"Advice for Beginners (or Anyone) Seeking to Buy A Telescope"

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This article will not necessarily tell you what telescope to buy however, it may help you understand telescopes better, and how to approach the decision making process.

Company Seven's staff has good qualifications, with each person averaging fifteen years of experience working with amateur and professional astronomers, using many types of related equipment. Our observation is that most people who enter the hobby having purchased a telescope at the common sources elsewhere will become bored or frustrated by the instrument with the result being it will end up in a closet or the trash. The frustrations tend to originate from 1) poor choice of instrument, 2) improper manufacture or assembly, and 3) the owner lacks of understanding regarding the use of that telescope. Not only will the loss of interest in the instrument result in the loss of that hundred or more dollars, but it is far worse when any fascination that one might have ever had about entering this hobby is destroyed.
Success with a telescope will be much more probable if some forethought is given the matter.

Common Approaches by Beginners: The first concept that one should grasp is that telescopes are "tools" with specific strengths, and weaknesses. How you approach buying a tool should be how you approach selecting a telescope. People often contact our showroom introducing themselves with something like "I want to buy a beginner telescope", or "I want to buy a telescope for $200 or so, what do you have?" These approaches are akin to greeting the staff in a hardware store with "I want to buy a tool and I have $50 to spend - what do you recommend?"

Without first describing what the tool (or telescope) is expected to do, it makes little sense to buy a telescope simply because it is within a preconceived budget. When someone visits the hardware store to buy a hammer they know just what they need; if you found that you could not afford a hammer that you wanted, would you buy a screwdriver instead just because it was within your budget? The matter of choosing a telescope is similar yet complicated by the fact that few newcomers to the hobby have a good understanding of what can be expected from a telescope.

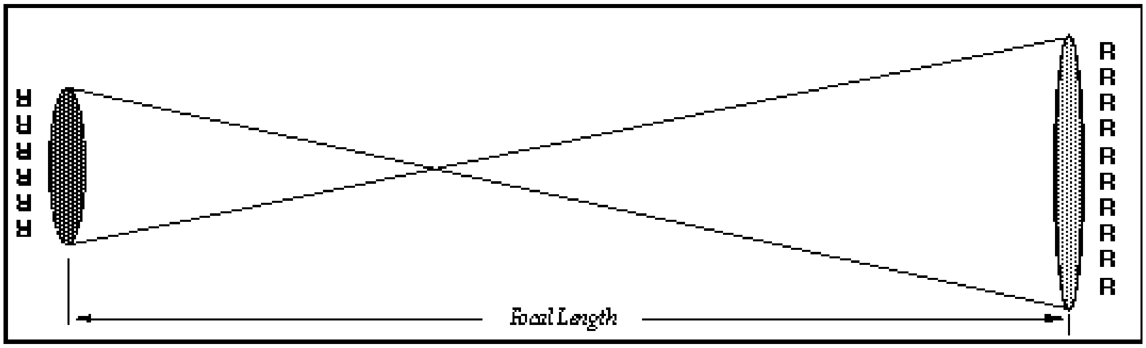
When we ask a visitor what they wish to see, they often answer "I want to see stars"; yet one can observe stars with the naked eye. In a telescope a star in the sky still looks like a pinpoint of light (in poor telescopes a star may appear more like a "blob"). And so one of our goals at Company Seven, particularly when working with a newcomer is to explain what one may realistically expect to observe with a telescope. If they are interested in astrophotography or CCD imaging then we will discuss what they might achieve. It is just as important to explain how simple or complicated it might be to use the various telescopes.

The "test" telescope: many first time telescope buyers reason "I just want to get him (or her) a cheap telescope to see if he is interested". This approach does not generally work because the novelty of a poor telescope generally wears off soon; the user will tire of going out night after night only to observe an object with no detail, or changes. Imagine going out night after night only to see Saturn appear as a "BB within a washer" - the views provided by a poor telescope is not enough to maintain the interest. Worse yet, a poor choice of telescope may destroy any budding interest there may have been in astronomy. On the other hand, if one does remain at all interested in the hobby then that poor telescope will be outgrown so fast that that the customer will be back soon for a better telescope, and the $100 or more invested in the first telescope will have been wasted. Furthermore, the accessories provided with the common department store telescope are not upwardly compatible (if at all desirable) for use with a better quality amateur telescope. The fact remains that when it comes to selecting a telescope, most people understand more about buying most other commodities than they do about buying a telescope.

God did not make all telescopes equal: telescopes do vary by design, aperture, physical dimension (length, width, and weight), and their degree of excellence. There is no one instrument that can achieve all that can be done in astronomy (or nature watching), even the Hubble Space Telescope has its strengths and weaknesses. Two telescopes may seem to be identical from the advertising description and from appearance, and yet one telescope may provide sparkling clear views while the other provides murky, dim views of celestial (or terrestrial) objects. It is important to understand that unlike other commodities such as cars where there are standards (every car has headlights, tail lights, can do 55 mph, etc.), or in foods where guidelines define what claims may be made, there is no regulatory authority governing deceptive advertising of telescope. And so one must understand that every telescope is therefore, an (often uncertain) compromise. The goal should be to make the most reasonable "compromise" possible after considering the realities of your particular circumstance and goals.

WHAT IS A TELESCOPE?

In the way a telescope works it can be thought of as a "Light Funnel" since the telescope (regardless of design) will gather light that enters through a relatively large opening (Aperture). The telescope optical components will then bend that light, condensing it to present one "virtual" image at a point ("Focal Plane") usually located just about at the telescope's focuser.



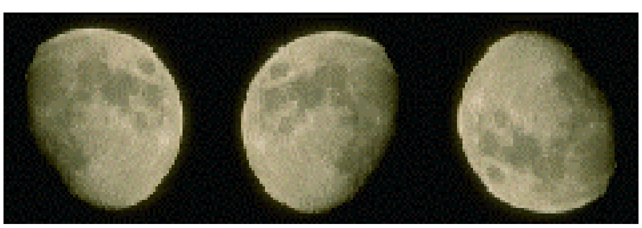
Above: Light through a telescope (refractor shown, Objective Lens at right) to form image at Focal Plane.

A good telescope will provide improvements over observing with the naked eye in two areas:

Light Gathering Power to see very faint objects - make the invisible obvious, and

Resolving Power to reveal fine detail on a distant object, or those smaller than the eye alone can perceive.

