Company Seven

Astro-Optics Division

Low Resolution Reprint of the:

QUESTAR BOOKLET
May 1954

Showroom: 14300 Cherry Lane Court
Laurel, Maryland 20707
301-953-2000
http://www.company7.com

Correspondence: Box 2587
Montpelier, Maryland 20709-2587
info@company7.com

☆Questar

Questar

QUESTAR is a beautiful, compact 20th century telescope of great power and versatility. Its superb new optical system embodies the first basic discovery in telescope optics for 200 years. These optics belong to the new family of catadioptric or mixed lens-and-mirror systems, which permit Questar to compress, by optical folding, a full-sized 3.5 inch astronomical telescope of 7-foot focal length into a sealed tube only 8 inches long.

All Questar's advantages stem from this ultra-compactness of its unique design, for it is only one-tenth the size and weight of conventional telescopes of similar optical power. Thus Questar may be said to have freed the telescope from the traditional 18th century form in which it has been frozen, and lifted from the telescope the ancient burden of sheer bulk and weight that has made it so awkward to set up and use, and so difficult to carry and store.

Eight years of research and development have served to perfect the long list of patented improvements that distinguish Questar from its predecessors. The happy result is that Questar is not one, but several instruments. It does many things superbly well. It does them so easily and conveniently that you will probably wonder why someone had not thought to build such an instrument before. The answer, of course, is that is was not possible to do so until the new lens-mirror optics were discovered. Only then could the old dream of a little giant, a mighty midget of telescopes, at last come true.

Now Questar is at hand. You will find it more fun to use than any telescope in history. If you are considering the purchase of a telescope, we think that Questar is the one you should buy, because we honestly believe it to be the most rewarding all-round instrument obtainable. We believe that you will probably keep your Questar no matter what other instruments your purse may ultimately afford, for no other telescope can provide so much entertainment to your family and yourself over the years.

Questar's price is $795, complete in velvet-lined cowhide fitted case, with all accessories. Your check or money order for $200 will reserve your instrument, with balance C.O.D. Shipped in metal and fiber Leverpak drum containers by Express Collect. Questar Corporation, New Hope, Pennsylvania.

In this booklet we propose to tell you in detail about Questar and what it can do, with some brief notes on the history of telescopes, the care of fine optical surfaces, and a section on what to expect of a small telescope. We hope some of this may prove interesting or useful, and we beg forgiveness if we have been either too technical or not technical enough.

Questar is:

1. A complete portable observatory,
2. The first safe and distortionless solar telescope,
3. A perfect telephoto lens,
4. A superb terrestrial and spotting scope,
5. The new long-distance microscope.

The Portable Observatory
—in one-half cubic foot

Questar comes in a beautiful velvet-lined fitted leather case of first quality, whose color, a deep maroon, serves well to set off the blue and silver instrument. Individual leather pockets grouped on the door panel hold all accessories.

The 7-inch rim of Questar's base slides under guides that hold it to the floor of the case, so that it travels free-standing, fully protected, while touching only the floor itself. Since it cannot touch anywhere else, no chafed holes or shabby spots will develop. Nothing projects beyond the 7-inch base circle, when the barrel is held rigidly vertical by its clamp in altitude.

Until now, conventional instruments large enough for serious work have had to be dismantled from 5-foot tripods, disassembled into several parts and stowed in great coffin-like wooden boxes which finally could be lugged about. Only those who have put up with the nuisance of unlimbering and setting up a traditional telescope can fully appreciate the wonderful convenience of Questar, which needs no assembly at all and is always ready for instant use. Only those who have staggered forth into the night with eight feet of assembled telescope tube and tripod legs can fully appreciate Questar's tiny size and feather lightness. Questar in its case complete weighs less than 12 pounds, and the case measures but 7½ x 8 x 15 inches, or one-half cubic foot. The problem of where to store a cumbersome instrument now ceases to exist. The amateur no longer need impose a large apparatus upon the family living space. Schools no longer need think of astronomy in terms of costly rotary domes to house traditional instruments, when even the smallest school can now afford to keep an observatory on its microscope shelf. We hope

to interest schools in the idea of acquiring Questar as a community project, so that everyone, young and old, may have the unforgettable experience of direct high power observation of celestial objects, for which there is no substitute.

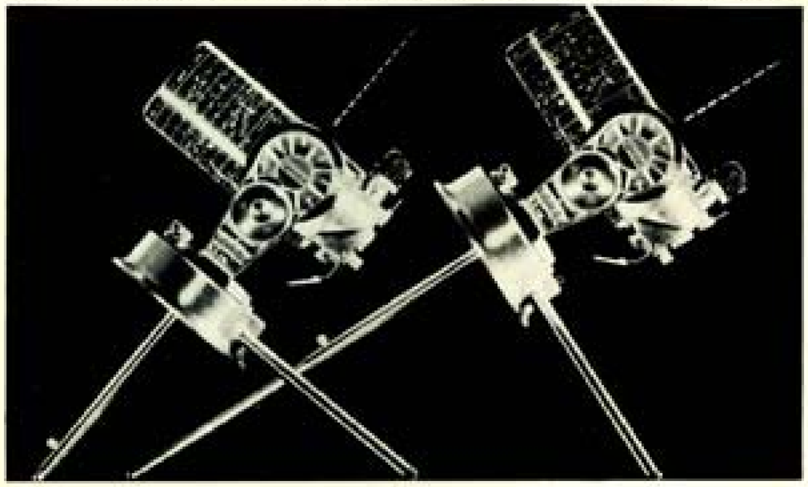
Woodcut after Gustave Doré

Questar slips out of its case all in one piece, ready for work. There is nothing to assemble. It is in its *altazimuth* form for general use, similar to the mounting on a surveyor's transit telescope, which points up and down in altitude and turns right and left in azimuth. Any convenient flat surface—tabletop, windowsill, wall top, shelf, or whatever is at hand, may serve as base for impromptu observing. Remarkable flexibility is afforded by Questar's unique rotating barrel, which inclines the eyepiece to meet the user's eye at any angle, permitting the instrument to be comfortably used without strain from many unusual situations and placements.

At the suggestion of Dr. Warner Schlesinger, Director of the Adler Planetarium in Chicago, provision has been made to mount Questar on any automobile. It attaches readily to a window glass, which then may be raised or lowered to the most convenient height. In this simple manner, the touring motorist may rapidly bring the full 160 diameters of Questar's magnification to bear upon whatever object, near or far, arouses his interest. Joining Questar's tiny mass to the great mass of the stationary car results in perfect solidity and steadiness of image.

Questar, in its *polar equatorial* form, combines all of its unique features to provide what is probably the most comfortable observing position so far discovered, thereby creating the precise conditions for the greatest sharpness of vision. The equatorial mounting used by all great telescopes is essentially only an altazimuth telescope tilted just enough to align one axis with the axis of the earth. The tilted axis becomes parallel with that imaginary line joining the earth's south and north poles around which the earth actually rotates.

