Why Celestron?

The optical quality of Celestron Telescopes is famous the world over. These telescopes are selected repeatedly by professional educators, amateur astronomers and research scientists, as well as by casual observers and photographers throughout the world.

Attractively modern, Celestron Telescopes are superbly crafted for the discriminating telescope enthusiast. And they are worlds apart in performance, reliability and versatility.

Celestron Telescopes feature large optics, and employ lenses and mirrors to optically fold long high-power focal lengths into a compact configuration. The result is observatory-size optics portably packaged.

Because these telescopes are of large aperture, their images are bright and detailed. Even at high power, the clarity, brilliance and detail of the images will astonish you.

By day, the Celestron is superb for long-distance macroscopy, nature studies, sports action and candids. You can bring into sharp focus the antennae of a butterfly at 15 feet, or the face of a friend at half a mile.

At night under adverse city light conditions you can study the Moon and planets from your backyard — exploring lunar craters and rills. You can observe the Moon-like phases of Venus, the surface features of Mars, the cloud belts of Jupiter, or the rings of Saturn.

Under dark skies, you will have at your fingertips the vast star clouds of the Milky Way, hundreds of globular and galactic star clusters, scores of diffuse and planetary nebulae, and galaxies millions of light years away.

At more than a thousand colleges and universities throughout the world, Celestron Telescopes are adding a new dimension to astronomy education — for the first time giving students access to large, modern, deep-space telescopes and the projects they make possible.

And at science centers around the world, these instruments are finding numerous research and industrial applications in such fields as laser communication, solar energy, satellite tracking, high-altitude atmospheric monitoring and pollution control.

These are truly scientific instruments, at popular prices.

The Ultimate in Operational Simplicity

Rest the Celestron anywhere, swing up its tube and it's ready for casual observing or scanning the night sky. The Celestron is the ultimate in operational simplicity.

With its sturdy fork mount, its slow-motion controls for fine adjustments in telescope point, and its instant-lock clamps, aiming the instrument is as easy as pointing your finger.

The eyepiece and observing controls are always conveniently located. All are within inches of each other for the comfortably seated observer.

The compact tube and the fork mount of the Celestron rapidly damp wind and mechanical vibrations, assuring image stability for astronomical observing or guided deep-sky exposures.

A closed-tube design eliminates image-degrading air currents inside the tube. It also seals the tube against dust and other contaminates, assuring years of maintenance-free service.

Also standard are finely etched star-locating circles. These setting circles make it easy to dial celestial objects into the field of view when the telescope is equatorially mounted (installed on the Celestron wedge assembly).

And in the base of the Celestron, a system of motors and gears compensates for the Earth's rotation during astronomical observations. This electric clock drive keeps celestial objects centered in the field of view automatically.

All this, and more, has made the Celestron the world's best-selling modern telescope.

And a Telescope That Grows With Your Interests.

But the Celestron is more than a telescope. It is also part of a fully integrated system of photovisual instruments and accessories — the most extensive such system ever offered.

The capability of the Celestron system ranges from casual nature studies to advanced telephotography, and from astronomical observing to professional deep-sky photography.

So the basic features of Celestron Telescopes and the capability of the Celestron system make these the most versatile telescopes available. And they also make the Celestron a telescope that grows with your interests.

For instance, convenient photographic adaptors for terrestrial, planetary or deep-sky photography couple your 35mm SLR camera body to the telescope instantly. And the tube assembly demounts readily from its fork mount for telephotography on photo tripod.

By adding other accessories to the Celestron, you can expand it into a research instrument or into an astro-photographic laboratory. And your photographs will rival in aesthetic quality those produced at the major professional observatories.

This is the Celestron. It is what every telescope should have been in the past. It may well be what every telescope will be in the future.