If one were to hold a thin sheet of paper at the telescope Focal Plane and move it in or away from the telescope until the image is most clear then one would observe the image formed by the telescope optical system. Furthermore, as light is bent and shaped on its



Above: How an image will appear at the Focal Plane of most astronomical telescopes. Left is Normal View, Center is Erect and Reversed - typical in an astronomical refracting or Catadioptric telescope with Diagonal, Right is Inverted and Reversed - typical of telescopes with no Diagonal accessory

way through the telescope the image will be reversed; this can be seen in the illustration below whether the image formed is upside down and reversed left to right. Viewing through a telescope of a reflecting design will usually present an image that is upside down, and inverted left to right.

Refracting and Catadioptric telescopes usually include a right angle Mirror or Prism Diagonal (or Zenith Prism") accessory which is installed between the focuser of a telescope and the eyepiece. The Diagonal will divert the cone of light coming out of the of the telescope to a more comfortable viewing position; this will be especially helpful if you are looking at an object overhead in the sky. A Diagonal installed onto a Refracting or Catadioptric telescope presents the image appearing right side up, and backward left to right.

Accessories impact the quality of the image. A poor quality Diagonal introduces problems, while a good quality Diagonal will produce only slight light loss and the convenience provided will be well worth it. This is why astronomers do not mind seeing an image that is reversed, and in fact it is not uncommon to find a sky atlas or Moon chart printed to match the orientation observed through a telescope. For viewing the brighter large objects such as the moon, or for daytime use when observing terrestrial objects then an image erecting prism may be employed with very little noticeable degrading of the image.

Terrestrial ("spotting") telescopes differ from astronomical telescopes in that these incorporate some manner of image erecting prism to present the right side up and correct left to right image. These telescopes are also generally more compact and rugged for extreme ease of of transport in the field.

A TELESCOPE IS THE SUM OF PIECES AND PARTS

The telescope is a system essentially made up of two components (plus accessories):

a) **Optical Tube Assembly (OTA) -** includes the optics, mechanisms that precisely hold the optics in place, and a focuser to support an eyepiece or camera. The OTA will determine what and how well you will be able to see, and how bulky the system will need to be. The OTA design will also determine how maintenance free, or durable the telescope will be.

The telescope OTA is characterized by 1) **Design**, 2) **Aperture** or the diameter of the primary mirror or refractive lens (expressed in millimeters or inches), and

3) **Effective Focal Length -** a measure of how much magnification the basic telescope optical system produces. Focal Length is expressed either in millimeters or inches.

So when you read the description of a telescope "60mm x 700mm", this indicates an aperture of 60mm (2.4 inches) and Focal Length of 700mm. The Focal Ratio would be 700 divided by 60 = f/11.7.

b) **Mount** is the component which will determine how one can employ that telescope OTA, how complicated or simple the system will be to set up and operate, the degree of convenience or ability to share the telescope with others, and how bulky or heavy the complete telescope system will be.

Above: Vixen 80mm refractor telescope on Alt-AZ mount head with slow motion controls, on wood field tripod. Courtesy Celestron.

The simple **Alt-Azimuth Mount** permits you to move the telescope smoothly left to right or up and down. This can be useful for casual astronomy, or for panoramic or other terrestrial uses. This mount may be suitable for a short exposure film or video photography of the Moon, or with a safe solar filter the Sun, or terrestrial objects and wildlife.

Now keep in mind that the Earth rotates at a rate of one revolution every 24 hours or so. So celestial objects appear move across the sky in arcs as the Earth turns. One can observe the Moon rising through the trees at only a magnification of 1X (naked eye). A view of the full Moon will require operating at a magnification of about 80X or more. One has to move an Alt-Az mount very carefully up and to the right as the Moon rises from the East peaking in the Southern sky, and then continue moving the telescope down and right as the Moon sets in the West. The mount may be equipped with hand driven gear controls with long, dangling flexible cables. Now speed up that motion of "up, right, etc." with the Moon moving across the field of view of an eyepiece at a rate about 80 times faster than when you observed it with the naked eye...get the picture? Now try following a Planet at 200X or more!

Above: Celestron 8" Schmidt-Cassegrain telescope with "Fork Style" mount, on equatorial Wedge and Field tripod. Courtesy Celestron.

The **Equatorial Mount** was developed to make tracking easier. Consumers seeking the capabilities such mounts provide will typically buy either an easy to use **Fork Equatorial** design, or the more awkward **German Equatorial**, or a **Computer Controlled** tracking Alt-Az mount. Either is attached to a suitable field tripod or a Portable Pier. When properly set up a good Equatorial Mount permits smooth and precise tracking of objects moving the telescope in an arc sweeping from East to West across the sky in the "Right Ascension" (R.A.) direction The mount may be equipped with hand driven gear to facilitate manual tracking. Many mounts will accept the option of (or include) a battery powered motor drive, in such a case you could walk away from the telescope and come back later to find the telescope still on the target. The drive is sometimes referred to as a "**Clock Drive**" since the earliest mechanical telescope drives were clock mechanisms modified to turn only once every 24 hours. The type, and quality of the mount and its drive system will determine what if any distractions from observing there may be, and if one will be able to get involved with astrophotography.

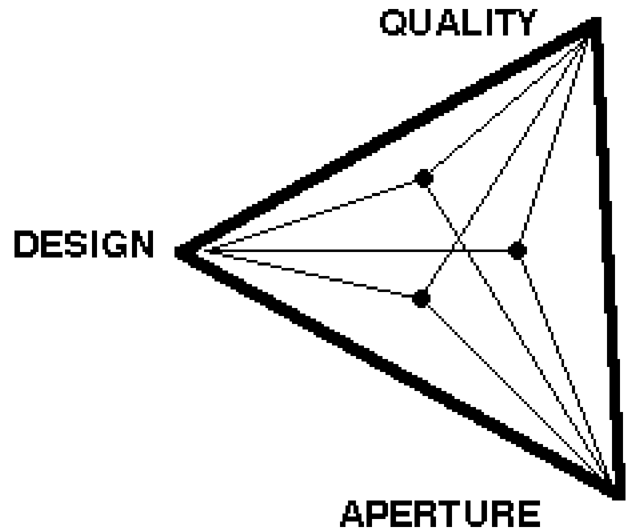
Above: The superb Astro-Physics 155mmf7 EDF Apochromat refracting telescope. on German Equatorial mount, and field tripod. Courtesy Astro-Physics.

A poor mount mated to a superb OTA produces a poor telescope. One good test of a mount is to smack the telescope optical tube lightly and then observe if the telescope jitters for more than a brief moment. This is not to say that astronomers strike the telescope while observing, but imagine how a slight breeze or the touch of a hand reaching to focus that telescope will appear in the eyepiece at 100X, when even a slight tap causes the telescope to vibrate for several seconds!