The chief advantage of this polar equatorial mounting is that once a star is in the field of view it can be kept there and followed by a single adjustment. Another advantage is that setting circles may be used, for now the stars on charts, including Questar's chart, are seen to be described in declination, which is distance in degrees above or below the celestial equator, and right ascension, or movement due to the rotation of the earth in the passage of time. The numbers on the setting circles of the telescope now correspond to the coordinate numbers on the star chart.



Questar is tilted into its equatorial form by pushing three sturdy legs into the precision reamed holes provided in the engine-turned base casting. The instrument is in balance without the use of heavy counterweights. Its center of gravity is low, with concentration of weight in the base, and feet widespread for utmost stability. By this excellent geometry and simple but elegant means, Questar is elevated so that its eyepiece and controls are raised approximately one foot above the tabletop on which it stands.

Many advantages result from this basic new conception of a tabletop equatorial telescope. For example, chairs and tables are everywhere in the world, and being of nearly uniform height, will always present Questar's eyepiece and controls to the seated observer in the same normal and convenient way. The observer seats himself facing south. He may now study the sky above him by looking comfortably down, as into an inclined microscope.

In this easy posture, the observer is at rest, in the normal, easy attitude of study. His whole body is unstrained and relaxed, and the retina of his eye is being nourished without the hindrance of a bent or twisted neck. He may rest his elbows on the table, put chin in hand, or cover with palm his unused eye and shift about in easy fashion while observing for extended periods. No user of conventional instruments, which have not changed their form in two full centuries and are still made today in their

eighteenth century patterns, has ever experienced this kind of comfort. With Questar the observer no longer need tire himself in strained, awkward, unnatural postures. He needs no stepladders nor sets of boxes nor adjustable chairs to alter his standing or seating height. He need not crane his neck to follow an eyepiece whose height and location change by several feet for different objects. He need not strain to reach a finder above his head somewhere in the dark, for at the flick of his finger, Questar's eyepiece itself becomes the finder eyepiece too, while eyepiece and controls can only vary their position by mere inches from his eye.

The center leg is adjustable, so that Questar's inclined axis may be pointed toward the north star, and the polar region, from any latitude from Canada to Mexico. This axis, which passes also through the adjustable leg, need only point to the general vicinity of Polaris, since the benefit of following a star in one smooth arc, which the polar equatorial mounting permits, instead of a series of zig-zag motions, does not depend on exact alignment to give splendid results. This leg is permanently assembled, so that no part of it could become accidentally lost, and all the legs have special rubber tips.

When facing south, the observer has the most interesting part of the sky before him, the part of greatest interest for visual work. Here are all the planets, the moon, the celestial equator, and ecliptic, from which the visible planets never stray by more than 2 degrees. With Questar's star chart, the major objects in the skies may be identified throughout the year, and details of the moon identified by the lunar chart. Naturally, too, a tabletop is the obvious place for notes and books of reference.

Unlike the shaky pendulous long tubes of conventional instruments, that tremble at the slightest touch or breeze, Questar's stiff short barrel is immovable, its period of oscillation very short, a fraction of a second. The result is that Questar's image is practically as sharp and steady as the image of a microscope. It is not blurred by constant needless motion. It does not commence to shiver the instant fingers touch the focussing knob, nor is that knob somewhere up above one's head; there is nothing to reach out for at arm's length.

The supreme touch of practical luxury is furnished by the built-in synchronous electric drive which keeps Questar pointing continuously at the same object in the sky. By precisely neutralizing the rotation of the earth, it keeps objects quite stationary in the field of view of the eyepiece.

Operating on 115 volt 60 cycle house current, the electric drive also actuates the engraved 6-inch right ascension circle, which thus becomes a sidereal clock reading to 4 minutes of time. The drive is smooth and imperceptible. It is free of falter, jump or backlash. It is nearly noiseless, is totally enclosed and its sealed gear train runs in oil, sufficient for a century of use. The special motor winding used was developed by Questar for the elimination of heat.

Liberated by this modern refinement from the necessity of manual following, the Questar owner is free to concentrate wholly upon observing and the problem of perception near the limit of vision. He will, of course, improve his visual abilities with practice, and will become better able to enjoy Questar's powers of resolution to the full.

Questar's outstanding performance is especially evident in observing planetary detail, possibly the most rewarding field for the amateur. It excels refracting telescopes of the same aperture by the complete absence of spurious color in the images, and it is superior to reflecting telescopes by its spiderless closed tube and the perfection of its images over a wide field.

The First Safe And Distortionless Solar Telescope

Since Galileo, men have tried to study details of the great sunspots that wax and wane, and wheel from day to day across the dazzling face of the nearest star, our sun. During his lifetime, the solar disc was viewed by projecting its image upon a white card or screen from the eyepiece of the telescope. This primitive method is lacking in sharpness, and the intense beam that must traverse the eyepiece lenses, although excellent for lighting cigarettes, quickly ruins the cemented doublets of modern highly corrected eyepieces by boiling out the cement. Thus, none but the eighteenth century eyepieces of Huygens or Ramsden types could be used, whose single lenses suffered less from heat.

The sun is best seen by direct observation. This method depends on some arrangement to keep the blinding light and heat from entering the observer's eye. Previous dispersion or absorption devices have always been applied near the very hot "burning glass" image of the sun at the focal point of telescopes. Incredibly enough, no one ever thought to diminish the solar radiation save *after* it had passed through most of the instrument, warping lenses or mirrors, heating trapped air within the tube, and sometimes damaging not only eyepieces, but observer's eyes as well, for dark-glass filters have been known to break from heat.

It has remained for Questar to produce a simple filter which keeps the harmful concentration of heat from entering the telescope at all. It completely shields the instrument from all the solar radiation, except one part out of fifty thousand. Questar's solar filter consists of a measured thickness of chromium metal deposited on glass, which is placed over the front lens. It rejects the sun's radiation by reflecting it away instead of absorbing it, thus both filter and telescope stay quite cool to the

touch on the hottest day. The choice of chromium is a happy one, for since its transmission curve in the visible spectrum is practically a straight line, all colors are truly seen at their reduced intensities. Its extreme surface hardness resists abrasion, so that it requires no special care.

The sun's face may now be studied with Questar in safety, comfort and steadiness of detail previously unknown. Since Questar is prevented from warming to the task, no internal convection currents or warped optical surfaces are set up to spoil otherwise good seeing. The gain in steadiness and clarity of image is at once apparent. By not falling off after the first few minutes, this sharpness serves to demonstrate how much of the poor seeing experienced in solar work actually originates within the tubes of conventional instruments themselves. The highest powers may be used at unimpeded peak performance with Questar for extended periods of observing.