Celestron—Challenge the Leader

Selecting a Telescope? Your question might well be ... I'm a complete novice but want the best value for my money—something I won't have to throw away if my interest expands. How do I judge which instruments are really good and which manufacturer's claims are grossly exaggerated? If you were an experienced amateur astronomer you would already know that a Celestron Telescope is the most coveted and recommended in its aperture range. So how do you determine how well a given telescope will match your interest requirements? On the following pages we will describe the various telescopes available in today's market. In addition a few simple phone calls will place at your disposal the experience of experts in this field. Contact a professional astronomer, a college professor in astronomy, a planetarium director. These people will be glad to assist you. Seek out one of the local astronomical groups and go to one of their star parties where you can compare various telescopes side by side. You will certainly find more Celestron telescopes at one of these meetings than any other make. Be sure to compare the convenience of controls and the ease of locating a given deep-sky object with each instrument. Tap the mount to see how quickly the vibration settles out. Compare visually ... How well is the globular cluster M 13 resolved? Does the delicate crepe ring of Saturn show? How much filamentary structure in the Orion Nebula is displayed?

THE IMPORTANCE OF APERTURE

Classical refractor, Newtonian reflector, Maksutov, Schmidt-Cassegrain—is there an optical configuration of unequivocal superiority? With every vendor proclaiming the merits of his own particular design, it is all too easy to overlook several truisms from veteran telescope users:

(a) All designs can perform satisfactorily if properly and responsibly made.
(b) Each design has its own special virtues.
(c) Far more significant to performance than any aspect of a telescope's *design* is its clear *aperture*.

On the last of these points, optical theory firmly establishes the limits of light grasp and resolution for a given aperture. In brief:

(a) Resolution is a direct function of aperture.
(b) Light grasp is proportional to the square of aperture.
(c) Airy-disc brilliance (the brightness of a point-source steller image) is proportional to the fourth power of aperture.

When you double the aperture of a telescope, you increase its resolving power by a factor of two and boost its light-gathering power by a factor of four. But more importantly, you also reduce the area of the Airy-disc by a factor of four. This results in a 16-fold gain in image brilliance.

For example, with a four-inch telescope at 150x, a globular cluster such as M-13 is totally amorphous—no matter how good the seeing conditions might be. With an eight-inch telescope at the same power, the stars are separated twice as well, are 16 times more brilliant and the cluster is resolved to the core—even during periods of poor seeing.

The same general principle applies when viewing the detailed structure of planets, nebulae and galaxies. When you increase the aperture of a telescope, you dramatically increase the amount of visible detail and contrast.

Assuming quality optics, it makes little difference whether the comparison telescopes are refractors, reflectors, or catadioptrics.

Thus, we look askance upon the claims of any supplier of small refractors or catadioptrics who implies that his instrument, because of its type, will outperform substantially larger telescopes of different design. The larger aperture always excels, and any advertiser who suggests otherwise is in need of a high school physics refresher or an evening at a star party where different type telescopes of varying sizes may be directly compared.

Frequently, these same suppliers claim their smaller instruments can split the closest doubles and reveal the smallest planetary detail with greater ease than larger professional telescopes.

The basis of their argument is that atmospheric scintillation will not permit the larger telescopes to achieve the resolution their larger apertures make possible. When turbulence is great, they argue, a four-inch telescope will show the same amount of planetary detail that is visible through the Mt. Wilson 100-inch reflector or the Lick 36-inch refractor, for example, under the same conditions.

In deference to the professional astronomers who have used such large-aperture telescopes to spectacularly probe the universe for the last half-century, we wish to correct this fallacy.

