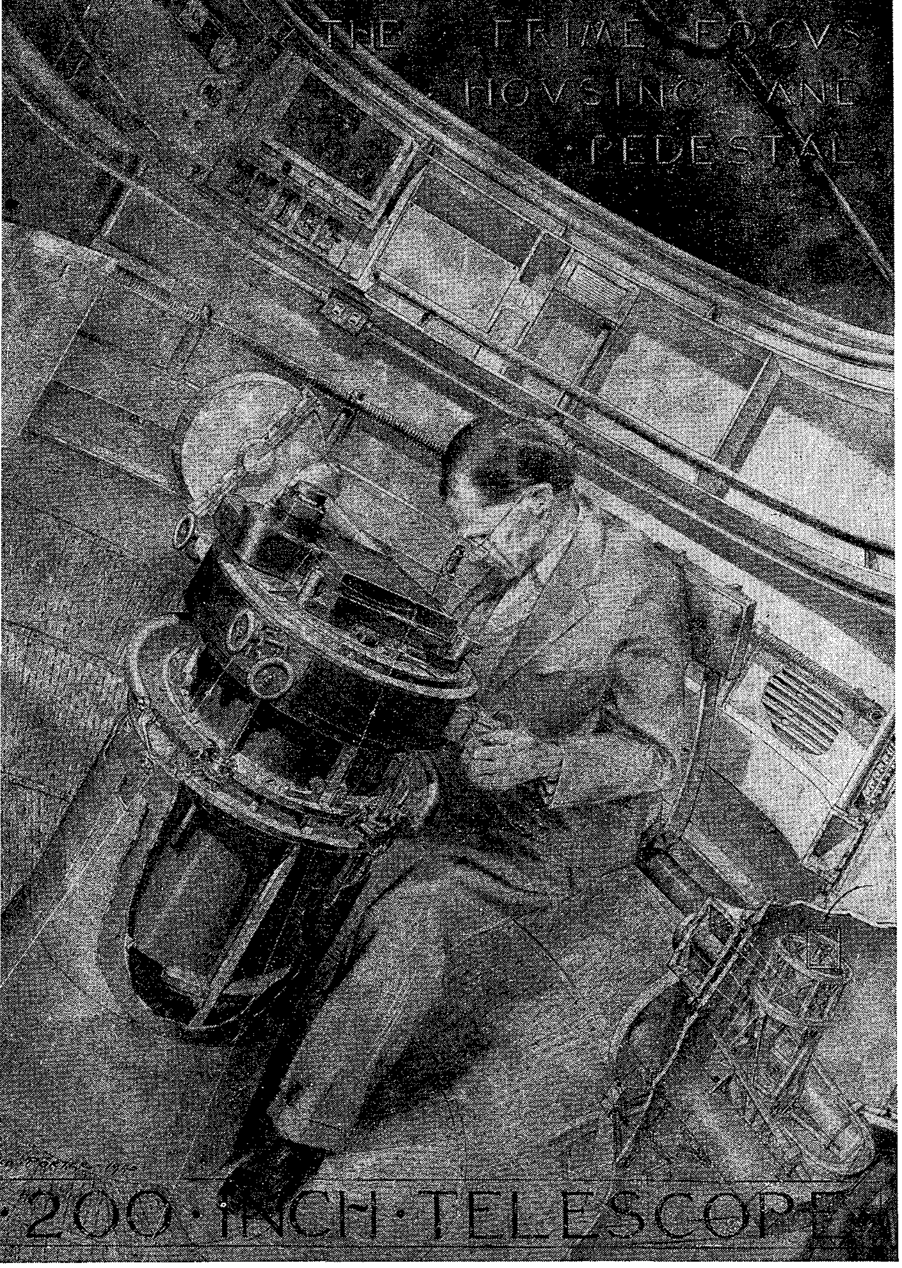


The Men at the Telescope

Astronomer seated in the prime focus cage at the top of the 55-foot-long telescope tube. His chair is adjustable so that he is comfortable while observing at any angle. Drawing by R. W. Porter.

HOW do astronomers work? How do they analyze and interpret the information they obtain with telescopes? What is this information they obtain by simply taking pictures of stars or of the spectra of stars? These are questions that people ask about astronomy, astronomers and telescopes such as the Hale 200-inch.