Common photo camera heads and tripods are inadequate for holding astronomical telescopes steady; tracking smoothly while maintaining proper balance become problematic. Most of these tripods will "shake, rattle and roll" with even the slightest touch of a guiding hand, or the pressure from a stiff breeze. If you adjust the head lock so that the motions are smooth and easy, then as the telescope is pointed higher and higher into the sky the center of gravity shits to the observer's side of the mount head and the weight of that telescope will cause it to slip and gradually slide. If you tighten the head lock to support the telescope then there is enough drag so that one can not move the telescopes smoothly - a move to just slightly center a planet in the field of view is likely to produce a "jerk" that shifts the object right out of the field of view.

The fundamental determinants of the optical performance of any astronomical telescope are with no exceptions: 1) Telescope Aperture: the effective diameter of primary mirror or objective lens. 2) Telescope Design: some designs are better suited for some activities than others. 3) Telescope Quality: a very good small telescope can outperform a mediocre larger telescope to a degree.

The three selection priorities shown in the illustration below may be balanced in a “matrix” to assist in weighing the variables, one against the other.



Note how the meeting points, which originate at the corners meet somewhere in between reflecting the potential compromises. This is not to say that one can not find all three good qualities in one telescope. For some examples consider:

Telescope "Model 1" is of Grade A quality and has a Grade A design, and it is of a relatively small (Grade D) aperture. A larger telescope (Model 2) has a large Grade B aperture with a weakness of Grade C or D in areas of quality or design or both. Depending on your priorities model 1 may yet actually outperform Model 2 The user may determine that telescope Model 1 is the best choice for performance and portability reasons. Or, if the cost of Model A is too high, then possibly the buyer may be able to find another telescope with a compromise of quality or design to a degree that it becomes a feasible acquisition.

One could increase the number of variables, possibly factoring in usefulness for astrophotography. While a similar matrix concept could be designed to consider the important criteria for the selection of a mount. One can complicate this the matter of selection, or simplify it to many degrees. We have encountered some persons who seem to prefer the research for the purchase more than the actual use of the acquisition!

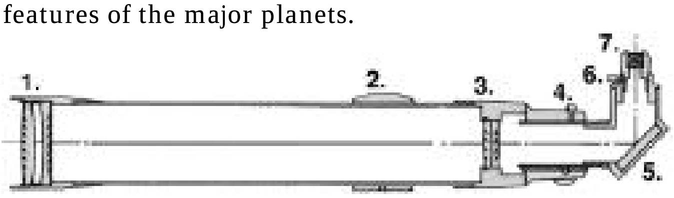
The goal remains straightforward, do not make so many compromises that the telescope will not have the characteristics necessary to keep one interested.

POPULAR CONSUMER TELESCOPE DESIGNS

The consumer is likely to run into only one or more of three basic telescope optical arrangements:

Refracting Telescope: a closed tube design employing glass lenses to bend (refract) light to form the primary image. Typically these are made with two or three lenses in one group placed at the front of the telescope, gathering and bending the light so that it comes to focus at a point just behind the telescope focuser. The ratio of aperture to length to diameter of a refractor is typically between 1 to 4 or or as long as 1 to 15.

Good refractors are the preferred choice of visual astronomers who seek the most natural, contrasting and clear images of the brighter objects (Moon, planets, stars, etc). The f5 to f7 focal ratio Apochromatic refractors are most sought after due to their highly perfected image quality, relative portability, and photo-visual versatility. These fast Apos offer low magnification wide field of view capabilities necessary to observe the larger nebulae, show breath taking views of the countryside, and yet they retain the high magnification clarity to see the changing features of the major planets.



Above: TeleVue 4 inch telescope optical arrangement. 1. air spaced doublet objective, 2. mounting collar, 3. doublet, 4. 2" focuser, 5. 2" mirror diagonal, 6. 2" to 1.25" reducer, 7. Eyepiece. Courtesy TeleVue

Some refracting telescopes employ more than three lens optical arrangements; these include the beautiful brass 4 inch TeleVue Renaissance, and the more conventional 101 telescope. Al Nagler's patented four element design is based on the "Petzval" concept where a two element air spaced objective lens at the front of the telescope passes the light through to a second doublet lens positioned at the rear of the telescope and before the focuser. The doublet lens group at the rear functions to 1) reduce the effective focal length, and 2) reduce or eliminate curvature of field so that images are sharp and clear from the center to the edge of the field of view. This is a way to make the telescope suitable for low magnification, wide angle work as well as providing crystal clear high magnification operations (views of planets, etc.).

Where they work well: refractors are well suited for use anywhere; at urban or dark sky locations. Models with apertures of up to 5 inch it is a simple matter to move the telescope with mount outside to a convenient location, and pound per pound these better models provide the best views. Commonly provided with either right angle prism or mirror diagonal, the view is right side up but reversed left to right; this is fine for astronomy and many terrestrial applications. The more compact (faster f ratio) varieties with magnifications that can go to as low as about 10X or less are the most highly recommended telescopes for terrestrial use with some being accessorized with an image erecting prim in order to correct the image left to right as well.

Assembly, Maintenance: refractors are essentially maintenance free systems with tube assemblies that are factory assembled, fairly impervious to the elements, and will not go out of collimation unless there is some catastrophic impact damage. This does not mean that those which are commonly marketed for $500 or less are made well, nor does is it to say they are even properly aligned when coming out of the box - the gist is that either they will work or they should be exchanged.

Other Thoughts - Many of the better made small refractors are considered by merchandisers to be priced out of the marketplace, and so very few good quality 80mm (or smaller) refractors remain in production today. More common than not, what can be found in department stores and mail order houses are cheaply made, sometimes identical in external appearance to the good telescopes which they mimic. Current cheap refractors are made in China and other low labor cost nations, while the better small telescopes are manufactured in Japan or Taiwan. As the quality of smaller telescopes has become shoddy, the reverse is true of the selection of better refractors. One good sign includes "Orion Telescope Co." which has taken the gamble of importing the bit more costly Japanese made "Vixen" Achromat and Apochromatic refractors and some other telescopes (formerly discontinued by Celestron International) are back on the market.

The best refracting telescopes now made are from the U.S.A. by 1) Roland Christen at "Astro-Physics" manufacturer of the world's finest triplet apochromat (with such unprecedented demand that waiting lists for deliveries average two or more years!). And by 2) Al Nagler's TeleVue Optics, pioneers of versatile 3 and 4 inch achromatic and Apochromatic refractors. From Japan there are "Takahashi" and "Vixen" - the first to make affordable high performance Apos available to the serious amateur in the early 1980’s, bucking the f15 Achromat by introducing much faster f ratio lines of 3 inch up to 6 inch Fluorite Doublet (and later the Takahashi FCT Triplet) Apochromat telescopes.

