshold of perceptible vision is 1; yellow light requires 100 times the intensity to produce the equivalent visual response, orange 1000×, red, incredibly 10,000×, blue 2× and violet 20×. This visual spectral sensitivity is based on scotopic (rod) vision. During photopic (cone) vision (light levels above approximately 10 lux), the peak sensitivity shifts upwards to 555 nm. The image intensifier phosphor screen spectral frequency is centered at 530 nm. With the phosphor screen output illumination level at 2.25 foot lamberts maximum, the visual response falls within the threshold region between scotopic and photopic visual sensitivity. Therefore, 530 nm represents the ideal median frequency for the typical level of visual adaptation that occurs when using a Generation 3 image intensifier. Also, and very importantly, as the intensifier illumination level drops (when imaging a low surface-brightness galactic object, for example), the eyes' response becomes predominantly scotopic and the perception of color will actually disappear, because of the retinal rods' insensitivity to color and the visual transition to gray scale. Therefore, the green image present at higher illuminated image levels will become less apparent as the objects' level of illumination decreases, to the point of showing little or no color, and as the tube output approaches the equivalent background illumination (EBI) of the tube. Green frequency phosphor also greatly reduces the power requirement necessary from the tube's power supply because of the much greater visual sensitivity to green 530 nm light, which in turn extends the operating hours with a given (battery) power source.

Tube Spectral Response

Refer now to Figure C.1, Generation 3 photo response. The peak spectral response of the tube is at 775 nanometers. The "gain" of the tube, which is gain = output illumination/input illumination, is independent of photo response. The gain setting for the Generation 3 tube is 50,000. This gain is present across the spectrum of photo response.

This brings us to one of the most important concepts concerning the use of a Generation 3 intensifier for astronomical objects. That is, the ability to dynamically amplify the optical spectrum of a star, nebula, or galaxy is directly related to the integrated spectrum of the object. The same statement applies to human vision except that the peak response is literally at the other end of the spectrum.

An excellent example of the differences between visual and intensifier response is apparent with SC galaxy types, such as M33. The naked eye response does not give the appearance of the galaxy nucleus being brighter than the spiral arms up to the magnitude that is actually measured with instrumentation for bolometric response. This is due to the eye responding with much greater sensitivity to the spiral arm section, made up of bluer stars, than the nucleus, which, although much more energetic than the spiral arms, is nevertheless

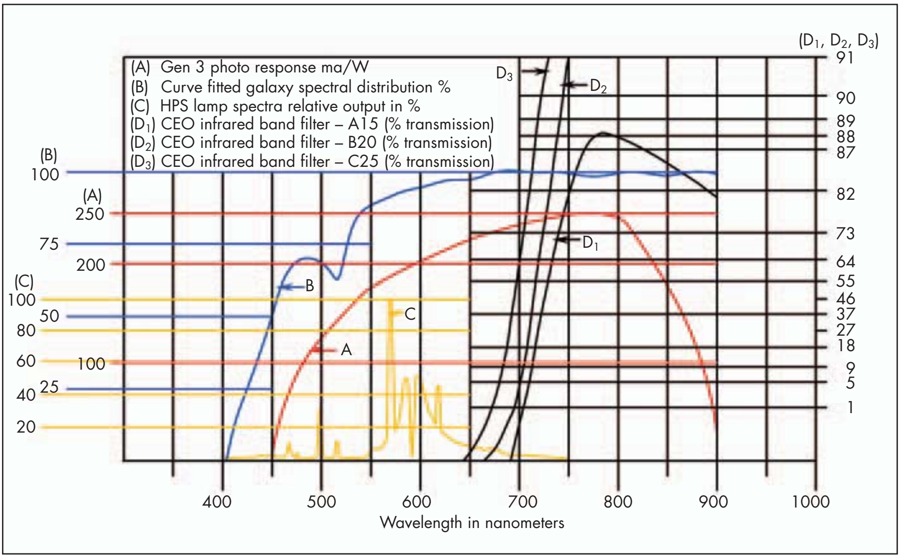

Figure C.3. Spectral response curves of Collins Electro Optics band-pass filters.

comprised of much older red M class stars and large H II regions, to which the eyes' response is much less sensitive.