Generally, astronomers do not live in the immediate vicinity of great observatories. Rather, they live in the vicinity of the laboratories where work done at the observatory is analyzed and interpreted. This is entirely true of both the Palomar and Mt. Wilson Observatories. The astronomers who use these giant instruments live in Pasadena for it is there that the California Institute of Technology and Mt. Wilson laboratories are located. Only about 20 per cent of their working time is spent in observing—say three to six nights a lunar month.

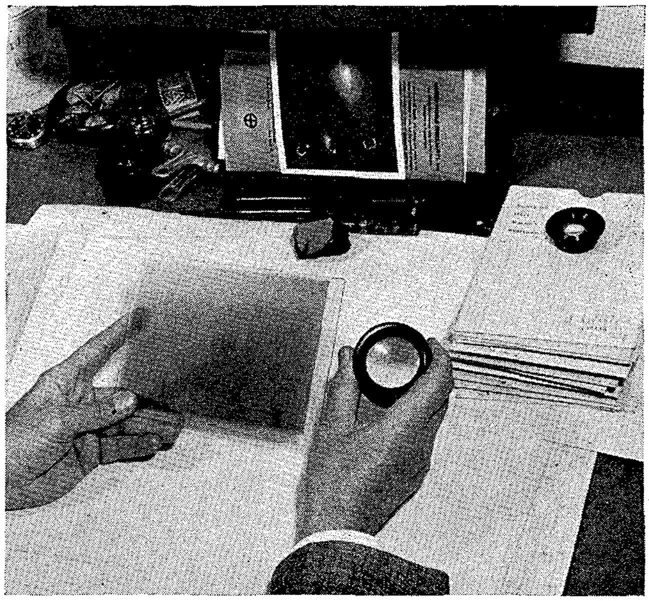
When at the observatory, astronomers live in quarters commonly referred to as "Monasteries". The Palomar Monastery, like all others, is designed for day, rather than night, rest. Each astronomer has his own room. Each window has thick black shades that can be drawn to keep the room in darkness during the day if desired. There is a modern kitchen and the astronomer takes his meals at the Monastery. It has a living room and library, dining room, and caretaker's quarters.

Astronomers observe according to the field in which they are interested. One might say there are "light of the moon" and "dark of the moon" astronomers. Those interested in photographing distant nebulae or stars must do their work in the dark of the moon when there is a minimum of light from other than the source they wish to study. In general, the dark of the moon period is devoted to direct photography, although some spectroscopic work may also be done then—particularly if it is concerned with nebulae.

Those interested in spectroscopic work are at the observatory during the light of the moon, for there are no direct photographs to be made, hence no worry about plates being fogged from unsought light sources. In fact, with bright stars such as Sirius and Arcturus, spectroscopic observation could be made in daylight. This, however, will never be done, since it would involve opening the dome during the day and consequently allowing it to heat up so that night observations would be delayed.

Two men are needed for observing—the astronomer and his assistant. The latter will be at the control desk on the observatory floor, the former at the prime or other focus. Assuming the astronomer is a "dark of the moon" observer, he will be working at the prime focus. He or his assistant will see to it that the huge

Preliminary examination of an exposed plate with a hand lens. Photograph by E. R. Hoge.



dome is opened as early in the evening as possible so that the inside temperature can become adjusted to that outside the dome. This is important since both the tube and mirror are affected by changes in temperature.

When ready to begin work, the astronomer rides the prime focus elevator to his observing station inside the upper end of the telescope tube. He takes with him a number of photographic plate holders, enough perhaps to last him through the night. He advises his assistant at the control desk by telephone or "talk-box" the coordinates of the nebulae he wishes to photograph. The assistant moves the necessary control desk dials to these predetermined positions, presses a button and the telescope moves to the desired position. With an eye-piece that magnifies, the observer looks into the mirror to make certain the telescope is pointed at the right object. Next, he sets the cross-hairs of his eye-piece on a guiding star just outside the field to be photographed, puts his photographic plate in place, and the exposure begins. From then until the exposure is completed, he keeps his eye on the guide star as the telescope follows it across the heavens. From time to time he may have to make adjustments, which he can do himself, in order to keep the big instrument on position.