Questar's synchronous electric drive again provides the final touch of luxury for observing. It keeps the sun's image quietly immovable in the field of view. This feature alone makes group demonstration and group observing practical and simple, for without automatic following, the instructor formerly was kept busy adjusting for each student, who often got little more than one fleeting glimpse of a moving object. Classroom astronomy at regular daytime hours now becomes easy and convenient.

A Perfect Telephoto Lens

Not only will Questar photograph everything that can be seen through it, but it will do so in a variety of ways. No color filters or supplementary lenses are required. Its direct primary image may be used upon the smaller films, and eyepiece projection may be used for negatives of great size.

Addition of merely a ground glass, filmholder and shutter, makes Questar a complete telephoto camera with the enormous focal length of 42 inches (1070 mm.) working at f:12. It may be focussed down to the fantastically close distance of approximately twice its own focal length. The 35 mm. camera body to be preferred is one of the single lens reflex type, with focal plane shutter.

No supporting cradles or mountings or focussing jackets are required, since Questar is already elegantly mounted with slow motions and a clamp in altitude.

Unlike ordinary telephoto lenses, no special setting needs to be estimated for infra-red work, for there is no chromatic aberration. There is no secondary and no lateral color. There is no coma, astigmatism, nor distortion.

In all instances, the performance is superior to existing telephoto lenses because Questar's optical system approaches much more closely the theoretical perfection of definition, actually achieving the physical limit of resolution as defined by Lord Rayleigh on the basis of the Airy disc. Unlike camera lenses, which provide sharper images by using reduced apertures to minimize their faults, Questar offers higher resolving power with increased aperture. This means that there is no need to "stop down" for critical sharpness when photographing with Questar. Both light-grasp and definition are at the maximum simultaneously, a new experience for the user of photographic lenses.

A Terrestrial Viewing Scope And Spotting Scope

Questar is unquestionably the finest telescope ever offered for terrestrial observing. Heretofore the great size and weight of the astronomer's long-barrelled instrument have kept its superior abilities from being much enjoyed in this pursuit, as did its inverted and reversed views.

Now the full powers of such telescopes are at our command in an instrument scarcely larger than a telephone, which shows everything correctly right side up as a matter of course. Standing less than 9½ inches high, Questar was designed for desk or tabletop, and to fit into any bookshelf. Placed upon a mantel, it is more than an elegant conversation piece—it is a good companion.

By keeping Questar always ready and at hand, we are free to use it easily and often, as our fancy or events suggest. For one thing, we are then able to swing it into action before the bird has flown, or the parade has passed. For another, there is now no packing or unpacking that might tend eventually to spoil our pleasure. There is a sensible and very human tendency to at first postpone, and finally stop using altogether, any instrument whose setting-up and taking-down involves a lot of work. Now Questar has removed the work, and what is left is sheer enjoyment.

How can we explain to those whose experience with telescopes may have been limited to field glasses, just what Questar's great powers of magnification really mean? The chief thing, of course, is that the view is narrow and the object seems very near. The bird, the flower, the leaf or child a hundred yards away, are crisply seen as though within our reach. We read a watch at a thousand feet, and plainly pick out wasp from fly and bee. Wherever we turn in the country landscape, nature reveals a thousand secret faces, and new surprises daily await our eyes. In all this astonishing wealth of detail it is so easy at high powers to get lost, that we often need the finder to locate our close-up scene. And one never

quite gets used to seeing objects clearly that have totally escaped the naked eye.

The city dweller also has no lack of splendid views; indeed, he may have several vantage points from which to look. Perhaps there is a harbor to explore. Everywhere the tasks of men go on, and then, after dark, when lights come on, the textures of drab things acquire distinction, as light and shade create another town.

For target shooting, Questar has no equal. At the private range of Mr. Walter Stocklin, a distinguished marksman, not only were bullet holes in the black well seen, but small print and handwriting were clearly read at distances up to 300 yards, a feat Mr. Stocklin found astonishing and quite beyond the grasp of conventional instruments. Questar's magnification of 160 diameters presented a view of the 900-foot target as though it were but 5 feet 6 inches distant from the eye.

The New Long-Distance Microscope

The long-distance microscope, a wholly new and previously unknown optical instrument, is now available in Questar. A new experience awaits both expert and amateur, for Questar can be continuously focussed all the way from infinity down to 7 feet. The exquisite definition of a superb astronomical telescope can be turned with startling effect upon all objects in this astounding range.

Conventional instruments are physically limited to viewing objects no nearer than several hundred feet. A 3½-inch refractor would require a tube a dozen feet long, to focus at 7 feet. To cap this absurdity, it would also need a new lens. Even binoculars or low-powered spotting scopes are seldom able to focus on things closer than 30 or 40 feet. Questar's exclusive internal optical leverage system with fixed eyepiece permits the exploration of the near with such tremendous powers, that here, for the first time, is a microscope that works at a distance.

The result is invariably thrilling, even to the most experienced persons. Lowly weed tops become symmetrical bouquets, the bee at the wild-flower is a monster of terrifying size, the fledgling suddenly appears mere inches from the eye, each hair and feather razor sharp and crystal clear. The naturalist will now be able to secure close-up views or pictures of wild life from distances that do not alarm the animals or birds, and without recourse to stalking blinds or remote control cameras.

Industry will discover many uses for Questar. Standing safely on the ground, the exact condition of elevated structures hundreds of feet high may be examined or photographed in color by the steeplejack or rigger. Dangerous processing may be minutely watched from hundreds of feet away, meters and gauges read as clearly as though they were but two feet distant, instead of 320, matter at white hot temperature may be studied from remote positions, and interior walls of long hollow structures may be examined inch by inch.

DISTINCTIVE FEATURES

If people exclaim at Questar's handsome appearance, that is because it is designed simply and in the tradition of functional utility. Conceived as an instrument for quick, convenient use, it becomes naturally an object for adornment of desk or table. Its color scheme was kept to deep blue and silver with that in mind. Its metals are honestly engine-turned, in variety of texture and polish.

The gem-like depth of color in Questar's patented star chart and moon map is due to the surface treatment of the metal. These maps, like the large circle, and name plates, are anodized by the electrolytic process which changes the surface of the polished metal into a layer of clear, hard, transparent aluminum oxide, a kind of corundum or sapphire. This protective coating has sub-microscopic pores which accept translucent dyes. The metal is engraved by etching through the anodized surface, and the sunken areas or lines are filled with colored enamels.

Some 340 stars are shown in six sizes to indicate stars larger than the fifth magnitude. The three brightest stars of each constellation are designated by the Greek letters alpha, beta and gamma. Turning the star chart, to match the earth's rotation, reveals the constellations as they rise, while hiding others as they sink below the horizon. Thus the stars on the other side of the chart correspond to those hidden by the earth. The chart gives accurate positions by hour angle or right ascension (celestial longitude) and in degrees of declination (celestial latitude—distance north or south from the celestial equator).

