Chapter 7

Accessories

Eyepieces

It's a telescope's *eyepiece* that does the actual magnifying of the image brought to a focus by the objective lens or primary mirror. It also happens to be the element in the optical train that is most often overlooked as the source of good or bad performance of the overall system. An eyepiece can literally make or break even the best of telescopes! Small imported refractors from the Far East are especially notorious for having poor quality oculars. And since a telescope would not be able to function without an eyepiece (at least for visual observing), an eyepiece can really be considered a "necessity" rather than an "accessory" as listed here.

There's a multitude of eyepieces on the market today, ranging from inexpensive, simple two-element oculars to sophisticated multi-element designs containing seven or eight individual lenses and costing as much as do some telescopes themselves! A good eyepiece should be well corrected for chromatic and other aberrations, have as wide and flat (no curvature) a field as possible, and provide good eye relief. It's especially important that *all* glass surfaces have antireflective coatings to eliminate internal reflections. (Some lower-grade eyepieces have so many "ghost" images that they are said to be "haunted"!) In premium eyepieces, the edges of all lens elements are actually ground and coated flat black in order to further eliminate any possible scattering of light. And finally, rubber eyeguards to help position the eye at the correct distance from the eyepiece and keep out stray light are supplied on most eyepieces today; if not, they are available separately from many dealers for a variety of ocular sizes, types and styles (Fig. 7.1).

J. Mullaney, *A Buyer's and User's Guide to Astronomical Telescopes and Binoculars*,
The Patrick Moore Practical Astronomy Series, DOI 10.1007/978-1-4614-8733-3_7,

Fig. 7.1 A fine example of a comprehensive set of quality 1.25″ eyepieces—in this case, Orion's Sirius Plossl collection, having focal lengths ranging from 40 to 6.3 mm. For all practical purposes, three eyepieces (providing low, medium and high magnifications) will suffice for most viewing applications (at least initially!). Courtesy of Orion Telescopes & Binoculars

Eyepieces come in several different size barrel diameters. The 0.965″ *subdiameter size* (sometimes referred to as the *Japanese size*) ocular is often found on inexpensive telescopes (especially the ubiquitous 2.4-in./60 mm refractor sold everywhere) imported from Japan and other countries in the Far East. They typically have very limited fields of view, poor eye relief and inferior optical quality. The 1.25″ *American standard size* is the one most widely used on telescopes, including many imported scopes in recent years. Its larger barrel diameter allows for big multi-element lenses that provide excellent eye relief, roomy fields of view and good optical corrections. And finally, there's the huge *giant size* 2.0″ diameter barrel employed for some of today's most sophisticated, ultra-wide-angle eyepiece designs. They are so big and contain so much glass that they are sometimes referred to as "glass grenades"!

Of the many types of eyepieces that have been developed over the years, the *Kellner* and the *Erfle* are two of the most common types long used by observers. Among the more popular forms today are the *orthoscopic* and the *Plossl*, which not only provide good optical performance and relatively wide fields of view, but are also very reasonably priced. And of the many modern ultra-wide-field designs now available to stargazers, the *Nagler* series leads the pack with their incredible "space-walk" views (offering up to a whopping 85° of apparent field—see below) and state-of-the-art optical corrections (Fig. 7.2).

Fig. 7.2 One of the legendary Nagler eyepieces having an amazing 82° apparent field and providing spectacular "space walk" views of the sky! These state-of-the-art oculars contain so much glass, and are so big and heavy, that they're sometimes referred to as "glass grenades." They also cost as much as do some telescopes! Courtesy of Tele Vue Optics