Reflecting Telescope: an open tube system which uses two reflecting mirrors to form the primary image. The ratio of diameter (Aperture) to Focal Length is typically between 1 to 4, or 1 to 8. The most popular consumer reflecting telescopes include traditional "Newtonian" (first made by Sir Isaac Newton) and the simpler and less costly "Dobson" variation; the focuser of these telescopes is at the side of the telescope near the front. Other more costly reflecting designs include Classical Cassegrain where the primary mirror (at the rear of the telescope) has a perforation in the middle thereby permitting the secondary mirror (at the front and center of the tube) to reflect the light back through the primary mirror and into the focuser at the rear of the telescope behind the primary mirror.

Reflectors may make up with quantity what they lack in efficiency however, these are particularly desirable instruments when a great deal of light gathering power is needed. Experienced astronomers generally suggest that at least a 6 inch aperture telescope of good quality (in suburban skies 8 inch aperture or larger) with focal ratios of between f6 to f8 be considered for uses astronomy if you are to have any hope of observing recognizable deep sky objects (assuming the local skies are dark) and the changing features on the major planets. Consider that an 8 inch reflector at f6 is physically just as lengthy as a 6 inch f8 telescope. And yet the 8 inch model (of similar design) will have a 56% increase in light gathering power over the 6 inch model, yet the difference in price between the two sizes may be only 20 or 25%.

The popular Dobson style is a variant of the Newtonian reflector. If made even reasonably well then “Dobs” can provide the best return on the investment in terms of what can be seen in the sky for the money spent

These most popular sizes for beginners are the 6”f8 and 8”f6 model. Since each telescope has a focal length of 48 inches then the physical length of the two telescopes are similar. The price difference between common beginner 6 and 8 inch Dobs is only about $100 while there is a 50% or more increase in light gathering power favoring the 8 inch over the 6. So we suggest beginners consider the 8 inch f6 at a minimum if they seek a good, economical, telescope and are comfortable with the other characteristics of these telescopes.

The smaller Dobson telescopes will have a tube made of weatherproofed cardboard (Sonotube), and a base made of plywood or treated particle board. These telescopes can become prohibitively bulky and heavy in sizes of 10 inch aperture or greater, even more so for children.

Above: Celestron 8 inch f6 Dobson reflecting telescope, note simple Alt-Az mount. Courtesy Celestron.

The best Dobsons of 12.5 inch and larger tend to be made in a “truss” design where the top and bottom assemblies of the telescope are made of wood or composites. Housings of the mirrors and focus mechanisms, these are held precisely in place by lightweight support tubes. A healthy adult can manage about a 20” (or larger) truss telescope since with current technology weight of the glass or ceramic mirror remains the limiting concern. If you attend any major Star Party or Starwatch event such as those organized by astronomy clubs then you may see very large (30 inch or larger!) well made Dobson telescopes such as those made by Obsession and our own AstroSystems providing breath taking views of faint galaxies, nebulae and more.

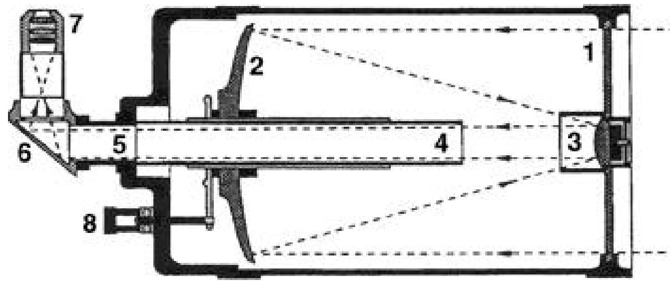
Where they work well: particularly well suited for use at dark sky locations, away from the city. The larger telescopes are a good choice where it is a simple matter to move the telescope outside to a convenient location. Being open tube telescopes, these are not recommended for use at sites near salt air since the corrosive dew will deteriorate the exposed mirror coatings.

Other Thoughts: these telescopes are best suited for astronomy being impractical for terrestrial uses due to the often awkward position of the focuser, inverted image, and the relatively long distance from target required to come to focus.

Newtonian reflectors as small as 6 or 8 inches in aperture may be too lengthy to fit into a car; and these or larger telescopes may be more bulky than many people wish to manage. Focal ratios of f5 to f6 provide good versatility, as they grow to f7 and longer these become awkward for many and limit the field of view more and more, though at f7 or more their contrast can improve to provide refractor like views of the planets, and moon. We recommend no Newtonian smaller than 6 inches in aperture for astronomy unless the Moon and Sun (with safe solar filter) are the only objects of interest. We also suggest that while solid tube designs of up to 10 or 12-1/2 inch aperture may be practical, anyone seeking a transportable system larger than this should consider the "Truss" tube design such as those by "Obsession" and "AstroSystems".

Assembly, Maintenance: there may be as many as 28 adjustments to be made in order to properly install and to center the optics of a Newtonian telescope. Most of the mirror (or Catadioptric) telescopes sold will have optics that are not properly aligned when delivered; it may prove to be quite a challenge for those who are not familiar with the procedure to assemble and collimate such telescopes properly. Due to inconsistencies of quality control at the mass production factory some poorly made telescopes simply can not be properly aligned without substantial modification. Company Seven will adjust this as is needed during our normal checkout procedure however, if we have to ship the telescope out to a customer we (and the documentation) do provide guidance on how to assemble and align the optics (collimate) of the telescope. Once assembled and collimated then a well made telescope should not go out of collimation on its own, but careful transport should be considered. We often observe amateurs at Star Parties spending quite a while tinkering with their mirror telescopes, hoping to improve the collimation.

Catadioptric: include a number of variants, most popularly either "Schmidt Cassegrain" or "Maksutov-Cassegrain". The primary characterizations are that these telescopes incorporate both refractive and reflecting components and tend to be closed relatively low maintenance systems. In order to work well with light being bent so radically, these often employ a sophisticated "aspheric" lens element. In the case of the poplar Schmidt-Cassegrain, light passes though a window at the front of the telescope; this may appear to be a flat window but in fact it is a difficult to make aspheric lens. After passing through the window then the light is gathered at the Primary Mirror, then forward to the Secondary Mirror, and then back through the perforated primary mirror to beyond the rear of the telescope to the eyepiece, or camera.