No longer need the observer hold complex star charts at arm's length overhead and face in various directions. Questar's chart takes the place of twelve because its rotating feature eliminates the need for a separate chart for each month. In use, Questar is simply pointed south, whereupon the observer, while comfortably seated, may identify objects by comparison with the chart. The amount of data, its scales and color contrast, have been carefully chosen for maximum readability in dim light. Because the planets move, they, of course, cannot be shown upon the chart.

The star chart slips forward to become a dewcap, guarding the front lens against fogging on those moist nights when glass or metal objects, like automobiles for example, radiate their heat and become covered

with dew. Under the star chart is a large map of the moon sheathing Questar's tube. All parts of the lunar chart can be examined because the whole telescope tube is rotatable about its axis in the mounting. The eyepiece may be inclined at will, a feature of the greatest convenience in so versatile an instrument.

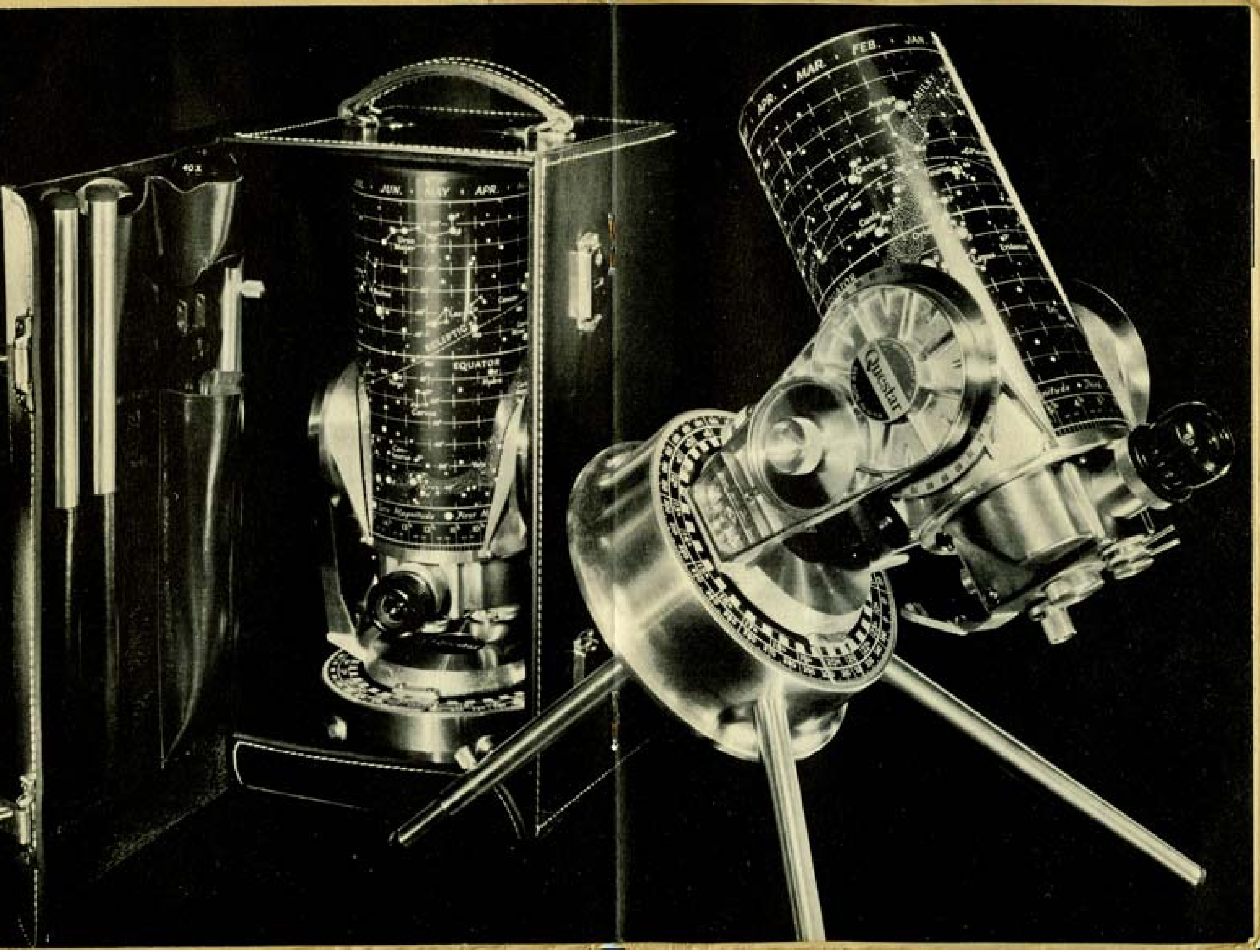
The barrel is supported wholly at its rear closure by Questar's patented double-U form of fork mounting. One side arm carries the declination slow motion and the other the clamp in declination. The knobs are of two sizes for recognition by feel in the dark, and are hollowed for lightness.

An important innovation is the patented Questar method of mounting the primary mirror on a thimble passing through its perforated center, with plastic shims to keep the glass away from heat-conducting metal. Aside from this support, the mirror is free-standing in air, with consequent mechanical and thermal stability. The long thimble is dry-lubricated, and free to slide along a stainless steel tube, permitting Questar to focus from infinity to the unheard-of short distance of only 7 feet, by moving the thimble and mirror only three-quarters of an inch. Without this ingenious method of internal focussing, we should be obliged to move the eyepiece through a distance of several feet to achieve a similar range.

Another unique innovation is the built-in finder, which projects a clear, sharp, wide-field low-power view into the single fixed eyepiece whenever the main erecting prism is thrust aside by its actuating lever. Thus a finger-flick at any time brings either system's image to the eyepiece. The user never has to grope in the dark for a finder eyepiece and stand practically on his head to use it. At choice, or for the most exacting work, the eyepiece may be used without the erecting prism, in the main optical axis. In this form Questar is sharpest, and the image is inverted in the conventional astronomical manner.

Among the vital refinements built into Questar that transform long hours of observing from drudgery into relaxed pleasure are the rotary controls and finger-flick levers. Slow motion knobs are completely without backlash, and are designed to work for a century without adjustment. The rotary focussing knob runs in nylon threads, and indicates the point of focus by its own position.

Questar's two small levers both actuate and indicate in darkness by the user's sense of touch. The side lever at the right controls the prism, as previously mentioned. The top lever causes an achromatic negative lens to swing into place which doubles eyepiece power when desired. Those who have tried to squint through the tiny lenses of conventional high-power eyepieces will especially appreciate this modern amplifying lens, which extends Questar's effective focal length from 42 to 84 inches—a full seven feet—permitting use of the superior larger eyepieces, whose


JUN. · MAY · APR.
ECLIPTIC
EQUATOR
APR. · MAR. · FEB. · JAN.
Questar

higher eye-points make them more comfortable to use, particularly by those who wear eyeglasses.