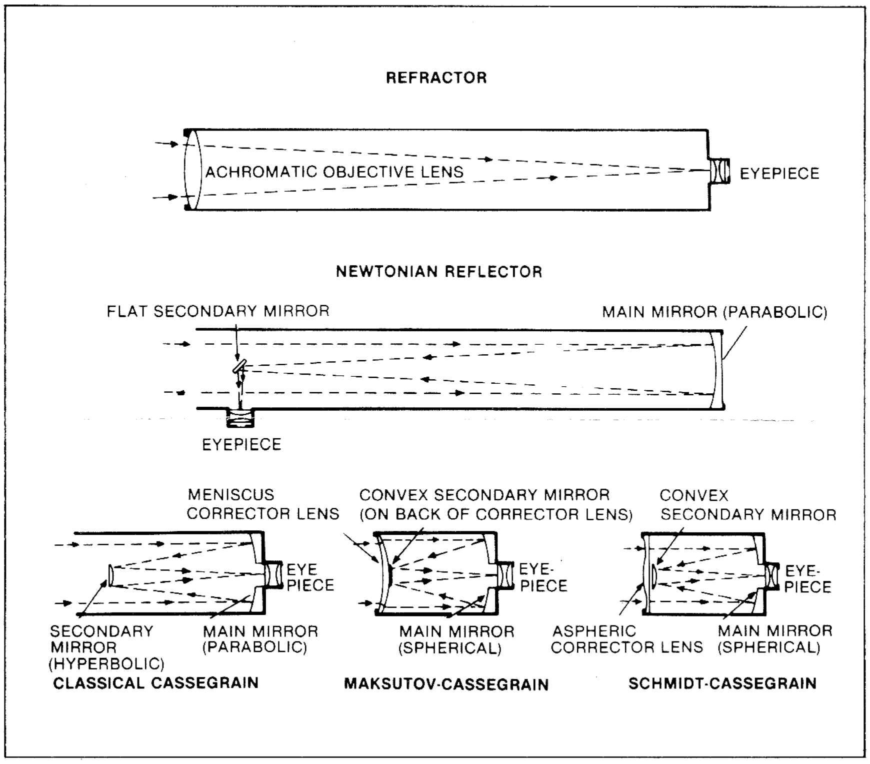
On nights of gross turbulence, we can see (within our own product line) that, at high magnification, the C5 will sometimes render a superficially steadier view of some bright objects than the C8 or C14, though this is <u>*never*</u> the case with low-contrast subjects such as nebulae and star clusters. What this really indicates is that the smaller instrument is incapable of resolving the more subtle aspects of turbulence to the extent of the larger. The same effect may be achieved by lowering the magnification of the larger instrument so that turbulence remains unresolved, and you'll still enjoy the benefits of substantial aperture—much greater image contrast and brilliance. Those of us who use large-aperture telescopes live for those not-so-rare evenings when the air steadies sufficiently to use our instruments for views that no small telescope can ever equal.

The simple truth is: At any given magnification, the larger the aperture of the telescope, the better the image will be.

Our C90 telescope is an excellent choice for the beginning amateur astronomer or for one who demands the utmost in portability. Considering the continually rising prices of poor quality, imported telescopes and the very high prices of some domestic catadioptrics, the C90 is, perhaps, the best telescope buy in the world. And if your astronomical involvement is already of serious proportions, we strongly urge you to consider our larger aperture telescopes—whose capabilities will provide a lifetime of observing enjoyment.

Above: a dramatic illustration that visible detail and brilliance increase with telescope aperture. From top to bottom, a 5-inch, an 8-inch and a 14-inch telescope reveal Saturn's structure on film with increasing resolution and contrast. The effect is even more pronounced during visual observation.

REFRACTOR, NEWTONIAN, OR CASSEGRAIN ???



Main types of telescope optics *are diagrammed at the left. All are shown drawn to scale. Objectives are eight inches in diameter, and have focal ratios of 1:10 or f/10. Thus the focal length of each scope is equal to 80 inches. The task of any objective, be it lens or mirror, is to bring light to a focus and form an image. This image is small, so an eyepiece— really just a simple magnifier—is used to enlarge it for easy viewing. Refractors bend light as it passes through the objective lens. Reflectors reflect light from a curved mirror. The mirrors are concave, and usually ground to a parabolic curve. They are made of thick glass—usually Pyrex—and are coated with a fine aluminum film. Some are given a special treatment to preserve the mirror finish. The classical Cassegrain reflector is shorter and easier to handle. The two ultracompact designs are catadioptrics using both lenses and mirrors.*

When confronted with the choice of which type of telescope to choose, there is an abundance of information to sort through from the various manufacturers. All try to claim theirs is the best and state all other designs are not good. The truth is that all designs have some excellent merits, as well as, some negative ones.