There are two basic parameters involving the fields of view of an eyepiece. One is its *apparent field*—the angular extent in degrees seen looking through it at a bright surface like the daytime sky. This can range from as little as 40° up to as much the 85° mentioned above, depending on type, design and actual brand. Most eyepieces in use today typically have pleasing apparent fields of 50–55°. The other parameter is its *actual field*—the amount of sky it encompasses when used on a given telescope. It's quite easy to find what this is; simply divide the apparent field (which is a stated design value for the eyepiece type being used) by the magnification it produces (see below). Thus, an eyepiece having an apparent field of 50° and magnifying 50 times (or 50×) on a particular telescope results in an actual field of 1° (or two full-Moon diameters in extent). At 100×, the field becomes ½ degree and at 200× it shrinks to only ¼ degree. Thus, the higher the power, the smaller the amount of sky a given eyepiece will show. (It should be mentioned here that 1° (1 degree) contains 60 minutes (60′) of arc and that 1′ contains 60 seconds (60″) of arc. The Moon at its average distance has an apparent angular size in the sky of ½ degree or 30, providing a convenient yardstick for judging eyepiece fields of view.)

Determining the magnification an eyepiece gives on a telescope is equally straightforward. The power (x) is found by simply dividing the focal length of the telescope by the focal length of the eyepiece. As already discussed in Chap. 3, the focal length is the distance from a lens or mirror to its focal point, specified in either inches or millimeters. A telescope having a focal length of 50″ (or 1250 mm) used with a 1″ (or 25 mm) eyepiece yields a magnification of 50×. Changing the eyepiece to one with a ½″ (12.5 mm) focal length increases the power to 100×, while a ¼″ (6 mm) eyepiece gives 200×. Therefore, the shorter the eyepiece's focal length, the higher the magnification it provides—and along with it, correspondingly smaller actual fields of view. Thus, the importance of using eyepieces with the largest possible apparent fields. While most telescopes today are typically supplied with one or two basic eyepieces of good quality and apparent fields of view, you may want to consider eventually upgrading to a premium wide-angle, low-power ocular.

Most of the major telescope manufacturers and suppliers have extensive lines of eyepiece sizes, types and designs, ranging from basic oculars priced at under $50 to premium ones going for as much as $300 each! Among others, Orion offers a quality selection of sizes and types at affordable prices, while Meade and (especially) Tele Vue provide state-of-the-art, multi-element designs of various focal lengths and apparent field sizes.

Zoom Eyepieces make possible a continuous range of magnifications using a just a single ocular. These have traditionally been considered much inferior to single eyepieces of a given focal length due changes in field of view and focus with changes in power. Improved models have recently appeared on the market in an attempt to change that. Tele Vue's 8- to 24-mm "Click-Stop Zoom" priced at $210 is a definite step up optically over traditional zooms (although the apparent field still does change from 55° to 40°). Its 3- to-6-mm "Nagler Zoom" (obviously intended for high-power viewing) has a constant 50° apparent field through its short range and sells for $380. Orion offers a 7- to 21-mm zoom whose apparent field varies from 43° to 30° and runs about $60. But for those of us who enjoy wide expansive eyepiece views, despite their convenience even these improved models still fall short of the performance a quality single ocular can provide.

Finders

Another accessory that's often skimped on with a commercial telescope is its *finder*. This is a small auxiliary telescope or other sighting device mounted on the main instrument itself to aid in pointing it at celestial targets so they will appear in the field of a low-power eyepiece—which typically provides an actual field of only a degree or so. Optical finders on the other hand, have fields of 5° or 6° (similar to those of binoculars), making it easy to locate objects in the sky. Once aligned with the main telescope using the provided adjusting screws so it's pointing at the same piece of sky, any target placed on the finder's crosshairs will then be in the former's eyepiece. Magnifications generally range from 6× or 7× for small finders to 10× or 12× for large ones (Fig. 7.3).

An old rule of thumb states that a finder should have an aperture one-quarter that of the telescope itself. Thus, a 4-in. glass should have a 1-in. finder, and 8-in. a 2-in. one and a 12-in. should have a 4-in. one. But this guideline is often ignored by manufacturers in larger size scopes and while followed for those in the in 2- to 4-in. range, the optical quality is often very poor. A 1-in. (or 25 mm—finder sizes are

Fig. 7.3 A conventional straight-through optical finder. Unlike this 9×50, finders on many small telescopes are greatly undersized and often are all but useless. Ideally, a finder should be one quarter of the aperture of the telescope it's riding. But Go-To technology has made this less of an issue today for scopes so equipped. Courtesy of Orion Telescopes & Binoculars

typically given in millimeters) finder on a 4-in. telescope is hardly adequate. An ideal size for 4- to 8-in. telescopes is a 2-in. aperture with a magnification of seven times (essentially half of a 7×50 binocular!), with correspondingly larger values for bigger scopes. Even a 2-in. glass can benefit from having a finder this size. While tiny finders may be adequate for sighting bright targets like the Moon and planets, they are nearly useless for locating fainter object like nebulae and galaxies.

