generally have a star diagonal, also, to bend the light at right angles before it reaches the eyepiece. This allows us to observe objects overhead with comfort.

Reflecting telescopes use a mirror, not a lens, for the objective. It is a highly polished concave glass disk coated usually with aluminum or silver. Light from the star falls upon this mirror and is reflected to a smaller diagonal mirror or prism in the tube. This reflects the light to the eyepiece.

Refractors go out of adjustment less easily than reflectors. Less maintenance, such as realignment or the resurfacing of mirrors, is necessary. But reflectors are less expensive and more readily made by amateurs.

LIGHT-GATHERING POWER The telescope's ability to reveal faint objects depends mainly upon the size of its objective. A lens or mirror 2 inches in diameter will gather two times as much light as a 2-inch, and a 6-inch will gather four times as much as a 3-inch. Figures given in the table here are only approximate. Some telescopes can do better. Actual performance depends partly upon seeing conditions, quality of the instrument, and the observer's vision.

HOW SIZE OF OBJECTIVE DETERMINES VISIBILITY OF OBJECTS

Diameter of Objective (inches)	Faintest Magnitude* Visible	Number of Stars Visible
1	9	117,000
1¾	10	324,000
2¾	11	870,000
4½	12	2,270,000
7	13	5,700,000
11	14	13,800,000
12½	15	32,000,000

*See pages 26-27 for explanation of magnitude.

A GOLDEN GUIDE

THE SKY OBSERVER'S GUIDE

Full-color, Easy-to-Use

Paths of Light through Magnifier and Telescope

TELESCOPE PRINCIPLES Astronomical telescopes are of two main types: refracting and reflecting.

In a simple refractor, light is gathered by a lens, and magnification is done by the eyepiece. There is no erecting lens, because this would cut down the amount of light delivered to the eye. The image seen by the observer is inverted, but this makes no difference in observation of most celestial objects.

With the telescope the observer usually gets several removable eyepieces. These are used for different degrees of magnification, as desired.

Every good astronomical telescope has a finder—a small telescope, usually of 5 or 6 power, with a wide field, mounted on the main tube. It is used for aiming the telescope, because the field seen through a high-power telescope is very small. Astronomical refractors

In the large prism binoculars, the objectives are centered farther apart. The light rays from them must be brought closer together before they reach the eyepieces. This is done by a pair of prisms in each tube.

Opera glasses have objectives of about one inch diameter and a magnifying power of 2 to 3. Prism binoculars, with their larger objectives and higher magnification, are preferable for astronomical observing. Popular types have objectives of 35 to 50 millimeters (about 1⅜ to 2 inches), and magnify 6 to 10 times.

Binoculars labeled "7×50" magnify 7 times and have an objective 50 millimeters in diameter. The area of the objective determines light-gathering ability; so 7×50 binoculars gather more than 7×35's.

Binoculars vary also as to field of view. The field is the whole circular area we see through the instrument. Thus in binoculars with a 6° field we can see an area of sky 6° in diameter—equal to an area 100 feet in diameter at 1,000 feet.

Heavy binoculars make the arms tired and unsteady. The magnification increases the effect of unsteadiness. Usually 7-power glasses are the limit for ease in handling. Bigger ones ordinarily require a support.

Magnification: Large and reduced sizes of this photo show the Moon as seen with unaided eye and through 7-power binoculars. *(Lick Obs.)*

THE SKY OBSERVER'S GUIDE

A HANDBOOK FOR AMATEUR ASTRONOMERS

by
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Paintings and Diagrams by
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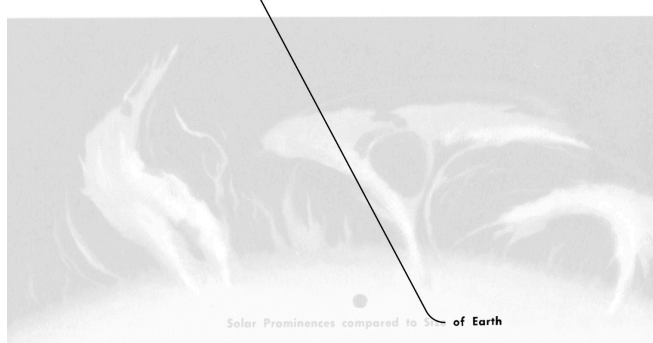

Solar Prominences compared to Size of Earth

in a star atlas become indispensable. There are atlases of convenient size that show nearly all stars as faint as can be seen with binoculars. For serious work with a telescope, more detailed charts are needed.