Stars move from east to west as the earth rotates. The Palomar telescope is designed to compensate for this rotation, but even though its driving mechanism is of the highest precision possible, it is still not possible to get the high accuracy required to assure the sharpest image. Thus the need for occasional adjusting.

The work to be done, the quality of the "seeing", and other factors determine how long the observer will remain at his station. If he is taking several photographs of not too long exposure, it is probable that about midnight he will come down out of the telescope for coffee and sandwiches—and also to get warm. Observing at the prime focus during the winter months calls for heavy clothing. The temperature may be freezing or below.

A great deal, of course, depends upon the weather. Perhaps "seeing" will not become good enough to take pictures until 1 or 2 a.m.—perhaps not at all. Again, it may be good most of the night. When the astronomer goes to the observatory, he can never be certain as to how much productive observing he can do in the four or five days he will be there. Nights when the "seeing" is ideal are not plentiful. But it is on such nights, which he dares not miss, that he gets in his most important work. There may never be more than a dozen such nights in an entire year.

From such direct photographs, the astronomer can determine many things—the distance of the star from the earth, the distribution of objects in space, the brightness of such objects, etc.

This, however, is not enough information. The astronomer also wants to know of what these stars are composed, the abundance of their chemical elements, their temperatures, their density, etc. The astronomer whose field is spectroscopy then comes into the picture. By breaking down the light from a star into its colors or lines by use of glass prisms or gratings, he can obtain this information. It is already known that if, for instance, the light source is a solid one—say the filament of an incandescent

Edwin P. Hubble

Dr. Edwin P. Hubble has served as staff member of Mt. Wilson Observatory since 1919 and is now chairman of the committee formed in 1946 to study and formulate a long-range program of research for the combined observatories at Mt. Wilson and Palomar. Receiving his B.Sc. and Ph.D. degrees from the University of Chicago in 1910 and 1917 respectively, Hubble filled the interim as a Rhodes Scholar at Oxford from 1910 to 1913, as a practicing member of the bar in Kentucky in 1913 and 1914, and as research fellow at Yerkes Observatory from 1914 to 1917.

During the first World War, Dr. Hubble enlisted in the infantry, served in France, and attained the rank of major. At the war's end he returned to the study of astronomy, came to Mt. Wilson where he joined research leading to the controversial "red shift" discovery, and has been a member of the observatory organization, studying nebular photography, photometry, and spectroscopy.

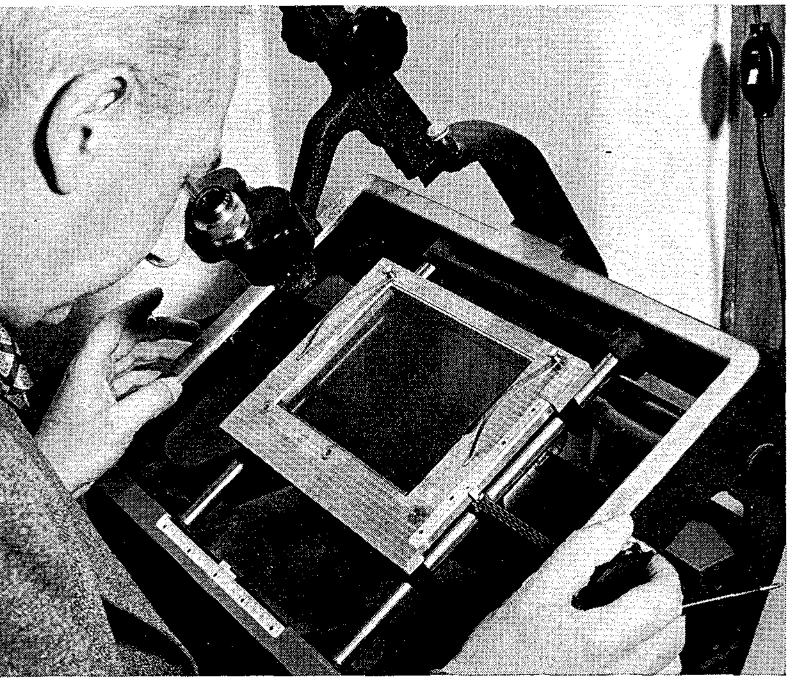
He has received honorary D.Sc. degrees from Oxford, Princeton, and Brussells, and holds an honorary LL.D. degree from Occidental. For his service as chief ballistician and director of supersonic wind tunnels at Aberdeen Proving Grounds, Md., in World War II, Hubble was awarded the Medal of Merit and has been retained as consultant at their research laboratory. He is a member of the National Academy of Sciences, the American Philosophical Society, the A.A.A.S., and the Astronomical Society of the Pacific. He holds honorary fellowships from England's Royal Astronomical Society and Vienna's Academy of Sciences.