Having a good finder often requires upgrading the one supplied with the telescope as original equipment—either at the time it's ordered from the manufacturer itself, or purchased separately later from other sources. Many of the telescope companies listed in Chap. 9 offer a selection of finders, with prices ranging from as low as $30 to well over $100 depending on aperture. Note that some of these may be equipped with right-angle "star diagonals" (see below) built into them to make aiming easier. Not only do you still have to sight along the tube for rough pointing, but they produce a mirror-reversed image of the sky, which can be confusing to beginners. It should also be mentioned that many of the latest "Go-To" systems supplied with telescopes today (as discussed in Chap. 3) are so accurate that a finder is not needed. But for "quick and ready" aiming at bright naked-eye targets, they still can't be beat (Fig. 7.4).

In recent years, a new type of finder has been increasingly supplied on telescopes in place of traditional optical ones. Known as the *zero*- or *unit- power finder* (it's actually one-power—that of the human eye!), this is essentially a sighting device that projects a red dot on the sky as you sight through it—typically centered on a bull's-eye pattern. This makes going from a star atlas directly to the sky in aiming a telescope quick, easy and surprisingly accurate. The original and still one of the best of many such devices now on the market is the famed "Telrad," invented by the late Steve Kufeld. If not already supplied with the instrument you select, these finders can be ordered separately from such companies as Apogee, Celestron,

Fig. 7.4 A unit-power (non-magnifying), reflex-sight finder like that now widely used on telescopes in place of (or in conjunction with) conventional optical finders. It works simply by superimposing a tiny LED *red dot* focused at infinity on a 10° view of the sky, showing exactly where the telescope is pointed. Courtesy of Orion Telescopes & Binoculars

Orion, Photon, Rigel, Stellarvue, Tele Vue and Telrad itself. Prices range from under $50 to over $100. It turns out that many observers actually prefer to use *both* zero-or unit-power and optical finders on their telescopes, the former for rapid pointing to the position of a target and the latter for positive identification and precision centering in the eyepiece.

Star Diagonals

Stargazers are typically pictured in cartoons and other media as peering through a long refracting telescope at the heavens. This image is quite misleading; for objects on the ground or low in the sky, this works satisfactorily. But most celestial targets are positioned high in the sky, even all the way up to overhead, and it's virtually impossible to bend the neck to view them straight-through a refractor. This is also true for Cassegrain reflectors and catadioptric systems, where observing is done at the back end of the instrument as with refractors. (This isn't a concern with a Newtonian reflector, since the observer looks into the side of the tube.) To overcome this problem, a *star diagonal* is used (Figs. 7.5 and 7.6).

This device consists of two tubes joined at right angles to each other in a housing containing either a precision right-angle prism or front-surface flat mirror, one tube fitting into the focuser and the other accepting the eyepiece. The converging beam

Fig. 7.5 Shown here is a convention prism-type star diagonal as commonly used on refractors, Cassegrain reflectors and compound catadioptric telescopes. One end fits into the telescope's drawtube and the other end (with lock screw) accepts the eyepiece. Courtesy of Orion Telescopes & Binoculars

Fig. 7.6 An optically-perfect mirror star diagonal, which provides better image quality than standard prism diagonals according to many discerning observers. Courtesy of Tele Vue Optics

from the objective or primary mirror is turned 90° to the optical axis by the star diagonal, where the image can be observed in comfort without contorting the neck. These are supplied as standard equipment on virtually all refractors and compound telescopes sold today, and are also available separately as an accessory from many manufacturers. Prism star diagonals can be had today for under $40, while mirror diagonals start as low as $60 and run up into the hundreds of dollars.