All designs can perform satisfactorily if properly and responsibly made. As our company has stated in the past, the most important aspect of a telescope is the aperture. In addition, several other factors must be considered such as portability, cost, versatility, useability, maintenance, etc. to suit the individual needs.

Let's look at the various popular designs available and point out some good things along with the bad:

THE REFRACTOR

The refractor is mechanically simple, rugged, and essentially maintenance free. It's closed tube design protects its optics and eliminates image-degrading air currents inside the tube.

Small refractors (2.4" to 3.1") are seen the most in department stores and imported from Japan. In the past these instruments have been reasonably priced ($100.00 to $300.00). During the last few years the prices have jumped substantially. Advertising claims of these stores are misleading, claiming those instruments to be 600X, etc. which is just empty magnification. The maximum power is 60X the diameter of the lens. For example a 3" telescope has a maximum power of 180X (3x 60).

If you investigate refractors in apertures large enough (5" or larger), for serious observing or photography, you'll soon discover this design has a major drawback — cost!! A quality 5 inch refractor bears a price tag approaching $10.000.00. In terms of value for aperture, this instrument compares poorly to the alternative Newtonians and catadioptrics currently available.

The refractor does suffer from chromatic aberration (color fringes). This, for example, is important in studying the colors of the stars and the planets. It also suffers from severe coma at the edges of the field.

An advantage of the refractor is that aperture for aperture (some focal lengths) it offers somewhat less light loss. In very small sizes, its absence of a secondary-mirror obstruction (or diagonal obstruction) generally gives it a slight edge in performance over Newtonians and catadioptric telescopes. They usually come in long focal lengths (f/15 or slower) which provide excellent views of lunar and planetary subjects and also double stars.

You can use most refractors for terrestrial use but the near focus usually prohibits detailed studies of subjects less than 100 feet. Also the focal lengths are usually long (f/15 of slower) which make photography more difficult.

Refractors are extremely bulky and not very portable after the instrument reaches a aperture of 3 inches or so. A quality 5 inch typically weighs several hundred pounds. Any bump of the tube during an observing session requires a considerable amount of time to quiet down. Most manufacturers do not even list the weights so you won't be discouraged immediately.

THE NEWTONIAN REFLECTOR

If one attends a star party you will see many Newtonian telescopes; either homemade by amateur astronomers or commercially purchased units. For beginners the Newtonians are relatively inexpensive.

Much of the potential performance of the Newtonian is often sacrificed to air turbulence within their open-ended tubes which can put it out of commission for the night. This open tube design exposes two delicate mirror surfaces to airborne contaminants which means the mirrors must be recoated periodically. In a Newtonian the diagonal obstructs some light and its necessarily small size somewhat limits the working field.

The Newtonian presents an excellent value for the economy seeker of large aperture compared to a refractor. An amateur can purchase a 12½ inch for the modest price of approximately $2000.00. Small 6 inch instruments can be purchased for as little as $250.00 to $400.00.

Most Newtonian optical systems are well made. The only optical aberration it suffers from is coma; a comet-like distortion of images that increases the closer the images are to the edge of the field.

You can use a Newtonian for terrestrial applications but it is awkward and the near focus is seldom under a few hundred feet.

An advantage of the Newtonian over the refractor of the same aperture and f/number, is that it has a slightly shorter tube. Although this is not really significant since even a 6 inch Newtonian can weigh up to 100 pounds. The long tube of a Newtonian requires a large and massive mount to achieve a reasonable degree of stability. If one needs to take the instrument out to a remote site it can be quite an experience and time consuming along with the necessity of a large vehicle (trailer or pick-up truck) to transport it due to the bulkiness and weight.

When using a large aperture Newtonian a ladder is required to reach the observing position. We have seen amateurs poised on unstable ladders posing a serious safety problem.

Compared to refractors and catadioptrics, the Newtonian is relatively fragile and requires complicated optical realignment after minor bumps and jars.