Above: Schmidt-Cassegrain optical arrangement. 1. Aspheric Corrector Lens, 2. Primary Mirror, 3. Secondary Mirror and Baffle, 4. Primary Light Baffle Tube and support for Primary Mirror, 5. Rear Cell (accessory holder), 6. Prism or Mirror Diagonal, 7. Eyepiece, 8. Focus Control Dial.

Their compact optical tube belies their relatively high f10 to f15 effective focal ratios. Commonly the actual length to diameter ratio of these telescopes is only about 1 to 3 or so. This makes these lightweight telescopes compact and suitable for use on the very easy to comprehend Fork Mounts, or on more conventional German Equatorial mounts.

Above: Celestron 8” Schmidt-Cassegrain telescope on Fork Mount, Equatorial Wedge. Courtesy Celestron.

These telescopes are a good choice for suburbanites who wish to observe planets or the brighter deep sky objects from the city. And for those who want to quickly pack a telescope and transport it to the country, or who is looking for simple to manage aperture in the mid size telescopes. Consider that a 8"f6 Newtonian tube will weigh about 30 lbs, be 10 x 48 inches wide and long necessitating a heavy German Equatorial Mount for a total weight of about 100 lbs. So the 10 lb. 8 inch Schmidt becomes more appealing to many; running on a Fork Mount with clock drive, lightweight wedge and tripod the complete weight may be only 40 lbs or less!

We have customers whose 8 years old children easily manage a C-8; 14 year old children using the larger C-11! The smaller models (Questar 3-1/2, Celestron C-5, etc.) are popular among nature watchers or those who need a compact ultra telephoto lens. Although it is not uncommon to see C-8's brought to Kennedy Space Center to observer spacecraft launches, or to wildlife areas to observe or photograph wild life at great distances.

Assembly, Maintenance: these closed systems are nearly maintenance free. It is no more difficult to clean the durably coated Corrector Lens than any camera lens. The optical tube is factory assembled and resistant to the elements (dew, cold, etc.). The expensive Questar Maksutov-Cassegrain telescopes are very rugged and resistant to abuse, some models are completely impervious to the elements (storms, dust storms, cold, etc!), and "ruggedized" models are flown into space! The Maksutov-Cassegrain telescopes will not go out of collimation (assuming they are assembled properly at the factory) unless there is some catastrophic impact damage. The more sensitive Schmidt-Cassegrain requires some common sense care; more than half that arrive at Company Seven are out of alignment (courtesy of R.P.S. or U.P.S.); we will adjust this as is needed during our checkout procedure. However, if we have to send a telescope to a customer the documentation and we do provide guidance on how to collimate the telescope.

Other Thoughts: the very best Catadioptric telescopes are made in the U.S.A. by 1) the Questar Corporation who specialize in superb industrial quality telescopes, and by 2) Celestron International who pioneered the mass production of the ubiquitous Schmidt-Cassegrain telescope. There are some new consumer scopes coming from overseas including the very well regarded Maksutov-Newtonians developed by "Ceravolo" of Canada, others from Japan and from former Warsaw Pacts nations where firms that formerly made optics for the military now struggle to survive - and their quality and consistency seem to be improving.

Each of these telescopes is a very good value, but the Schmidt-Cassegrain (SCT) is arguably the best value if one is trying to balance versatility and performance. A Celestron 8 inch (and larger models) will do a little bit of almost everything in astronomy fairly well. The value of the SCT to the community has improved over the years due in good measure to the fierce competition by two of the giants in the consumer telescope industry - Celestron and Meade Instruments. Their innovations and need to compete in many areas of technology have resulted in dramatic improvements since Celestron introduced the landmark "Celestron C-8" telescope in 1970. One should note that the original Celestron C-8 telescope (with equatorial wedge and field tripod) of 1970 sold then for about $1,000 (one is on display in our showroom/museum) while a four door family vehicle sold for $4,00 or less. A much improved version of the C-8 telescope with features that were not even imagined in 1970 sells 30 years later for $2000!

With advances in technology, manufacturing, and with fierce competition the consumer has never before been able to obtain such good telescopes, and at a cost of a smaller portion of an average person's annual income.

The **Eyepiece** (Ocular) is the accessory required for visual use of a telescope. A magnifying lens which enlarges the image at the telescope Focal Plane, the eyepiece is attached at the telescope focuser and is adjusted in or out to bring the image to focus. Eyepieces vary in grades of quality and sophistication, and in size of barrel diameter (0.965, 1-1/4 inch, or 2 inch). Their enlargement factor (Focal Length) is usually described in millimeter (mm) units of measure. A good eyepiece may be made up of as few as three, or up to eight ground glass elements precisely mounted into a metal cylinder. The better eyepieces will have printed or engraved: manufacturer, focal length, and design; if we know these three items then we can pretty well predict how that eyepiece will perform on a telescope.

Above (left to right): 14, 10, 6 and 4mm focal length TeleVue "Radian" series eyepieces, 1.25" diameter.

Do not underestimate the importance of the good eyepiece. Plan to spend between $80 to $400 (or more) for each and realize the cost of a selection can equal or surpass the cost of the telescope! It is advisable to plan these purchases carefully so that the eyepieces and other accessories that you buy today may be upwardly compatible if you buy other telescopes in the future.

The eyepiece will determine several variables:

Magnification: determined by dividing telescope Focal Length (in "mm") by the eyepiece F.L. (in "mm"). To determine magnification, divide the telescope F.L. by the F.L. of the eyepiece. A 1000mm telescope employed with a 10mm eyepiece operates at magnification 100X.

Field of View (FOV): the area that can be seen through the telescope, usually expressed in Degrees. There are two terms which may seem similar but in fact are not.

1. Apparent Field of View is the angular area one thinks is seen when looking through the eyepiece. This is the angle subtended from the one edge of the field to the other. With reasonable eyepieces this will be somewhere between 40 and 80 degrees or so. Generally wider is better (assuming the field remains sharp and clear) since this provides a more natural wide angle view as opposed to having the appearance of looking through a narrow drinking straw.

This factors in only eyepiece design and does not consider the magnification effect from the telescope.

2. Actual Field of View does factor in the effect of the magnification of the telescope; it calculates the actual area of sky which may be observed.

A simple formula to determine this is divide telescope magnification (often expressed in X) by the Apparent Field of View of the eyepiece (in Degrees). So a telescope operating at 80X, with an eyepiece of 50 degree Apparent Field of View will show 0.63 Degrees of sky (a bit more than the area of the full Moon).

A telescope with a wider angle eyepiece of 82 degree Apparent Field of View operating at 80X, with an eyepiece of 80 degree Apparent Field of View will show full 1 Degree area of sky (about 4 times the area of the full Moon).