Thus, two more innovations result from Questar's basic concept of merging telescope and accessory, of the finger-tip control of auxiliary optical elements built right into the instrument—Questar has two focal lengths, and each eyepiece has three powers instead of only one.

All these built-in features that set Questar apart are genuine advances in conception and design, calculated to make the use of the instrument an unfailing pleasure.

Many advanced engineering features are not visible to the eye, such as the lavish use of nylon bearing surfaces for the finest, smoothest turning, and to insure that no lubrication should be required for periods of many years. Not obvious at first sight is the system of convenient and safe clutches for quick motion. Not evident at once is the doubly-sealed gear train of the synchronous electric drive, perhaps the simplest ever built into any telescope. It is so devised that once started, there is no lost motion at all throughout repeated settings. The sealed oil-filled motor is the finest available and incorporates a special winding and a special non-magnetic internal shield to eliminate heat. It runs on 60 cycle 115 volt alternating current. An inexpensive adapter may be obtained, permitting its use from a 6-volt car battery.

To insure against corrosion, Questar's fastenings are of stainless steel, the strongest and most costly engine turned screws procurable being used.

To demonstrate Questar, one need not wait for night or clear skies. The perfect clarity and enormous magnification of the telescope may be shown anywhere at any time, even in the smallest of rooms. We need only make sure that the test objects are extremely well illuminated, so that the image does not become too dim with enlargement. The solar filter may be demonstrated on a white hot lamp filament just a few feet away.

It is very rewarding to show Questar to the old-timers, the real optical experts, and feel their pleasure. Mr. A. G. Ingalls, who as an editor of the *Scientific American*, is the dean and patron saint of amateur astronomers and who has recently had a crater on the moon named in his honor, said this: "Questar is a little gem, and you know very well I never say such things lightly."

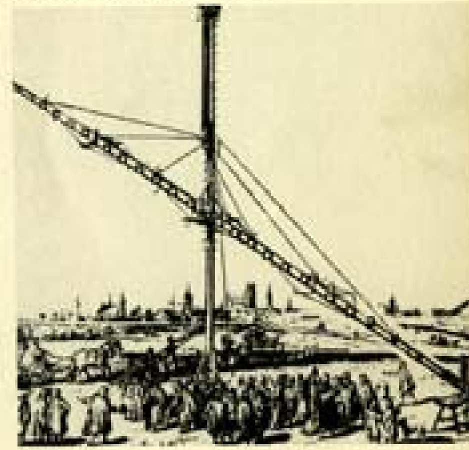
HISTORY OF THE TELESCOPE

The origin of the simple lens appears to be lost in the mists of antiquity. Little is known of its use until spectacles appeared in the thirteenth century and spread throughout Europe during the following three hundred years. That spectacles were used for 300 years before 1608 when the

Dutch Van Lippershey used a positive and negative eyeglass lens to make the first telescope, has astonished some historians. The reason was probably that while the simple lens relieved the farsightedness of middle age, it was not until 1575 that the special form of negative lens also required was developed for myopia and hypermetropia.

Galileo's rapid development in 1609 of Lippershey's 3 or 4 power "optic tube" produced the first useful refractor, of some 30 power. For the next 140 years the history of this instrument is the chronicle of attempts to eliminate the colors of the rainbow from the image at the focus of single lenses, for no single lens can bring all colors to one point.

Good glass was hard to make, a three-inch lens being only latterly achieved. To dodge unfocussed color, telescope length became tremendous, resulting in fantastic derricks from which were slung open tube refractors, sometimes 200 feet in length, with a veritable ship's rigging of block and tackle. Incredible labors to keep up with the movement of the stars must have attended each observation, for the heavens seem to be in motion as the earth keeps turning. The diameter of Venus was measured in 1722 by James Bradley with a telescope 212¼ feet long!

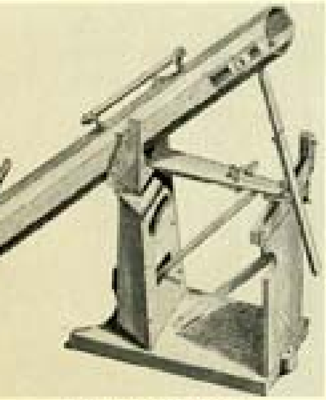


Hevelius' 150-foot Telescope

A wholly new way to eliminate color and shorten the telescope was invented by James Gregory, a Scottish mathematician. He proposed a concave parabolic mirror with a central hole, through which focussed rays returning from a smaller concave mirror in front of the first one, might pass to an eyepiece behind it. This was in 1663, and five years later the great Sir Isaac Newton made a model of a simpler version of Gregory's system, using a small flat mirror to reflect the cone of rays sidewise out of the tube. In an historic error he declared that a spherical mirror was quite adequate to correctly focus all rays. A similar small model of 6-inch focal length presented in 1672 to the Royal Society is still in existence.

At the court of Louis XIV an artist and sculptor named Guillaume Cassegrain proposed another type of reflector in the same year. In his scheme a perforated primary mirror like Gregory's brought rays to a convex secondary mirror, from which they were reflected back through the hole. By 1672, then, the three principal forms of reflecting telescopes, that still endure, had been invented in a single decade—the simple Newtonian, and the compound Gregorian and Cassegrain forms, the latter shortest of all.

Fifty years were to elapse before any of these could be constructed. Gregory tried everywhere, but no maker with sufficient mastery of the art of polishing mirrors could be found. Then suddenly in 1722 John Hadley submitted an elegant Newtonian reflector of 5 foot focal length, with the then enormous aperture of 6 full inches, to the Royal Society in London. Two astronomers were delegated to test it against the Society's 125-foot refractor. Its performance was sensational. It was relatively portable, with a tasteful mounting and a tube only 6 feet in length. Mr. Hadley was instantly acclaimed, and prospered mightily thereafter.



The First Reflector. John Hadley, 1722

By 1755 the two-lens refractor of Hall and Dollond had achieved a partial solution of the color problem and no longer required a flagpole. It became essentially the refractor of today in size and general appearance, the familiar big spyglass raised on a tripod standing 6 to 8 feet high.

Thus, two centuries ago the basic shapes of refractor and reflector were established. They ushered in the age of great discoveries, and have functioned side by side in friendly rivalry until today. It was to take until the twentieth century before these two would finally be combined.

In this brief summary, we might pause to note an interesting development. In the hands of James Short of Edinburgh after 1722, the compound, reflecting telescope, usually a Gregorian of 3 or 4 inches aperture, had become a powerful compact instrument with normally erect image. The brittle speculum-metal mirrors upon tarnishing after a few months, could only be repolished by a complete refiguring. The exquisite problem of matching two non-spherical curvatures had been mastered as well by other makers at mid-century. A beautiful example of the compound instrument, probably made for Louis XV, is in the Adler Planetarium. The aperture is 4 inches, length 30½ inches. It is lavishly ornamented in silver, and is supported by a turned column with three curved legs to stand upon a table. The hundred-foot telescope in one short generation had become compressed by skill and ingenuity into an ornamental tabletop machine of greater power.