It should be mentioned that a star diagonal produces a mirror-image of what is being viewed, so objects appear right side up but reversed left to right. This causes directions in the eyepiece to be somewhat confusing until you get used to it. To find your bearings, let the image drift through the eyepiece field (turning off the telescope's motor drive if it has one). Stars will enter the field from the east and leave it to the west. Nudging the scope toward Polaris, the North Star, will indicate which direction is north.

There is another type of diagonal supplied on some telescopes intended mainly for terrestrial viewing known as an *erecting prism diagonal*. These turn the image 45° instead of 90°, and provide fully correct images. But not only are they awkward to use for sky viewing due to the angle the light is turned, but the roof prism that erects the image produces an obvious luminous line radiating from bright objects such as planets and first-magnitude stars. As a result, they are definitely not recommended for stargazing purposes!

Barlow Lenses

There exists a marvelous little optical device that effectively doubles or triples the focal length of any telescope, yet it measures only a few inches long! Called a *Barlow lens* after its optical inventor, it consists of a negatively-curved achromatic (or sometimes three elements instead of two) lens fitted into a short tube, one end of which accepts the eyepiece while the other goes into the telescope's focuser. With the proliferation of short-focus refractors and fast Dobsonian reflectors in such wide use today, these "focal extenders" are enjoying renewed popularity among observers (Fig. 7.7).

The Barlow's negative lens element decreases the angle of convergence of the light being brought to focus by a telescope's objective lens or primary mirror—causing the latter to appear to be at a much greater distance from the focus than it actually is. This effectively increases the original focal ratio/focal length of the system. Barlow's are typically made to amplify between two and three times (2–3×). The actual stated "power" is based upon the eyepiece being placed into the drawtube at a set distance from the negative lens; the further the eyepiece is pulled back from this lens, the greater becomes the amplification factor. (Some adjustable Barlows use this very principle to provide a range of powers.) By adding extender tubes, many observers have pushed their 2×- or 3×-rated Barlows to 6× and more!

Fig. 7.7 This 2× Barlow lens is just 3″ long and effectively doubles the magnification of any eyepiece used with it. Other models provide amplifications of 2.5× and 3× (or even more using extender tubes, as mentioned in the text). Courtesy of Orion Telescopes & Binoculars

Also note here that the eyepiece-Barlow combination is normally placed into a star diagonal as a unit. But if instead the eyepiece itself is placed into the diagonal, with the Barlow inserted ahead of it in the telescope, the extra optical path length though the diagonal to the eyepiece will also greatly increase its effective amplification.

Solar, lunar, planetary and double star observers have long used Barlow lenses to increase the image scale and magnification of the objects they are viewing. The great advantage of these devices to the casual stargazer is that they make it possible to achieve high powers using eyepieces of longer focal length than would normally be required by themselves. Such oculars have bigger lenses, wider apparent fields of view and more comfortable eye relief than do ones of shorter focal length. Thus, a 25 mm (1″) focal length eyepiece combined with a 3× Barlow used on a telescope having a 1,250 mm focal length (50″) would result in a magnification of 150× (50× times 3). To achieve the same power with an eyepiece alone would require one with a focal length of about 8 mm.

Barlow lenses are not normally supplied as standard equipment on commercially available telescopes (except for imported 2.4-in. (60 mm) refractors, which are notoriously already way overpowered without using one!). But they are widely available from many of the companies listed in Chap. 9, at prices beginning under $50 up to more than $200 for premium units. Here’s a great way to effectively double or triple the number of eyepieces in your collection for a very modest investment!