An advantage many Newtonians have over refractors and catadioptrics is that they are available in short focal lengths (f/5 to f/8) which give excellent bright images for deep-sky objects (although it hinders lunar and planetary work).

THE CASSEGRAIN

The classical Cassegrain reflector telescopes are an improvement over the Newtonian. It uses a short focal length parabolic mirror in conjunction with a small hyperbolic secondary mirror. The combination gives the same performance as the long tube Newtonian but in a more compact size requiring a far less massive mount for the same degree of stability. It also places the eyepiece at a more convenient position. The disadvantages of the Cassegrain reflector telescope are the difficulty in parabolizing the short focal length primary mirror to the required degree of accuracy (much more costly than a Newtonian) and the open tube construction which also exposes the mirrors to contamination. It also suffers coma to the same degree or more as the equivalent Newtonian.

CATADIOPTRICS

The catadioptric instruments combine the best ingredients of the above to form the most advantageous telescope for many. These instruments are relatively new and have been commercially available for only about 20 years. They are now the most popular type of instrument marketed throughout the world in 3½" and larger apertures.

Catadioptrics have closed tubes which eliminates image degrading tube currents and makes the optics basically maintenance free. Due to the folding of the optical paths the instruments are extremely portable. A Celestron 8" Schmidt weighs in at only 21#.

Like the Newtonian it is totally free of chromatic aberration (with the Schmidt-Cassegrain, at least, and nearly so with the Maksutov). Moreover, the additional optical elements permit correction of various off-axis (or edge-of-field) aberrations (coma) especially with the Schmidt-Cassegrain and somewhat with the Maksutov.

Catadioptrics are easy to set up and use. Large apertures still come in relatively small packages.

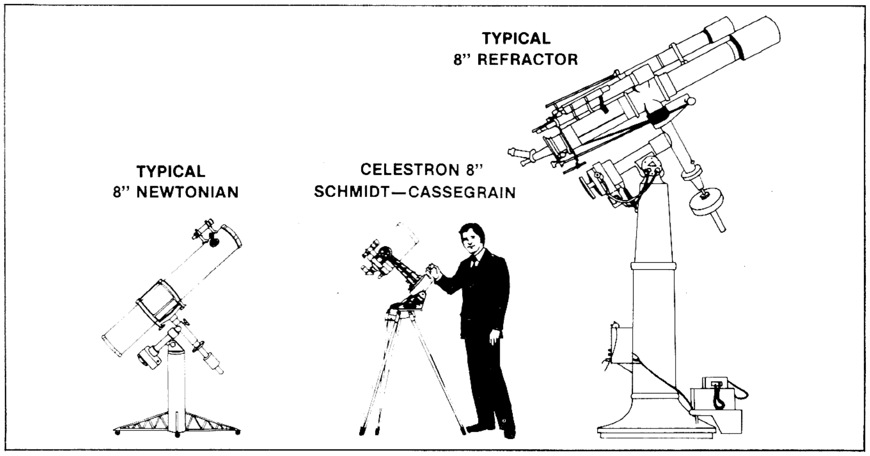
Are there any disadvantages to catadioptrics? One of the few is cost. They do cost more than Newtonian reflectors of equal aperture but still considerably less than refractors. We sometimes say that if one wants to mainly observe, lives in a good dark-sky location, and wants the largest aperture he can afford then the Newtonian is the best selection because it is less expensive. But also take into consideration the larger dome needed, safety factors, maintenance, etc.

Another disadvantage of most catadioptrics is that they are longer focal lengths (f/10 to f/20). The long (f/15 and longer) are good for lunar and planetary work. The f/10 systems are a good optimum ratio for lunar, planetary, and also deep-sky work. The Newtonian's of fast speeds (f/5 or so) make brighter the deep-sky objects than do the catadioptrics (although Celestron does have adaptors to make their Schmidt-Cassegrain usable at f/5).