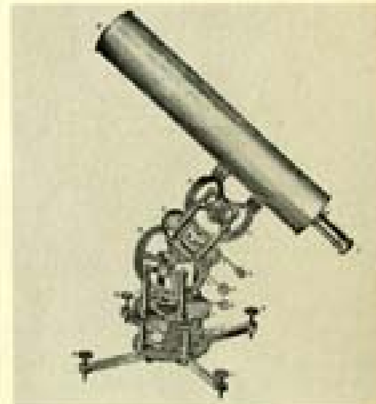
During the rest of the eighteenth century such useful instruments, in the great quickening of interest in astronomy, were to be found not only in the libraries of royalty, but upon the tables of gentlemen of means and education throughout Europe. The difficulty of construction of such Gregorian telescopes may be inferred from the fact that Short's standard price was no less than £500, the price of a splendid town house or country estate in 1745.

The nineteenth century saw Foucault's silver-on-glass discovery of 1857 and the steady increase in size of both types, with reflectors now free to use silvered glass mirrors, which could be recoated without repolishing.

Perhaps first intimations of a merger of the two classical types came in 1895, when Goerz patented a corrected spherical mirror system in which back-silvering made of a lens a mirror too. In 1899 Schupmann showed in a patent application that faults of a big simple lens might be corrected by a small concave mirror.

Then in 1930 Bernhard Schmidt invented the enormously useful combination of spherical mirror corrected by a thin lens, which permits photography of extremely wide star-fields with great speed and perfect sharpness. This Schmidt camera joins lens and mirror into one instrument, the mixed or "catadioptric" form.

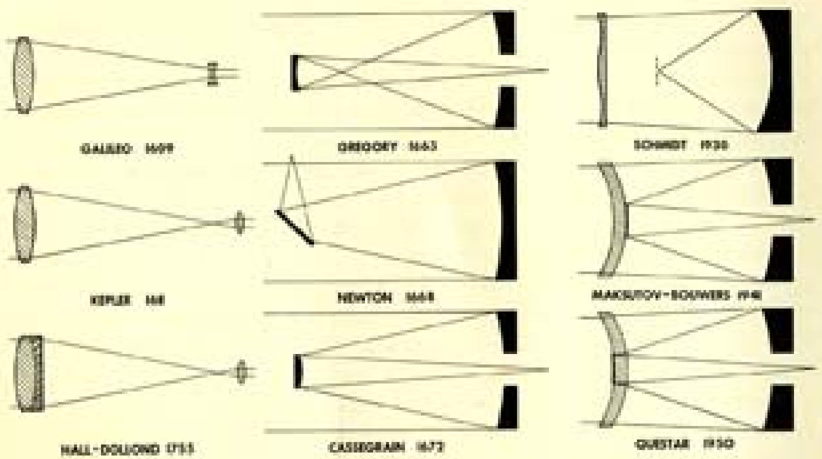
The only flaw in this marriage is the non-spherical correcting lens, which is very difficult to manufacture. Bouwers and Maksutov independently in 1941 achieved similar results by means of a much thicker but all-spherical correcting lens.



Short's Equatorial Mount

Questar grew out of these twentieth century discoveries in optics. Its compound system uses a weak negative meniscus to correct the spherical aberration of a perforate spherical primary first-surface mirror. A second-surface Cassegrain secondary mirror is formed by a metallized spot on the front curvature of the lens. Partial correction occurs at the primary and the balance at the secondary, with all the light passing three times through the correcting lens. Questar's triple-passage correcting lens distinguishes it from previous constructions and permits both a slightly shorter design and a fully-protected secondary mirror. With an axial separation of only six inches between lens and mirror, the Cassegrainian optical leverage produces an effective focal length of 42 inches. A negative lens before the eyepiece extends this at will to 84 inches.

The sealed all-spherical compound optical system in one leap carries the small astronomical telescope from eighteenth century handicraft to twentieth century precision manufacture.



WHAT TO EXPECT OF A SMALL TELESCOPE

It has long been known that small telescopes like Questar enjoy unique advantages over larger instruments. Size for size, nature has so arranged matters that the little fellows are relatively much more efficient. They can often use their fullest powers on nights when the big ones are in serious trouble—"poor seeing" trouble.

Air turbulence and lack of tranquility at various heights in the atmosphere is the cause of most of this difficulty. Disturbed air makes the stars twinkle, and when we magnify the twinkle we cannot see the star for its apparent acrobatic explosions. Planetary detail becomes obliterated, shimmering in a fuzzy dance.

Questar's short barrel permits an easy demonstration of this phenomenon. If a lighted match is held a few inches below and ahead of the front lens, while some object is being viewed indoors in still air, the refractive power of the warm rarefied gases becomes evident. Multiple moving images overlay each other in the familiar pattern of bad seeing. And, of course, the bigger the aperture, the bigger the trouble with poor seeing.

That telescopes may be too large to define well may surprise many whose newspapers have assured them that "the new giant eye" will bring the moon "closer," certainly a wholly natural assumption. But the great reflecting telescopes are not built to look at moon or planets, which are more clearly seen with instruments of much more modest size. They were made to collect faint light in time exposures for astrophysical research. They can photograph the moon in very large scale, as the 200-inch

has recently done, but without increased sharpness or better resolution of lunar features.

For the same reason of atmospheric difficulties, the powers of magnification used by experts is usually moderate, often no more than Questar's 160 diameters, and sometimes even less. As usual, everything depends on tranquil air. The possessor of a large telescope chooses the best power for given seeing conditions, and it usually turns out that a relatively low power shows the finest detail, except on those rare occasions of unusually fine seeing.

"Empty magnification" is usually a thing the beginner has to learn first-hand. A telescope producing an image of the moon is using its fullest powers. We can observe the real image if we remove the eyepiece—it seems to hang there in the air, small and crisp. All the resolution is in this image, all the detail and contrast that our telescope can show. To examine the image, we select an eyepiece, which is only a special magnifying glass. A big low-power eyepiece shows the moon small. A medium eyepiece may just barely show it entire, while the highest power may fill the field of the eyepiece with only one-half the diameter, or one-fourth the area of the lunar image. In each case we only magnify what exists in that real image including all the faults and virtues. Of course, we assume fine eyepieces.

Questar's eyepieces are of exceptional quality. Each has two powers, as previously mentioned. The low power 40x is a three-lens Koenig type. The 80x is a five-lens Erfle eyepiece with the phenomenally wide field of 75°. With this eyepiece the moon is a glorious sight, and an impressive demonstration for Questar. There is no sensation of looking through a narrow tube as with the antique Huygens, Ramsden, or even some four-lens orthoscopic oculars. Rather, one seems to look through a nice big window.