Some beginners use a planisphere to learn constellations. One type has a "wheel" on which is printed a map of the constellations. The wheel is rotated within an envelope that has a window. When the wheel is set for any particular month, day, and hour, the window shows the positions of the constellations at that time.

BINOCULAR FACTS Every observer should own a good pair of binoculars. These gather far more light than the eye; they magnify images and use the capacity of both eyes.

Opera-glass binoculars consist essentially of two small refracting telescopes mounted together. At the front of each is a large lens, the objective, which gathers the light. At the rear is a smaller lens, the eyepiece or ocular, which does the magnifying. In the front part of the eyepiece is a third element, the erecting lens, which is necessary to prevent getting a upside-down view.

A planisphere. Basic with this are highly useful for learning the various constellations.

Optical aid: Binoculars are ideal for viewing features and vast star fields. *(Stellar)*

Three types of telescope: The reflector, with a mirror for its objective, is a common all-purpose design. The refractor, using a lens for the objective, also is an all-purpose type. The tracking telescope has the extra-wide field needed for fast-moving objects.

The Observer's Equipment

CHARTS AND BOOKS Just as we gather a supply of maps and booklets before touring the country, so we must gather certain sources of information before touring the sky.

This book provides all necessary information for a good start in sky observing. The index will guide you to explanations of observing techniques and equipment, to lists of interesting objects to look for, and to tables indicating where and when to look for planets, eclipses, meteor showers, and periodic comets. For more background in astronomy, the reader may turn to books and periodicals recommended on pages 146-147.

Hundreds of stars, nebulas, and other objects can be located with the aid of the maps on pages 148-157. For fainter objects the more detailed charts to be found

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SUN
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EARTH
MOON
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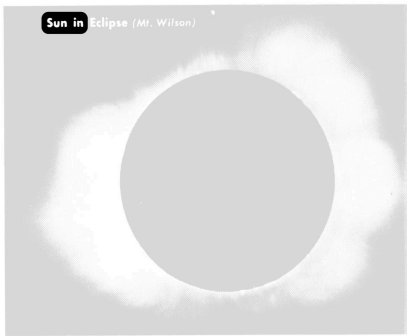
JUPITER
SATURN
URANUS
NEPTUNE
PLUTO

Ring Nebula *(Mt. Wilson)*

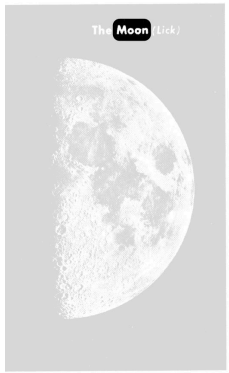
Giacobini's Comet *(Yerkes)*

Sun-spots *(Yerkes)*

Some FAVORITE SKY OBJECTS For OBSERVATION



Sun in Eclipse *(Mt. Wilson)*



The Moon *(Lick)*

Jupiter *(Mt. Wilson)*

Nova Herculis *(Yerkes)*

Hercules Cluster *(Mt. Wilson)*

Orion Nebula *(Lick)*

A Meteor *(Yerkes)*

For a serious amateur: This homemade 12-inch reflector, equipped with a camera, can give high performance. *(Clarence P. Custer, M.D.)*

lenses and mirrors, and design the mountings. It takes special knowledge and skill, yet hundreds of amateurs have made instruments that perform splendidly. Telescope-making classes are held at some planetariums, universities, and observatories. Books on telescope making are available from booksellers.

ORGANIZATIONS OF AMATEURS Many amateur observers belong to national organizations. These give members information on equipment, observing techniques, and standard methods of reporting their work. They set up observing programs and receive observational data from members. Data are sent to observatories for use in programs of research. Some organizations publish news of developments that interest amateurs. Local groups observe together, compare equipment, and promote public interest in astronomy.

and magnifying power of telescopes brings out details of the Moon's surface. It reveals Jupiter's larger satellites and its banded clouds, as well as markings on Mars and the rings of Saturn. With telescopes we can "split" double stars and distinguish star clusters, nebulas, comets, and sunspots. We can watch the Moon occult (that is, pass in front of) stars and planets. Light fluctuations of faint variable stars and novas can be detected.