If one wanted to see a much larger image of the Moon, filling the entire field of view then one could employ a much higher magnification.

Eye Relief: The spacing between the lens of the eyepiece nearest to the observer (Eye Lens) and the observer's eye. Eye Relief is a critical concern for those who much wear prescription glasses.

Quality of Image: Eyepieces of excellent or superb quality are those made by Brandon, Carl Zeiss, Clave, and TeleVue. The dominant innovative force in eyepiece design is Al Nagler founder and President of TeleVue Optics Inc. Other companies market eyepieces that range from barely adequate to very good, and some are excellent: Celestron International, Meade Instruments, Orion Telescope Center.

However, quality of excellence alone does not determine compatibility. For example consider the wonderful Carl Zeiss "Abbe Orthoscopic" that does not work well on telescopes with focal ratios less than 7.

Apparent Field of View: hold an eyepiece near your eye at the proper observing distance (Eye Relief) of the eyepiece. As you look from the left edge of the picture it shows (Field of View) to the right edge of the Field of View the angle subtended is known as the "Apparent Field of View". The area which one can observe is limited by the design of the eyepiece. Some eyepieces are very simple to be inexpensive and these will show only modestly narrow Fields of View; in astronomy this is something like looking at the sky through a strawAn astronomical telescope will usually be accessorized to include at least a few of these accessories. Possibly one low magnification for the larger deep sky objects, another (about 80X) for a close up the Moon or Sun and deep sky objects, and a third to observe the changing features on the planets (ideally about 200X or more).

WHO SELL TELESCOPES

Telescopes are sold at retail department stores, "science" or "nature" or mail order oriented stores, and at a very few remaining service oriented specialty shops (who also mail order to the customer). During the 1980's visit of Comet Halley, New York mail order camera stores entered the market squeezing traditional telescope mail order houses and stores even further. The camera mail order source's advertised prices may or may not be the lowest, but their advice is often brief or abrupt and may be less than capable. With the advent of the Internet, small often unlicensed amateur (or semi professional) persons with no traditional overhead expenses have also entered the fray. And so more than ever before, the shopper may not easily determine the competence, and character of the company which he or she is dealing with. Mall based chain stores typically offer only one product line, while specialty shops offer a selection of products broader in scope of telescopes and of the better third party accessories (by Astro-Physics, Lumicon, TeleVue, DayStar, etc). Some degree of assistance may be obtained by mail order oriented telescope stores however, their profit margins are often so low that to maintain a high volume of sales they do not spend too much time with any one caller.

At none other than the service oriented specialty shops will you be able to see the product and also talk to someone who knows the telescope, or obtain any quality control assurance, or training. The quality control will be left more and more up to the factory since fewer and fewer of the specialty stores want the overhead of maintaining inventory; many products are simply Drop Shipped directly from a factory to the customer. Assembly and any trouble shooting will be left up to the customer; this is not much of a concern if you are very familiar with setting up and evaluating a telescope, and if you choose a product line with a reputation of impeccable quality control and customer service.

WHAT AND HOW THEY SELL

Persons who mean well, but may have never used an astronomical telescope often staff common retail sources of telescopes. Customers and these sales people are often at the mercy of exaggerated sales literature produced by those who have no understanding of that telescope which they are contracted to market.

Price point: poor telescopes targeting the amateur astronomy market exist because store and factory management are concerned about Price Points. They understand that so many people will impulsively spend $100 for what to them appears to be a telescope, and fewer buyers will spend $250 etc. So the store telescopes have been gradually cheapened (in terms of optics, mechanics, mount rigidity, and accessory quality) in order to keep them marketable. Note how few stores stock telescopes that cost much more than $500 - this is the threshold where customers pause to think more carefully, and consult specialty shops that are poised to advise and support the customer.

Most telescopes sold in retail stores are poor to modest quality instruments. Incorporating mediocre reflective (4.5"/114mm diameter or less) or refractive optics (2.4"/60mm or less) these are too small in aperture and therefore inadequate in terms of light gathering power to reveal the faint, extended "deep sky" objects (generally considered to include galaxies, nebulae, etc.) outside our solar system, or faint comets as well if any better than a good binocular. These telescopes lack the resolving power necessary to show changing features of the planets. The Moon or Sun is about all they can manage to reveal, and then not that clearly. There is something to be said for spending $600 to show a child the Moon, Sun, and glimpse of a couple of planets. But for less money you could spend time with him, possibly out with an astronomy club using their better telescopes, or build your own telescope!

Qualifying the customer: the first question a salesperson may think to ask a customer is "how much do you have to spend?" Some salesmen call this "qualifying a customer", while others simply understand no other way to help. Asking only about budget is not really in the customer's long term best interest; can you imagine a salesperson at the hardware store first asking "what do you wish to spend on a tool" before considering what type of tool you may need? Shopping by price is a poor approach by either the customer, or sales staff. Then of course there is the matter to be considered of some sales people who experience a nearly sexual thrill at "closing" a sale - no matter if the customers best interest is served well.

And so we suggest that if you are greeted with "what do you want to spend" or "I have a $119 telescope, a $239 telescope, and a $359 telescope… which do you want" then you should consider such approaches to be among your "walk away" parameters.

Special events: when sales are motivated by an attraction in the news then merchandisers tend to build up false hopes planting misinformation, promises of spectacular visions, and the like. They may hustle telescopes so ill suited to the task (such as the "Halleyscope" of the mid 1980's) that an attraction such as a comet may actually appear worse (if at all) when viewed through their telescope than when viewed through a binocular, or by the naked eye. The quality controls of most consumer products tend to suffer as production increases to meet the sudden demands of Christmas or special events.

PROMISE THEM ANYTHING

There are measures taken by some manufacturers that we consider to be downright deceptive; the packing box is likely to have stunning artwork or photographs of Galaxies, or Nebula (probably taken by the Hubble Space Telescope), implied promises of what you are not ever going to see with what's inside:

Misrepresentation of Effective Aperture: examine a selection of common department store "astronomical" refracting telescopes. Many of these incorporate a poor quality objective lens that may be advertised to have a certain diameter - commonly 2.4" (60mm). However, just inside the barrel and behind the lens may be an Aperture Stop (not to be confused with anti reflection Baffle. The washer like device effectively stops down the lens opening to a fraction of what is advertised. The result is a view that may appear "sharper" that it would otherwise but the brightness of the image may be 1/5 or less than what it should be. And the detail observed with such a lens could be something like 1/3 of what should be seen in a true 60mm aperture telescope. If the washer is removed, then all sorts of defects (aberrations) related to the poor quality of the lens would become even more obvious to the user.