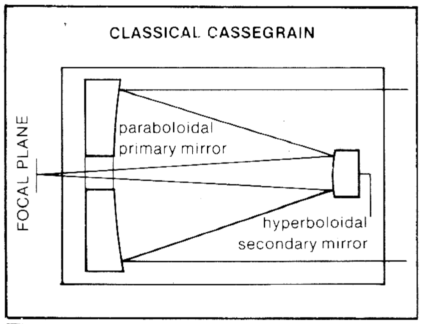
Many catadioptric instruments are ideal for terrestrial observing and/or photography with near focus with some instruments of 10 feet or less. Speeds of f/10 or faster provide the best instruments for this application. Using a telescope for terrestrial work expands the useability of your telescope and adds greater enjoyment.

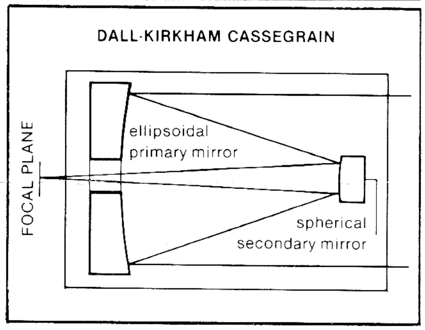
Collimation (alignment) is seldom a problem whether one is using an adjustable instrument (as a Schmidt-Cassegrain) or a permanently aligned Maksutov.

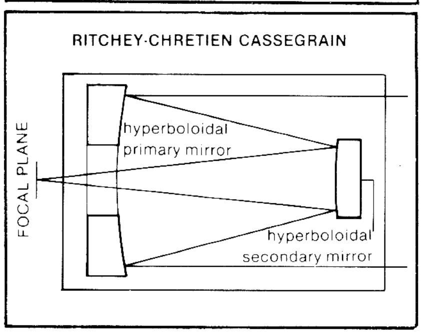
Of the catadioptrics available we feel that the Celestron offers the most value for your money and provides the most extensive array of visual and photographic accessories available to cover the interests of the varied consumer audience.



WHICH CASSEGRAIN IS BEST???



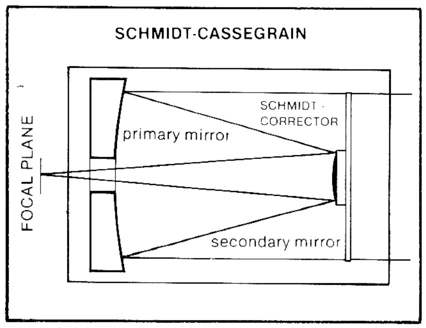


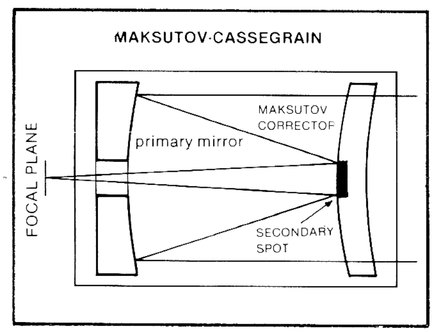


The cassegrain telescope is a reflecting type employing two curved mirrors to gain a long focal length. Light is beamed from the main mirror back up the tube to a second mirror, which beams it right back down again and through a hole in the center of the main mirror to the eyepiece. The combination gives the same performance as the long tube Newtonian but in a more compact size requiring a far less massive mount for the same degree of stability. It also places the eyepiece at a more convenient position. The disadvantages of the Cassegrain reflector are the difficulty in parabolizing the short focal length primary mirror to the required degree of accuracy and the open tube construction which also exposes the mirrors to contamination. It also suffers coma. Other than the true cassegrain system there are two other recognized systems made, which are the Dall-Kirkham and the Ritchey-Chrêtien. The more popular Dall-Kirkham is cheaper to make than a true Cassegrain but it has extensive coma making its useable field of view smaller than a true Cassegrain. The R-C reduces coma to almost zero but suffers from astigmatism and severe curvature of field. None of the above systems are manufactured in large quantities and when available are very expensive compared to alternative catadioptric systems.