Resident of San Marino, Calif., Dr. Hubble is also active in Southern California as a trustee of the Huntington Library and Art Galleries, member and past chairman of the Los Angeles Committee on Foreign Relations, and a member of the United World Federalists of California.

light—the spectrum is continuous and each color blends into the next, starting with red at one end and continuing through orange, yellow, green and blue to violet at the other end.

However, if the light source is a glowing gas—gas such as that used in a neon sign for example—the spectrum is broken up into a series of bright disconnected lines. In some instances, such as light from a filament shining through a gas, the same lines appear as black ones cutting across the continuous colors of the incandescent light.

The arrangement and number of these lines, regardless of whether they are dark or bright, are determined by the gaseous chemical elements in the source. Helium has one characteristic group of lines, hydrogen another, vaporized iron another, etc. Thus it is possible to determine accurately by spectroscopic analysis the presence of elements in a star source.



Dr. Walter Baade of the Mount Wilson Observatory examining a plate with a comparator. Photograph by E. R. Hoge.

Also, the brighter the line the greater the amount of this element, so by measurement of brightness and characteristic groups of lines, both the element and its quantity can be determined.

By comparing the relative brightness of red and blue parts of the spectrum, the astronomer can determine the temperature of the star. He can also determine the velocity at which the star is moving by comparing the shift in spectrum lines with those of the same element in the laboratory. So too, he can determine the pressure in the source star by studies of intensities of lines.

Thus, by all these means, the astronomer can learn a great deal about the makeup, size, distance, temperature and pressure of a star millions of light years away (a light year is the distance light, traveling at 186,000 miles per second, goes in one year).

In obtaining spectrum information, the astronomer uses a spectrograph. Here too he takes photographs and does not observe visually. Spectroscopic exposures may require an entire night, or even more than one night.

After photographs have been obtained, the astronomer returns to Pasadena and begins his laboratory analysis of what he has secured. These laboratories are equipped with many precision instruments designed to measure astronomical data obtained photographically. There are comparators which can measure the position of a star image or a spectrum line with an accuracy of a few thousandths of an inch. There are microphotometers for measuring the blackening of photographic images quantitatively to determine the brightness of the star or the strength of the spectrum line. This information can in turn be used to calculate the distance of the star or the amount of any given chemical element it may contain.

It may often take weeks, or even months of work in the laboratory to measure and interpret information obtained on photographic plates in a single night. Thus, between the time an observation is made and the determination of complete information about that particular photograph, there may be a lag of months. It is for such reasons that knowledge of new information about the universe obtained by the 200-inch telescope may not be announced for a year, perhaps years, after such data was actually recorded on a photographic plate.

PHOTOGRAPHING THE STARS

TODAY'S astronomer observes a photographic plate. In large observatories the visual observer has all but disappeared. At Mt. Wilson, in all of the solar and stellar records that are made, the only visual observations now taken are a drawing of the sun and a record of the magnetic field strength of sun spots. Except for the possible examination of a comet, it is very improbable that an astronomer at a large observatory will look through a telescope.

The many photographs exposed at an observatory are used not only for immediate scrutiny, but also for future reference. Of the over 50,000 taken since the Mt. Wilson Observatory commenced operation, a great number have been filed after only a cursory study. While stars that have been recorded by the 100-inch Hooker telescope may be traveling at a rate perhaps one-quarter the speed of light, the distances involved are so great that a wait of many years, perhaps 20 to 50, will be necessary before a shift can be measured. It is with this future comparison in mind that so many photographs have been taken.

Another of the advantages of photography is the accumulative property of photographic emulsions. A five-minute exposure will show all of the stars that