Dew Caps/Light Shields

Reflectors have their own built-in versions of *dew caps/light shields* since their primary mirrors are located at the bottom ends of their tubes. But refractors and catadioptric telescopes need to have extensions added to their tubes to prevent dew from forming on their front optical elements and also to help keep stray light from entering the system. Although refractors are generally provided with a dew cap/light shield, these are typically much to short to offer any real protection. And, surprisingly, virtually every catadioptric telescope sold on the market today comes without one at all! In any case, the observer can (and definitely should!) either fashion one out of some black, opaque flexible material like common poster-board—or purchase one from the manufacturer at the time the telescope is ordered. They are very affordable (well under $100, depending on actual size) and are an absolute “must” for anyone using a refracting or catadioptric telescope. (A useful rule of thumb here is that a dew cap/light shield should be at least 1.5 times as long as the aperture of the telescope, and to be fully effective 2.5 times as long. The main concern here is that it does not extend out so far as to reduce the aperture itself. This can readily be checked by looking up through the instrument without the eyepiece in place at the daytime sky.)

Miscellaneous Items

The following additional accessory items are mentioned here for the sake of completeness. Few are ever supplied as standard equipment with a telescope purchase, and in many cases they have relatively limited utility (especially for beginning observers). In addition to the primary resource listing in Chap. 9, the advertisements in *Sky & Telescope*, *Astronomy* and other magazines provide other sources for most of these items.

Binocular Viewers make possible using both eyes at the telescope instead of one. While some light loss is involved in splitting the incoming light into two separate beams, as with binoculars image contrast, resolution, color perception and sensitivity to low light levels are all increased over viewing with one eye only. And there's also the wonderful illusion of depth perception in looking at objects like the Moon, for example, where the observer feels suspended in orbit above its vast globe! A downside is the matter of cost. Not only are these devices quite expensive in themselves (ranging anywhere from $300 to $1,600), but two precisely matched eyepieces are necessary for each magnification range that's used. In other words, a double set of eyepieces is required for the telescope! The binocular viewer fits directly into the drawtube of a Newtonian reflector (its vital here to make sure the telescope has enough "back-focus" to accommodate the light path through the viewer to the eyepieces; if not, a Barlow lens inserted ahead of the viewer itself can be used to extend the focus), and into the star diagonal of a refractor or catadioptric (which typically have plenty of back-focus) (Fig. 7.8).

Fig. 7.8 A binocular eyepiece holder, allowing use of both eyes at the telescope. Note that two oculars of identical focal lengths are required by these units. Some observers actually have a complete double set of eyepieces for use with their bino-viewers! Courtesy of Tele Vue Optics

Rotary Eyepiece Holders offer the convenience of having anywhere from three to six eyepieces (depending on model) at your fingertips ready to rotate into position for rapid changes in power. The holder itself is a prism star diagonal and fits directly into the telescope drawtube just as a standard one does. Unitron was the first to market such a device with their “Unihex” rotary eyepiece selector. Another from the past was Criterion. Prices run around $125 and up.

Dew Heating Strips avoid the annoying formation of moisture onto the eyelenses of oculars left exposed to the night air, as well as objective lenses, corrector plates and even secondary mirrors.

These are typically elastic nylon strips with Velcro pads for attaching them to the various optical surfaces and are operated from a 12-V DC source such as a car battery or power supply. Prices average under $100. While the dew caps discussed above generally provide adequate protection for objective lenses and corrector plates themselves without recourse to heating strips, eyepieces are particularly vulnerable to dewing up. (So too are the lenses on finders.) They should never be left exposed to the night air in an open eyepiece box, for example. Except for the eyepiece that’s actually in use on the telescope, they must be kept covered. Note that rotary eyepiece holders do leave their eyepieces exposed to the air, sometimes requiring that they be capped until positioned into place for viewing. (Many observers today also employ ordinary hairdryers to remove dew from the various optical surfaces of their telescopes, but care must be taken not to overheat them. In this case, dew is dealt with after it forms on the optics—while heating strips prevent it from forming in the first place.)

Image Erectors are typically found supplied with small imported refractors for use in terrestrial viewing. Their long tubes make them awkward to use on a telescope and their optics often leave much to be desired. An image-erecting star diagonal (mentioned above) offers a much more convenient and optically superior way to achieve a fully corrected image for land-gazing.