The intensifier responds in a much more linear fashion in comparison to the eye. Let's look at the bandwidth between 505 and 605 nm for the eye and the intensifier. First, for the eye, at 505 nm the response is 1; at 605 nm, it is 1000 (in this case, 1000 is 1/1000 or 0.001 as sensitive as at 505 nm). For the intensifier: at … 505 nm, it is 135 ma/w; at 605 nm, it is 205 ma/w, a ratio of 205/135 = 1.52:1, versus 1000: 1 for the eye. This illustrates an additional important point: the Generation 3 intensifier provides a more linear and therefore more accurate response to astronomical objects over a large portion of the spectral response of human vision, as compared to the eye over the same spectral range.

Appendix D
On the Philosophy of Building versus Buying

As you became aware in Chapter 2, I always had a "thing" regarding the direct connection between the telescope, as an entity in itself, and observing with it. Even so, designing and building the telescope by oneself expands this further. For many years I simply could not separate these two worlds, as there is no doubt in my mind that there is another dimension added to the wonder of it all by having fashioned an instrument oneself. Even more remarkable is the near disbelief one experiences when an assemblage of seemingly unlikely and non-astronomical components actually works when at the inaugural viewing session! There is a profound satisfaction in putting together, in unconventional fashion, a unique, semi-designed apparatus, one which is determined partly out of ingenuity, and partly out of the force of circumstance, as well as luck. Even better is that stunning and memorable occasion when it exceeds one's best hopes. For me, this delight would never go away, even with frequent use of these creations.

Not only was a good deal of the entire observing experience very much connected to this sense of working with this contraption of one's own making, but even in preparing it for use before the session. In the meantime were all the times of planning, with a never-ending stream of improvements and refinements to its design that might be possible to bring about. I cannot pretend that all of this does not have some considerable effect on how one relates to astronomy: it serves to personalize it in a way that cannot be appreciated or experienced any other way. Meanwhile, if you conclude that you (a) have the time needed to pursue home scope-building, (b) have the minimum required facilities to carry it out, or (c) are actually pushed into it by circumstances similar to those that pushed me, you will never have any regrets. However, don't go into it oblivious to the demands that the pursuit will place on you, some brought about through the inexplicable and energizing absorption that will come out of its very being. You might even elect to construct a hybrid of your own design, combining various components you make yourself with some commercial parts.

As a project right out of the box, you would be ill-advised to tackle anything too grandiose or sophisticated. While I believe you should be encouraged to try something on the more adventurous side (I never started small and unassuming, an 8¼-inch F8 reflector being my first homebuilt!), design your edifice with some practical considerations in mind. For a scope of its aperture and focal ratio, only the simplest of facilities are needed, and you can expect some good results with very straightforward designs. Maybe the easiest mounting is a yoke-type, made of a wood rectangle with roller bearings at each end of the polar axis, and on both sides for declination. It would be possible to fit this telescope with commercial digital setting circles (probably not an item for home construction – although this has been done, too), as well as a commercial or homebuilt drive on one or both axes.

Remember, there is no such thing as too massive or stable in telescope construction! Designing your own scope presents some special opportunities: in making the above 8¼-inch reflector, I used an oversize tube, both in diameter and length. The secondary was therefore well-buried far from the top of the tube, and this limited any stray light or observer-induced air currents from interfering with that part of the optical path. However, I still needed to access the secondary in order to adjust it, something made quite difficult by its very strategic placement. To do this, a door was cut out and hinged adjacent to the mirror, which solved the problem in a very pleasing and efficient way. An easy system for collimation was devised using a novel approach, which I carried over as well onto my largest scope construction (the 12½-inch). From three protruding "ears" connected to the mirror cell I attached (by a rotatable coupling design) three long rods with turning handles at the opposite end. These rods were mounted parallel to the tube through holes in their mounting brackets, which allowed them to turn, and they resembled in some ways the multiple operation rods and turning wheels we see on all the grand old observatory refractors. It was easy to collimate the scope while looking in the eyepiece hole at the same time with no stretching or straining; a very effective solution to an age-old problem. It is surprising to me that this system has not been more widely configured by other builders, and even commercial makers.