The typical reflecting astronomical telescope in the retail environment today has an aperture of about 114mm (or 4.5 inch) or less. Up to about the mid 1980's such telescopes were not even available as anything other than finder telescopes (Meade Instruments used to make a really nice 4.5 inch “finder/photo guide telescope”) for larger telescopes! A number of manufacturers that formerly had good credibility among amateur astronomers have to one degree or another "sold out" or rationalized, making excuses to offer such mediocrity under their names too – the dollar is a tempting mistress.

It is generally accepted by the astronomy community that at least a 150mm (6 inch) aperture decent quality reflector system (with good transparent skies) is needed to show recognizable views of the popular "Messier Catalog" of deep sky wonders. This catalog lists about 100 or so objects, some which can be seen naked eye which appear in the sky over the course of one year. With few exceptions, Company Seven does not consider less than a 6-inch aperture mirror of decent quality, or a good 3-inch (80mm) Achromatic refractor useful in astronomy. The makers of amateur telescopes used to state this clearly in their literature as recently as the 1980's when these were the smallest systems they sold.

Magnification claims: too many companies make unrealistic claims of magnification - as if it were even that important in astronomy.

When I was in elementary school I became interested in buying an 80mm refracting telescope. I compared a few shown in competing catalogs. One catalog described a telescope of 450X magnification, the other claimed 454X at about the same price. So, naturally I assumed the 454X telescope was better. It is technically possible to operate a telescope at uselessly high magnifications but this is synonymous to having a small pocket camera film negative enlarged to produce a wall size print - it can technically speaking be done however, there will not be much to see clearly. With a little experience, one will learn that anyone that claims much more than 50X to 60X per inch of aperture for common consumer grade telescopes is either an optimist or a defense attorney! *Where in the heck are the Federal Trade Commission, and class action attorneys when you really need them?*

Not long ago we noticed a cheap 60mm refracting telescope distributed by Celestron and marketed by a science store chain. The packing box marking which indicated the maximum suggested magnification was pasted over with a sticker claiming something to the effect that this was a "special edition telescope" made exclusively for that chain. The claim was far higher magnification than what Celestron recommends. This is another tactic employed make the telescope seem competitive with other similarly priced telescopes advertising similar claims. By Christmas of 1999 the claims had evolved to see a Tasco 60mm telescope in a “Dicks” sporting goods store claiming 525X; where do they dig up the guys who write that stuff?

Shaky Mounts: often the mount and tripod contribute to the inadequacy of the system by being spindly and vibrating even on a mild breezy evening. Anyone touching the telescope to adjust its position, or to focus it onto an object will find the vibrations distracting at the least.

Eyepieces: furnished are usually of modest or poor quality. Often with such little eye relief (distance from the eyepiece lens to the observers eye) that using the telescope is at the least uncomfortable, and for those who must wear prescription glasses when observing - inadequate. This is aside from the concerns of passing disease (Bacterial or Viral Conjunctivitis for example) when sharing such eyepieces among a number of people. The poor eyepieces are often the result of consumers "I want a best buy" mentality which drives suppliers to provide two or more cheap eyepieces in place of one of good quality.

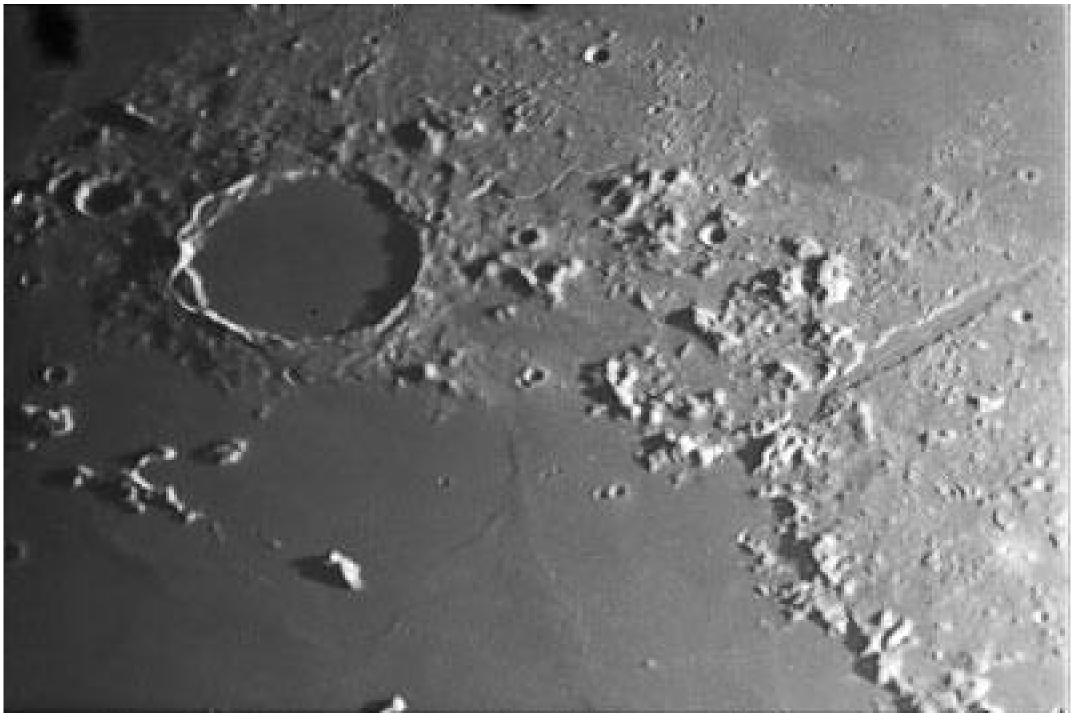
Unsafe Sun filter: A number of imported small telescopes are furnished with a dark glass "Solar Filter" that threads on to the eyepiece. These are harmful, capable of leading to eye damage or possibly blindness. Many early astronomers gradually went blind (including Galileo) because they looked at the sun over time with smoked glass neutral density filters which attenuated the brightness but failed to filter out the harmful portions of the sunlight spectrum. Smoked glass filters may crack and open to pass sunlight from heat build up if a suitable aperture stop is not in place. We suggest all telescope users be cautioned about the dangers of observing the sun without the use of proper safety equipment; small children may need constant adult supervision or restricted access to the telescope.

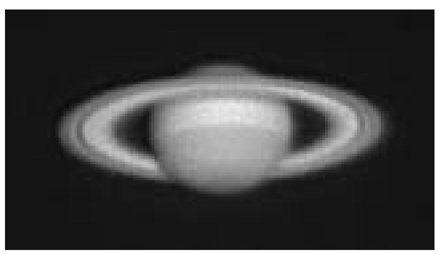
SO WHAT TO CONSIDER AS A FIRST SCOPE?