THE CATADIOPTRIC

A dramatic improvement over the above is the catadioptric system. It is a combination mirror-and-lens system offering long focal length in a compact, closed tube. The lens is used ahead of the mirror to correct known faults in the mirror. It combines the best of both mirror and lens-only telescopes. There are two basic types of catadioptric systems which are the Maksutov Cassegrain and the Schmidt Cassegrain. The Maksutov uses a thick meniscus correcting lens and the Schmidt uses a thin aspheric correcting lens. The Schmidt is more difficult to produce than a Maksutov.



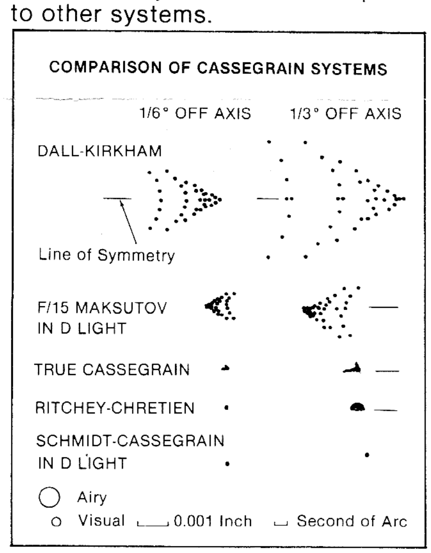


Let's look at some of the factors of the catadioptic systems.

OPTICAL ALIGNMENT—Contrary to what many manufacturers say the Celestron Schmidt Cassegrain telescopes are relatively easy to collimate when it is needed. Let us state that the Schmidt rarely needs aligning even after transhipment across the world while sustaining rough handling. If the Schmidt needs aligning (only one element is adjustable) it will only take a couple of minutes following easy step-by-step instructions given in the operating manual.

Maksutov instruments are permanently aligned. However, rough handling can cause them to come out of collimation and this renders the system to be in permanent **decollimation.** This usually requires a return trip to the factory.

OPTICAL CHARACTERISTICS - Chromatic aberration and coma are virtually nonexistent with the Schmidt but are noticeable to a small degree with all Maksutov designs. Off-Axis performance of the Schmidt is by far the best compared to other systems.



The on-axis performance of all of the folded systems mentioned is the same. If any one of them is pointed at a point source at infinity, all of the light entering the system will pass through a point at the focal plane of the lens. It is the off-axis performance of these lenses where the performances markedly differ.

The modern computer, in ray-trace techniques, provides an excellent method for evaluating the off-axis performance of a lens system. The illustration is from an article by James Wiley, ***Sky and Telescope,*** *April 1962. It gives the results of a computer ray trace of the several folded optical systems at 1/6° and 1/3° off axis. Each dot in the pattern is the point at the focal plane through which a given ray through the system will pass. The spread of these dots indicates the amount of distortion. For convenience in evaluating the distortion, the small circle in the lower left of the illustration is the size of the Airy disc for the system checked. It is evident from these ray tracings that the Celestron Schmidt Cassegrain produces the sharpest images across the entire focal plane.*

CENTRAL OBSTRUCTION - Effect on Image Contrast.

A great deal has been said in amateur oriented literature and by some of the manufacturers whose instruments may be lacking a central obstruction or perhaps boast a slightly smaller central obstruction about the effects of central obstruction on image contrast. It is desired that maximum image contrast be achieved for viewing certain low-contrast narrow-field objects such as Jupiter and Saturn. The seeing condition (or air turbulence) is the single factor that most adversely affects image contrast when seeking planetary detail through a telescope. Instrument problems that can also adversely affect contrast are: optical figure, collimation, optical smoothness, baffling, and a small increase in central obstruction. Note that the increase in central obstruction is rated as the smallest contributor to adversely affecting contrast.