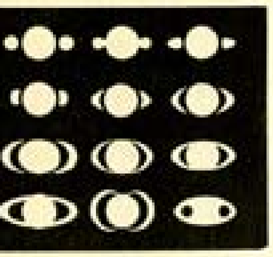
Which eye to use is a matter of choice, as is the use of spectacles. The thing is to do what comes naturally. Not everyone, even after long practice, can keep both eyes open as the microscopists recommend. But an open eye may be covered by the palm sometimes to good effect, and "palming" both eyes with cupped hands is most refreshing to tired eyes at any time.

The eye is living tissue, marvellously made and delicately poised within the all-embracing fabric of capillaries and blood vessels. Only constant nutrition and repair can keep its retina and nerve cells at peak sensitivity. To hostile cold or wind the eye responds with tears. Any kind of body strain, or a constriction of the neck arteries quickly registers itself in diminished vision. Even emotion or mood is able to affect the tone of our organism, of which the miraculous eye is but a part. The eye itself is also the last lens of any visual optical system, a point not always realized, for what good would be a telescope unfitted to this final living crystal?

The perfect environment for best seeing is from a seat indoors, away from insects, wind and chill. Until now, only the costly, complex polar telescope, with indoor eyepiece, met this condition. Now Questar, raised by the ingenious person above a windowsill, and penetrating a plastic cloth hung from opened sash, will provide a fine warmed-room observatory, with no light-loss from auxiliary mirrors.

Contrast is a vital factor in magnification. The smaller the power, the more concentrated the light, and vice-versa. In doubling magnification we have only one-fourth the light to express the relative brightness of areas that compose the image. It follows that the perception of fine detail, which is resolution, sharpness, depends upon degree of contrast as well as size of image, and in this matter people have personal preferences. The old rule of thumb says that telescopes should never be used at powers greater than 50 diameters per inch of aperture, for above this ratio all magnification is "empty," revealing nothing new.

It is possible by simple means to apply enormous magnification to any telescope's primary image. For example, any standard microscope can be used in place of eyepiece. We soon discover, however, that the image simply fades out. But long before it vanishes, the coarseness of everything seen becomes most objectionable. We seem but to enlarge all defects. The experienced observer keeps magnification moderate to secure a nice degree of contrast precisely because the human eye demands such a balance for sharpest perception. The novice only too often has been led to expect constant "high-power views" from his "high-powered telescope." What experience will have to teach him is how to get fine resolution from his "high-powered telescope" instead of empty magnification.



Saturn drawings by early observers before Huygens' discovery of the ring in 1659.

We must not expect any instrument to penetrate the haze and fog so apparent near the horizon in most climates without encountering a maximum of air disturbances and loss of contrast. The long view through the densest layer of air at horizon level reduces even the sun, so fierce above at noonday, to a quiet red disc at sunset. Dust and water vapor actually absorb all colors but the red rays, whose wave length is larger than the particles themselves. To demonstrate a telescope, particularly in cities, the nearer, more contrasty objects are preferable to distant views.

We may confidently expect to use Questar's 160 diameters frequently upon the moon's contrasty and brilliant disc, even in climates of normally mediocre seeing. As we have noted, small telescopes enjoy many advantages not shared by larger ones. They work particularly well upon the planets, especially on Jupiter and Saturn. But we must not expect too much from any telescope when objects are too close to the horizon. Venus seldom rises very high, nor does Mars at those times when its apparent size is greatest, and most suitable for observation. Unfortunately, Mars, at the closest opposition, is low in the sky, being well overhead only near the earth's equator. It is more rewarding to observe objects at least 30° above the horizon.

First Mars drawing, Huygens, 1659, shows Syrtis Major. Used 23' telescope of 2½" aperture, 100X.

Because of their size, small instruments are best upon bright objects and simply lack the light-collecting ability that is needed to intensify the contrast of nebulae or comets. Bearing this in mind, it is applicable to all the observing we do with Questar. In viewing nature, we should favor our instrument by seeking objects in full sunlight, or against a contrasting bright or dark background. Even in indoor close-up demonstrations, the value of bright illumination is at once evident.

The possessor of a small fine telescope may certainly expect a great deal from a minimum investment. For here too, the small instrument has considerable advantages. Dollar for dollar, small telescopes give us more for our money. Resolving power increases directly with aperture, a 7-inch resolving twice as well as a 3½ inch. But the weight and cost increase as the *cube* of any dimension! Not everyone is familiar with this fact, so well known in industry, but it is important to remember in contemplating a sizeable instrument.

The *Scientific American* for December, 1952, describes the work of Mr. James C. Bartlett, Jr., of Baltimore, a selenographer whose recent studies of the moon near the crater Fontenelle have resulted in the changing of lunar maps of that region. On the great Wilkins map of the moon the changed feature has been renamed "Bartlett" in his honor.

No serious person would have the temerity to suggest that original discoveries of this type can be expected to be made upon the moon except with instruments of considerable aperture, say from 6 to 12 inches. There are many telescopes of such sizes in use by observers all over the world, and the planets are under constant scrutiny, especially from that region of fine seeing, the southwest United States.

It is therefore a pleasure to report that the aperture of Mr. Bartlett's telescope is 3.5 inches.

THE CARE OF FINE OPTICAL SURFACES

A century from now, in 2054, your Questar should be in the prime of life, and good, perhaps, for another hundred years. In closing this booklet with some words on the care of optics, we had this thought—that the purchase of a telescope is in reality the selection of an heirloom, for fine instruments are made to weather time. Perhaps it is only fitting that the kind of thoughtful person who would own a telescope should be remembered by an instrument of such historic importance in mankind's quest for knowledge.