In order to be a "successful choice" a telescope must:

Maintain interest: show enough detail (deep sky, planets, etc.) in the sky to keep some one's interest over the course of a year or more.

At the very least it should reveal a variety of deep sky objects (ideally at least the "Messier Catalog" of diffuse nebulae, star clusters, planetary nebulae, galaxies, and more) as they appear throughout the course of the year. And they will be able to reveal at least the major changes that the planets under go throughout their seasons: the white Polar caps of a distinct red disc of Mars as the caps grow and shrink from summer through winter and back, the dark markings of the red planet; the 4 largest moons of Jupiter as they orbit and occasionally pass in front of the planet revealing themselves by the distinct dark shadows of their discs. Observe the milky white, tan, beige, and brownish colorful tropical bands of Jupiter as they change latitude, thickness and color intensity. Watch the rings of Saturn and how their tilt angle relative to Earth appears to change over the years!





Above: *Close up views of Moon, Saturn, Jupiter with three moons (one of which is transiting) This is close approximation (albeit in black and white and two dimensionally) of what may be seen through a good telescope. Photos by Roland Christen, Astro-Physics Company*

Lifestyle: the telescope must compliment the users' life style. Consider where the person will use the telescope (suburban or rural environment, etc.), how much weight the person will feel comfortable moving in and out of a home. Viewing concerns addressed by us include who will use it, and if they wear prescription glasses. If using a reflecting telescope then will the user care to make adjustments that may be necessary to keep the optics clean and aligned? Will the telescope be shared by many or used by only one or two people? There are many more aspects to factor - these are only a few.

READ!

You could buy astronomy magazines including *Sky and Telescope* or *Astronomy* to learn about events in the sky, yet more and more you will find the latest astronomy news on the Internet. These popular U.S. magazines can not be counted on to stand up and say much about poor marketing practices. Their reviews are shallow, and not very technical. They allow advertisers to claim just about anything, “we do not censor advertiser” they quiver. Understand these **magazines are profit making businesses: not too altruistic.** One product review of a 4.5 inch Newtonian stated its inefficiency resulted in only a usable 3.6 inch aperture yet they left the reader thinking this is just fine. If you wish to read good product reviews then translate either Japan's *Gekkon Tenmon,* or Germany's *Stern und Veltrum* magazines. But why must we have to learn Kanji or German to learn technical facts about the equipment?

You might go online to read Users Group opinions of particular products. Keep in mind that one amatuer’s opinion may not be enough information to justify a large expenditure but if you hear good about a product from ten people then it is likely that you can trust it.

YOU DO NOT NEED TO BUY A TELESCOPE TO GET STARTED

Those who are unsure of their degree of interest, or for those with modest financial means should consider.

Binoculars: explore the night sky with binoculars and by naked eye; there are a number of good books dedicated to just that subject. This learning will better prepare you to understand how to use a telescope later.

Astronomy Club: Join a local astronomy club and participate in their activities. One will benefit from the experience of others, make new friends, and attend "sky watch" activities with an opportunity to look through other people's telescopes. These observing opportunities are usually open to the public at no charge. Many clubs operate out of municipal Planetariums, or Colleges. Also, you may glean some ideas from discussions with enough members to gain a consensus about what will serve your needs best. Clubs often publish newsletters available at a modest subscription cost advising readers about the coming celestial events, and how and where to see them best. For assistance in finding a local club you may ask us, or search the Internet.

Build a telescope: from basic raw materials using amateur guides, or from manufacturer’s components. This can be an economical means to an end, provide an education for a young partner in discipline and following directions, a lesson in optics, and a sense of satisfaction that only comes from accomplishment. It is pleasing for us to see an older person visit our shop asking for restoration advice or service for a homemade telescope that will now serve the next generation. Such telescopes are more often preserved than store bought telescopes because the home made telescopes provide a fond remembrance of time spent with loved ones. Company Seven offers books that are helpful including:

Build Your Own Telescope: Hardback, by Richard Berry. One the first books which we recommend to those who are deliberating the decision of whether or not to build an astronomical telescope, or who have decided to build a telescope. Clear, step-by-step instructions explain how to build telescopes from a simple reflecting telescope, up to a telescope capable of sustaining a lifetime's interest in astronomy. Detailed instructions include complete plans and photographs that show how to construct a capable telescope with ordinary household tools and materials. We also suggest this for use in guiding children who are doing such a task as a science fair project. It is written and illustrated so that anyone between a teenage novice to the adult amateur astronomer will find the book interesting, and helpful.

Company Seven offers books that are very much up to date and offer sound advice selecting and using astronomical telescopes, most notably:

Backyard Astronomer's Guide: by Terry Dickinson for $40.00, Hardback (please add $4.00 for postage if you wish to have us deliver it to you).

Starware: by Philip Harrington for $20.00, Soft cover (please add $4.00 for postage for delivery to you).

These two books offer good introductions to astronomy, with advice about selecting equipment (binoculars, telescopes, accessories), how to observe a wide range of astronomical subjects. They are written in a fashion that is understandable to a youngster, and yet an adult will not find it to be as a "Dick and Jane" novel. Most of the numerous photographs are done by the types of amateur telescopes discussed (many by our customers) - not by Mount Palomar, so one can glean a good idea of what is truly possible with amateur telescopes.

The Observer's Handbook: This is an annual soft cover publication by The Royal Astronomical Society of Canada available from Company Seven for $21.00 (please add $4.00 for postage if you wish to it sent). Our most highly recommended guide book for those who own a telescope; it is a concise, easy to read, compact paperback book which will guide children or adults through the night sky on a night to night basis. It has good articles about telescopes, observing, and news about major and minor events that are known to occur.

If practical, visit our showroom in Laurel, Maryland (near Washington, D.C. and Baltimore, MD). Our showroom houses a unique display of telescopes, with a staff who each average many years of experience using telescopes. Some of our people have been involved in highly challenging tasks and projects. This will be your best opportunity to obtain truly interactive assistance with your needs. If you do visit, then you might plan to spend two or more hours here since there is much that you may wish to see. This showroom is open Monday to Friday, from 11 AM to 5 PM, and Saturdays from 11 AM to 6 PM Eastern Time. It is closed on Sundays, we close in respect of all U.S. Federal Holidays and from 25 December to 1 January inclusive. You may call for directions, or download a map with directions or text of directions at our Internet Web Site at “http://www.company7.com”.

We hope you find this information helpful, and at the least it should have helped you to better focus any follow-up inquiries. Wishing you Clear Skies!