Focal Reducers can be thought of as “reverse Barlows” in that they reduce the effective focal length of a telescope rather than extend it. Originally developed for use on catadioptric systems with their long focal ratios (typically f/10 to f/14), they are intended primarily for increasing the photographic “speed” of these relatively slow telescopes for astroimaging purposes by reducing their effective ratios by as much as half the original values. This correspondingly reduces the lowest achievable magnification and with it increases the maximum actual field of view that can be obtained with a given telescope. However, focal reducers have found only limited use for visual work among stargazers.

Aperture Masks are used to reduce the effective aperture of a telescope, which many observers feel improves the visual image quality and reduces image motion under conditions of less than ideal atmospheric seeing. This goes along with the claim that small apertures are less affected by poor seeing—supposedly because the turbulence “cells” average around 4–6″ in size, so that only one or two are over a small telescope at any given instant, compared to many of them over the light collecting area of a large telescope. While reducing the aperture can indeed often improve image quality on the Sun, Moon, planets and double stars in poor seeing, this also reduces the resolution and light gathering powers of the telescope as well. The masks can be made by simply cutting a hole in a piece of cardboard smaller than the original aperture itself. Note that the opening should be on-axis in the case of refractors, and off-axis for reflectors or catadioptrics in order to avoid their central obstructions (which limit the mask's clear aperture to less than the radius of the primary mirror).

Coma Correctors do just what the name implies—reduce the amount of coma in fast (f/3 to f/6) short-focus Newtonian telescopes. This is especially useful for the immensely popular large Dobsonian reflectors in use today, most of whose parabolic mirrors operate at f/4.5 and exhibit noticeable flaring of images a short distance from the center of the eyepiece field. Few of these devices are to be found commercially at present, Tele Vue's "Paracorr" corrector being one of them and probably the best ever made. Like some of this company's famed wide-angle Nagler-series eyepieces discussed above, its coma corrector costs as much as a small introductory telescope itself! But the improvement in image quality and useable field of view are well worth the price for those who can afford this accessory.

Photographer's Cloths are simply dark opaque pieces of fabric that are thrown over observers' heads and the eyepiece area of the telescope to eliminate stay light and preserve dark adaptation (see Chap. 10). They are available both commercially from camera stores and some telescope dealers, and are also easily made. In practice, these can be a bit suffocating—especially on warm muggy nights—and are sure to raise the eyebrows of any neighbor who happens to see you lurking in the dark!

Telescope Covers are used to protect a telescope's sensitive optics from dust, pollen, moisture and other airborne contaminants at all times when not in actual use. While these may simply consist of plastic sheeting thrown over the entire instrument, more typically they are fitted plastic caps supplied with the telescope for covering both ends of the tube in the case of a reflector, and the front lens or correcting plate for refractors and catadioptrics, as well as eyepieces and finders. The best way to keep a telescope clean is to not let it get dirty! If not already supplied as standard equipment, plastic bowl covers or heavy-duty shower caps can also be used for this purpose.

Filters of many different types and intended purposes are offered commercially for use on telescopes today. Among these are solar, lunar, planetary, nebula and light-pollution filters.

With the exception of solar filters, which are placed over the front of the telescope (never over an eyepiece, as are those supplied on many imported small refractors), the other types screw into the front end of eyepiece barrels—virtually all of which today are specifically threaded to take them. The author has never been a big fan of filters (except, of course, ones for viewing the Sun!), but they do serve a purpose. Planetary observers have long used color filters to enhance surface or atmospheric features, and an entire set of them can be purchased for as little as $50. Many deep-sky observers today routinely use nebula and light-pollution filters to increase the visibility of faint objects. These are much more specialized and difficult to manufacture than are planetary filters and single units begin at $50 and up. It's perhaps best to use your new telescope for a while to see where your interests lie before investing in them. (Full-aperture optical glass solar filters run from about $60 to nearly $150, depending on aperture.)