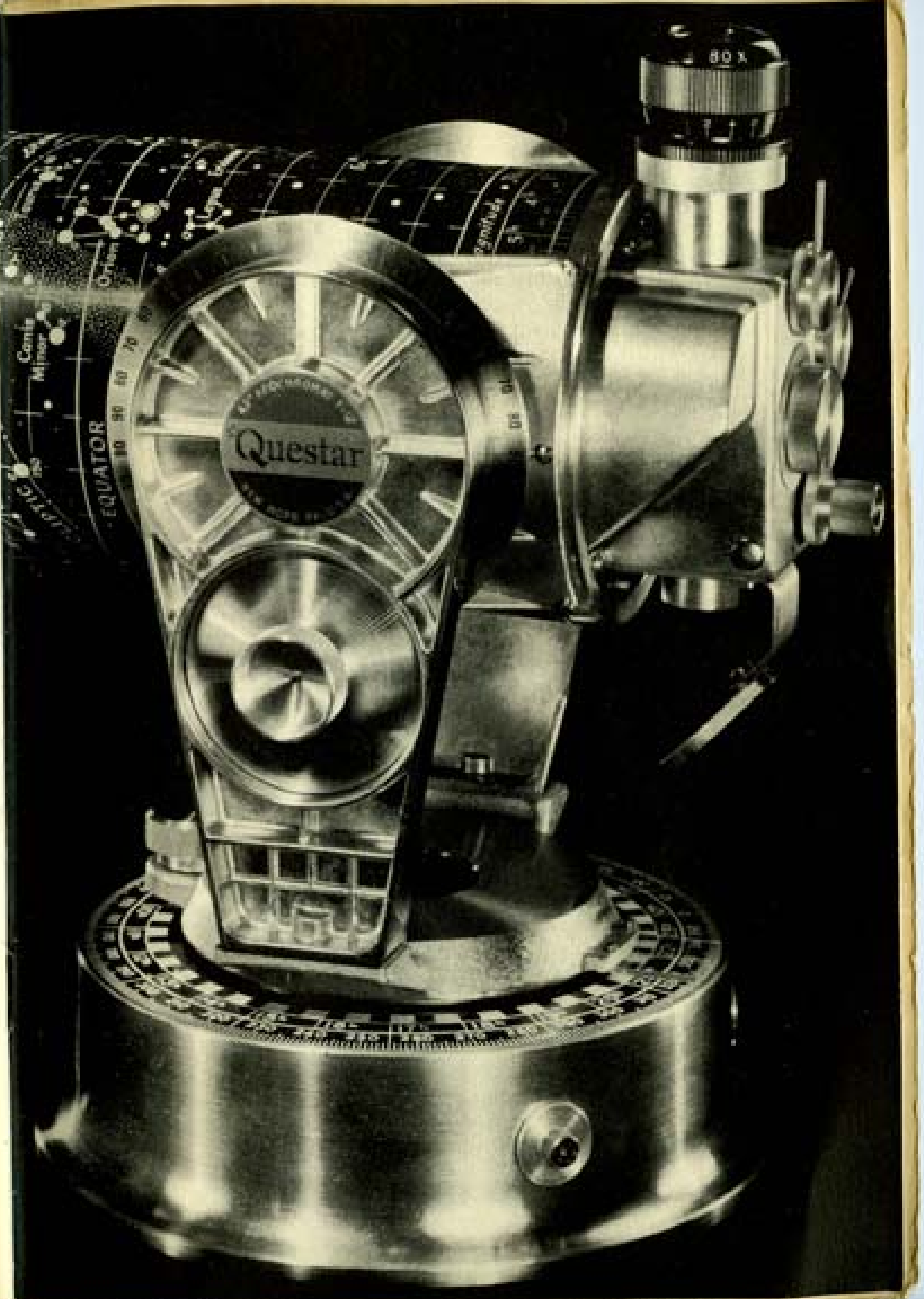
To preserve optical surfaces for any length of time, it is only necessary to see that the surface is not damaged. The greatest source of damage to the lenses of optical instruments is said to be due to overzealous owners who cannot bear to touch them without vigorously shining up the glass. It goes without saying, that an instrument should be kept in its case, or somewhere out of the dust, but dust itself does not hurt glass until someone starts to rub it off, and makes it act like sandpaper.

Dust is everywhere, and a large part of it is tiny grains of sand, harder by far than optical glass, because it is actually quartz. To clean off a dusty lens with a handkerchief is to rub the sharp little quartz crystals into the optical surface, neatly plowing tiny furrows. This kind of damage is irreparable, for a network of thousands of tiny scratches will lay a fog upon the image, whereas one big bold scratch does no perceptible damage to performance at all.

Beauty defects, as they are known to the trade, are a headache at best to opticians. A floating dust mote from the air may cause a single sleek or scratch during the last strokes of final polishing. Minute bubbles, pits or edge chips, too often cause the rejection of an otherwise perfect lens that may represent a great number of dollars in labor alone. The great Fraunhofer, who made the best refractors of his time, was once reproached by a patron for a defect in a surface. "Sir," replied the master, "this glass is to be looked *through*, not at."

So, the way to preserve a fine optical surface is to restrain as best we can our natural desire for cleanliness. Since we cannot avoid the presence of a little dust, perhaps it is wise to learn to live with a bit of it. The thing is, let's not keep polishing the front lens and eye lens every time we use our instrument. Internal surfaces may go untouched for years.

The secret of cleaning lies in getting the grit off before rubbing, then rubbing as little and as lightly as possible. Brush the grit off with the softest little brush obtainable. Then use cotton, or facial tissue fresh from the box (unfold it and use the inside!). Or a soft clean piece of old cotton cloth. If you can breathe on the lens without droplets, a fog of



distilled water is condensed from your breath. To avoid leaving lint, breathe on the tissue or cloth too, a useful wrinkle. Lens tissues should be avoided like the plague for anything better than the cheap lenses of spectacles, since they just invite you to commence rubbing. Eyeglass cleaning fluid, however, which is sold under various names, is excellent for removing finger marks whose acids can quickly hurt the coated surface. But get the dust off first.

Questar's glass surfaces, each of which would normally lose some 4½% of light by reflection, are coated with a layer of magnesium fluoride 5 millionths of an inch thick. This shows as a faint purple-bluish tint, reducing reflection loss at each air-glass surface to less than 2%. The net gain in contrast and brilliance is some 25%. The hardest coating available to date will still scratch and rub off eventually. So dust off with soft brush sparingly, and use water and cloth only once or twice a year if you can't resist the polishing impulse.

Questar's primary mirror should never be touched. It is aluminized and has been coated with 5 millionths of an inch of hard quartz to protect the soft surface of this metal.

There are, of course, a few pretty obvious don'ts to mention in passing. Extremes of temperature or humidity should be avoided. Don't put a telescope away in summer soaking wet with dew, or store it in a sizzling attic or damp cellar. Too much dry heat may affect the balsam of cemented eyepiece lenses. Heat and humidity can breed the fungi that etches glass, as we learned in the South Pacific war. On a cold winter's evening any glass and metal object is likely, after being brought back indoors, to frost up like an iced drink in August. Just let Questar warm up and get dry before putting it into the case. Probably the only optical instruments that should be used continually at the seashore are the sealed type of marine binoculars, expressly developed for salt atmosphere. Doubtless Questar's metals, like any others, would profit little from extended exposure to the corrosive salt-spray of the ocean.

In conclusion, we should remember that all over the world fine microscopes and telescopes more than a century old are still working beautifully. Questar should exceed their useful life with only ordinary care. A nice thought, too. What other of man's engines is built with such a life expectancy? Our thoughtful care may some day thus give pleasure to our great-great grandchildren.

ILLUSTRATIONS:
Page 3—Bettman Archive.
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Printed in U.S.A.—5-'54

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