The larger sizes present ever-increasing problems. With growing apertures the need to avoid unwieldy tube lengths becomes one of the great mechanical challenges. Simply reducing the focal ratio is not nearly such a ready solution as it may sound, since short ratios and larger primaries also create diametrically increasing optical challenges for the amateur glass worker; the tolerances for accuracy shrink to minute amounts. Both of these factors were significant in my calling it a halt at 12½ inches. In Chapter 2, you may recall that this, my last homebuilt, had a focal ratio of F9, a readily feasible optical surface to fashion at this aperture with the relatively limited means and facilities I had at the time. However, I have to point out that the tube length definitely represented an upper limit for what I was prepared to deal with or risk using in total darkness; it necessitated platforms and rigs that began to approach dangerous extremes. I realized that I had reached my limit, and that any future scopes would have to be made to smaller focal ratios if I wanted to keep the apertures growing.

As a point of interest, I built a large German equatorial mounting for this $12\frac{1}{2}$-inch monster. The main body of it was made out of two massive 6-inch pipe fitting T's, with 6-inch pipe lengths filled with concrete as shafts. The declination axis and polar axis required me to ream out both T's so that the 6-inch pipe could pass through and rotate freely. When greased they provided quite an excellent bearing due to the large surface areas of each. I burned out two electric drills fitted with grinding wheels in achieving that goal, and the finished mounting was indeed highly successful, and a remarkably smooth and responsive affair. Friction or locking on each axis was provided by a large simple right-angled screw, drilled and tapped into each T, and bearing down on the pipe inside by being threaded through the T's. Counterweights were huge disks of lead attached to the 6-inch pipe by locking bands. The tube was all skeletal, and because I had constructed it fully enclosed and baffled at each end, it provided ventilation and light shielding, as well as reasonable protection from operator heat and breathing. Focusing was achieved by moving the focusing unit attached to the secondary on a track along the tube, and not by the eyepiece itself. This was similar to a design in *Telescopes for Skygazing* by Dr. Henry E. Paul. This allowed for a smaller secondary, because the eyepiece can remain closer to the tube. It also featured as well a two-stalk secondary mounting, which appeared as only one because they were in line with the tube when looking from the top. The thin metal that was allowed by this approach gave all the needed sturdiness, as well as a wide latitude of adjustments to the secondary. Also featured was the usual three-point adjustments on the secondary mirror mounting itself, which we are used to encountering. Since I had intended the scope primarily for planetary viewing, the long focal length, together with the secondary's greater proximity to the eyepiece, allowed it to be smaller than the conventional size. The much more limited diffraction, in practical effect zero, unlike that caused by larger secondaries, had to be amongst the reasons it performed so well.

Ultimately, I experimented with a hydraulic drive on the polar axis, but before the time that the telescope was packed away (only to lie dormant in my basement), I did not feel that I had eliminated all the bugs in it, and so can only claim its operation was partially successful. A simple arrangement based on such drives outlined in *Amateur Telescope Making*, edited by Albert Ingalls, served as my model, and it was driven by falling weights driving a piston into a cylinder of oil. This, like so many other concepts described in these volumes, seems quite old-fashioned and archaic now, but there remains so much of value in these books that they will probably always be an inspiration to new readers. It is also fascinating to see how far the sophistication and availability of astronomical equipment has become, compared to the lengths that our predecessors had to go to solve so many of the things we now take for granted. I can't help thinking that these pioneers enjoyed the finest hours in amateur astronomy with their new-found wonder and innovations.

If I were to build again, at this point a highly unlikely prospect, I would certainly be influenced by the design of the JMI NGT-18, which has been such a delight to use. The influence, and the main inspiration behind amateur telescope making, Russell Porter, remains as strong as ever in this design. It seems to address all of the engineering and optical issues that I wrestled with during my earlier days of telescope construction, though with a quality and sophistication that I could never have matched, or even approached. If you find yourself traveling down the homebuilt road, no matter how long, during your astronomical life, I can assure you of the positive effect it will have on your hobby. Maybe you will never escape its clutches, and for all the frustrations you may experience as you work to solve the problems unique to your creation, the influence this will have on your interest in astronomy will indeed be lifelong, regardless of whether you continue to build or ultimately succumb to one of the many commercially available solutions.

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