Micrometers are devices for measuring the angular size or separation of celestial objects (usually in arc-seconds) and their relative positions on the compass heading (position angle) in degrees with a telescope. Of the many different types in use, the filar micrometer is the traditional such device. The few available commercial models run from around $600 to several thousand dollars, depending on features (such as digital readouts). Another form that's becoming more popular today and one that's much more affordable is the reticle eyepiece micrometer, which cost about the same as a good eyepiece. Micrometers are most often used in measuring the separations and position angles of double stars, an activity ideally suited to amateurs looking for a serious observing program to undertake. For more information about micrometers and their application to double stars, see the following two books published by Springer-Verlag: *Observing and Measuring Visual Double Stars* by Bob Argyle (2004), and *Double and Multiple Stars and How to Observe Them* by the author (2005).

Photometers measure the apparent brightness or magnitude of celestial objects (particularly stars) in visual or other wavelengths, generally employing sensitive photocells and electronic circuitry. For the amateur astronomer, they find most application in following the changes in the visual magnitude of variable stars. Commercial units are few and far between, and as a result many observers have built their own devices. However, see the section on CCD imaging and photometry in Chap. 14. (Note that in the original edition, astrocameras, video cameras, and CCD imagers were touched upon here in Accessories—which they indeed are!—but there is now an entire chapter devoted to these and related devices.)

Spectroscopes use one or more prisms or a finely ruled diffraction grating to separate the light from celestial objects into its component colors or wavelengths. This makes it possible to glean such amazing physical information about them as their temperatures, compositions, sizes, and rotational and space velocities. For amateur use, the fun is seeing the absorption lines and bands in the various spectral classes of stars. In years past, Edmund marketed an imported eyepiece spectroscope that became very popular and is still to be found today on the used market. Today, Rainbow Optics among a few others offers a visual star spectroscope that fits over a standard eyepiece—one capable of showing not only the absorption lines and bands in the brighter stars but also emission lines if present. The visual model sells for $200 while one that includes photographic and CCD imaging capability as well goes for $250. Readers interested in learning more about visual spectroscopes and stellar spectroscopy should consult Mike Inglis' excellent book *Observer's Guide to Stellar Evolution*, Springer-Verlag, 2003.

Computers have become an important tool in observational astronomy, as in almost every other area of modern life. While they can hardly be considered an "accessory" for the telescope in the normal sense of the word, they are used for such tasks as aiding in finding and tracking celestial objects, and in making, processing and displaying observations by electronic imaging—all typically done remotely from the observer's living room, den or office. While all this certainly has its place, such "robotic" remote observing, however satisfying and comfortable (especially in muggy or frigid weather), is *not* seeing the real sky—or in many cases not even being out under the real sky! As one observer put it, "Looking at a celestial object on a computer screen is like looking at a picture of your wife when she's standing right beside you."! And here again, for perspective, please see the discussion concerning the "photon connection" in Chap. 16.

Setting Circles/Go-To/Push-To/GPS Systems are all designed to help the observer find celestial objects, using various levels of sophistication. Some are included on various model telescopes as standard equipment while in others cases they are add-ons to be ordered along with the telescope itself. As already mentioned in Chap. 3, the traditional use of mechanical setting circles (and subsequently digital ones) on equatorial mountings displaying Right Ascension and Declination to find celestial objects is rapidly disappearing in favor of these state-of-the-art computerized systems. These make it possible to locate thousands of sky targets essentially at the touch of a few buttons while at the same time providing excellent tracking capabilities. In the case of Push-To systems (mainly used by Orion on its "IntelliScope" series of Dobsonian reflectors), after the target object's name or designation is entered on the keypad, the observer moves the telescope by hand instead of with drive motors until a "null" or zero reading is reached on the LCD display—at which time the object should be in the eyepiece's field of view. The latest innovation (as of the time of writing) is self-actualizing systems based on GPS technology which require no setup on two or three alignment stars as most others systems do.

These devices make finding objects easy and are especially helpful under light-polluted skies or when there's little time available to search for elusive targets. They certainly do have their place and are firmly entrenched in modern amateur astronomy. Again, however, for us purists automated finding takes much of the fun out of celestial exploration and typically leaves the observer not knowing the sky. We prefer old-fashioned leisurely "star hopping" from bright naked-eye stars to the object sought after using a good star atlas, enjoying the many new and unexpected sights encountered along the way!