In a telescope that has no central obstruction and is otherwise perfect, 85% of the light energy from a point source is imaged in the primary maxima or Airy disc. Half of the remainder (7.5%) is in the first diffraction ring. However, since the area of this first ring at the image plane is approximately six times greater than that of the Airy disc, the actual apparent intensity of this first ring will be 1.5% of the intensity of the primary maxima. Now, if the energy in the primary maxima is reduced by 10% by the introduction of a central obstruction, the energy in the first ring would increase from 7.5% to 12.5%. This would have the affect of increasing the visual intensity of the first ring relative to the primary maxima from 1.5% to 2.8%, a change that would hardly be detectable. The relative intensity of the second diffraction ring as well as all of the rest would be so low as not to even warrant consideration.

If you wish to play games with advocates of smaller central obstructions, select a night of good seeing, use the Cassini division of Saturn as a test subject and vary the size of the central obstruction by using a set of cardboard circular masks of various diameters. See if they can tell the difference in contrast with the various masks. You will find that a very gross change in central obstruction would be required before any noticeable difference in contrast could be detected.

THERMAL EQUILIBRIUM - All Celestron telescopes are manufactured with aluminum tubes which allow the optics to stabilize and reach thermal equilibrium in the minimum time.

FOCAL LENGTH - Most of the Maksutov telescopes offered are of long focal ratios (f/15 of f/16), whereas, Celestron Maksutovs and Schmidts are much faster (f/10 or f/11). For terrestrial photography this means the Celestron is about a full f/stop faster than the other popular units. This in turn means a brighter focusing image - and sharper photos since one can shoot at twice the shutter speed required. Also other popular units vignette seriously on terrestrial subjects. The longer focal ratios do have a slight advantage on lunar, planetary, and some double star subjects but are at a serious disadvantage on deep sky subjects. The Celestron f/10 and f/11 systems are excellent for all purposes especially deep sky. Celestron recently introduced a new accessory R.F.A. (richest field adaptor), for visual use that reduces the focal ratio to f/5 or f/5.5 (a photographic device - the Tele-Compressor does the same thing photographically).

QUALITY CONTROL - Since inception, Celestron's philosophy has been continuing product improvement. Each year brings new advances in the manufacturing processes of mechanics and optics. Recently we have purchased the most sophisticated and most accurate machines available in the world for our machine shop. We have the most sophisticated optical testing equipment and each instrument is exhaustively tested.

Since we manufacture our own optics as well as mechanics, and also do our own optical coating, we have complete control with quality control stations set up throughout the manufacturing process.

WARRANTY - Celestron offers a *full* one year warranty. This means 100% of the instrument and accessories plus freight *both* ways so that the customer does not pay a penny if anything is wrong. Normally if something goes wrong with an instrument it will happen in the first few months of usage. However, if some obvious defect due to manufacturing occurs several years after purchase we routinely repair the instrument at no charge. This warranty is better than a five or ten year limited warranty offered by others, especially when the clock drive is not covered (the part most apt to need repair), and also the customer must pay the freight charges at least one way and in some cases both ways. Also some manufacturers offer long warranties that will be useless if within a couple of years they are no longer in business (80% of all new businesses fail within 5 years). In essence, the Celestron warranty is as good, or better, than any other.

ACCESSORIES - Whatever your interests are in a telescope whether terrestrial or astronomical, Celestron has the most extensive line of accessories for visual or photographic purposes and we are always looking at and developing new products. In addition, we offer the most extensive aperture range . . . 3½ to 14 inches to suit your needs.

COST - The Maksutov is optically considerably easier to produce than a Schmidt system and, therefore, may be offered for less. This was the major reason Celestron chose the Maksutov design for its smallest telescope, the C90, to make it available at a reasonable price to the mass market. There are some Maksutov's priced similar to our C90 but the more popular models are at least two or three times more expensive. Are these more expensive units better? The answer is *definitely not.* Celestron has long proven that it's products set the highest standards in quality production. Large volume has allowed greater purchasing power and advanced production techniques where cost savings can be passed on to the customer.

CONCLUSION - From the above description on optical characteristics, alignment, focal lengths, quality control, warranty, accessories, costs, etc., there is little doubt that the Celestron (first the Schmidt and then Maksutov) stands alone as the supreme telescope available in the marketplace today.