Good small telescopes can give surprising performance. When conditions are right, an observer with a good 3-inch refractor or 6-inch reflector can see some features of Jupiter and Saturn more distinctly than they appear in observatory photographs.

FUN WITH THE CAMERA Many amateurs make use of the camera. The eye is sensitive only to the light it is receiving in the present instant, but photographic film is sensitive to light received over a long period of exposure. An amateur's camera can detect faint objects which the eye, even with the aid of a telescope, could never see. Even a simple camera gives exciting and useful results.

MAKING A TELESCOPE Some serious amateurs, not content with factory-made telescopes, make their own. They grind the

Transit of Mercury, Nov. 14, 1907: The movement of a planet across the Sun's disk is a rare sight. Arrows point to Mercury and show the direction of its path. *(Yerkes Obs.)*

Becoming a Sky Observer

All of us, from childhood, have gazed at the sky in wonder. Sun and Moon, the wandering planets, the fiery trails of comets and meteors—these are things to marvel at. Man will never tire of looking up into the tremendous, sparkling bowl of space.

Skywatching was undoubtedly a pastime of prehistoric man. The ancient Egyptians and Babylonians, several thousand years ago, observed the heavens carefully enough to devise quite accurate calendars. Observations by Copernicus, Galileo, and others in the sixteenth and seventeenth centuries were among the first great steps to modern science. Even today, the science of astronomy depends on observation.

ASTRONOMY FOR EVERYBODY Astronomy is for the amateur as well as the professional. The amateur can see for himself the sights that stirred Galileo, the Herschels, and other great astronomers. A high-school boy may be the first to see a comet, a rug salesman may discover a nova, and a housewife can observe and map meteor showers. An amateur's faithful observations of a variable star may be just the data an observatory needs.

Although in some regions weather and climate

Mars—a challenge to astronomers: This photo of the red planet, always a favorite of observers, is one of the finest. *(W. S. Finsen, Union Obs., Johannesburg)*

Great Nebula in Orion: This famous object was painted as seen by the artist in his 8-inch telescope at 200 power. The pattern of four stars near the center is the well-known, colorful Trapezium.

are often unfavorable, any interested person in any part of the world can become a sky observer. The aspect of the sky differs from place to place, but the majesty of Sun and Moon, of stars and planets and nebulas, is to be seen everywhere.

This book is a guide to observing—to the use of binoculars and telescopes, the locating of sky objects, and what objects to look for and how best to see them. The beginning observer should have also a book on general astronomy. Even a little knowledge greatly increases the pleasure of observing, and it prepares us to undertake real astronomical projects. Most old hands have found that the fun of amateur astronomy is greatest when they are working on observation programs that are scientifically useful.

OBSERVING WITH UNAIDED EYES Even an observer without binoculars or a telescope can see many wonders of the heavens. The important thing is to know how to look and what to look for. The constellations can be traced and identified. Some star clusters can be located, and eclipses and some comets observed. The changing positions of Sun, Moon, and the brighter planets can be closely watched, and some artificial satellites can be seen. The brightness and length of meteor trails can be estimated. Get used to finding your way about the sky with the eyes alone before trying a telescope.

BINOCULARS AND TELESCOPE Your first look at the heavens through good binoculars can be exciting. Binoculars with 50mm. lenses gather about 40 times as much light as the eye alone, revealing such features as mountains and craters of the Moon, sunspots, the four larger satellites of Jupiter, double stars and star clusters, and luminous clouds of cosmic gas such as the famous nebula in Orion. (Before observing the sun, see pages 66-67!)

With no more than binoculars, some observers do useful scientific work, such as recording light changes in variable stars and watching for novas and comets. A telescope is obtained by every serious amateur sooner or later. Refractors, with lenses 1½ to 4 inches diameter, and reflectors, with mirrors of 3 to 6 inches, are popular types. The light-gathering

Telescope on wheels: This home-made 8-inch reflector is kept in the garage and wheeled out at observing time. *(William Miller)*