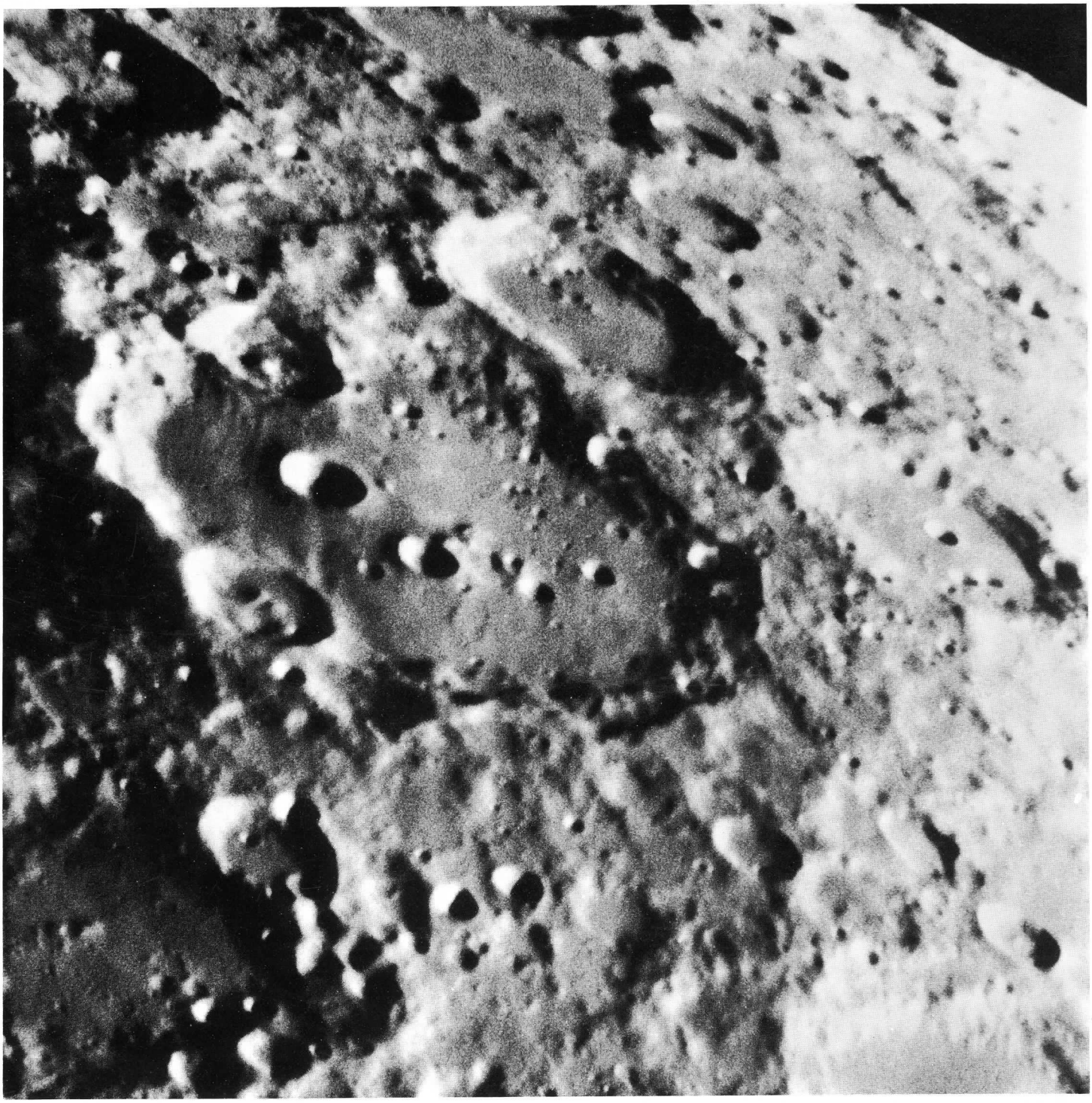
the ASTROGRAPH



VOLUME 5 NO. 1 AUGUST SEPTEMBER 1973

THE ASTROGRAPH



Cover Photograph
Crater Clavius and Surrounding Area

Photographer	R. Price
Date	November 9, 1971
Telescope	12.5 inch F/6 Reflector
Exposure	1 second
f No.	80
Film	IV-E
Developing Time	6 minutes
Developer	FG-7
Temperature	70°F
Enlarging paper	Agfa Brovira #5

Volume V No. 1

Editor — Robert C. Price

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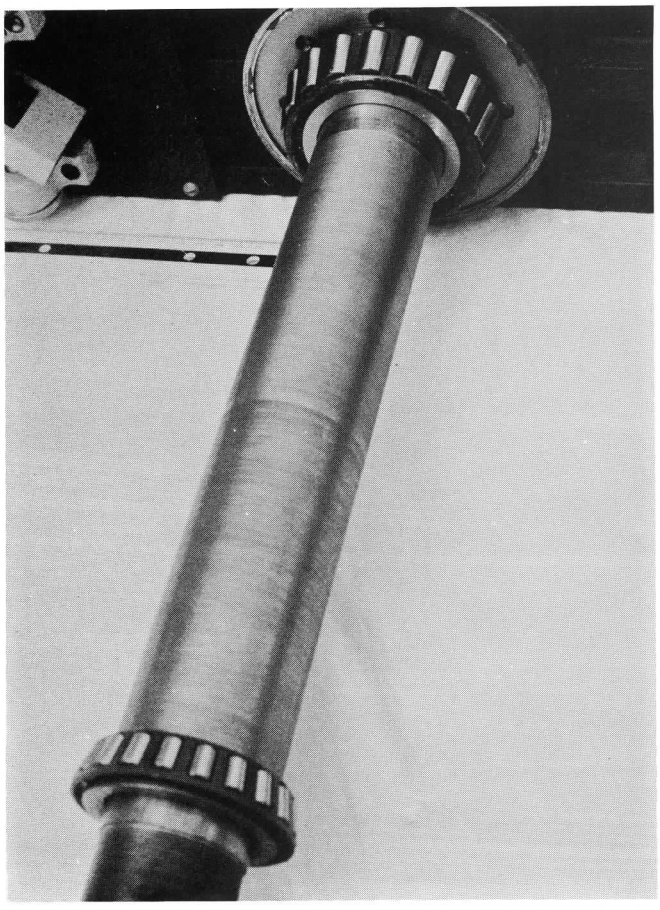
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BASICS OF ASTROPHOTOGRAPHY

The Equipment

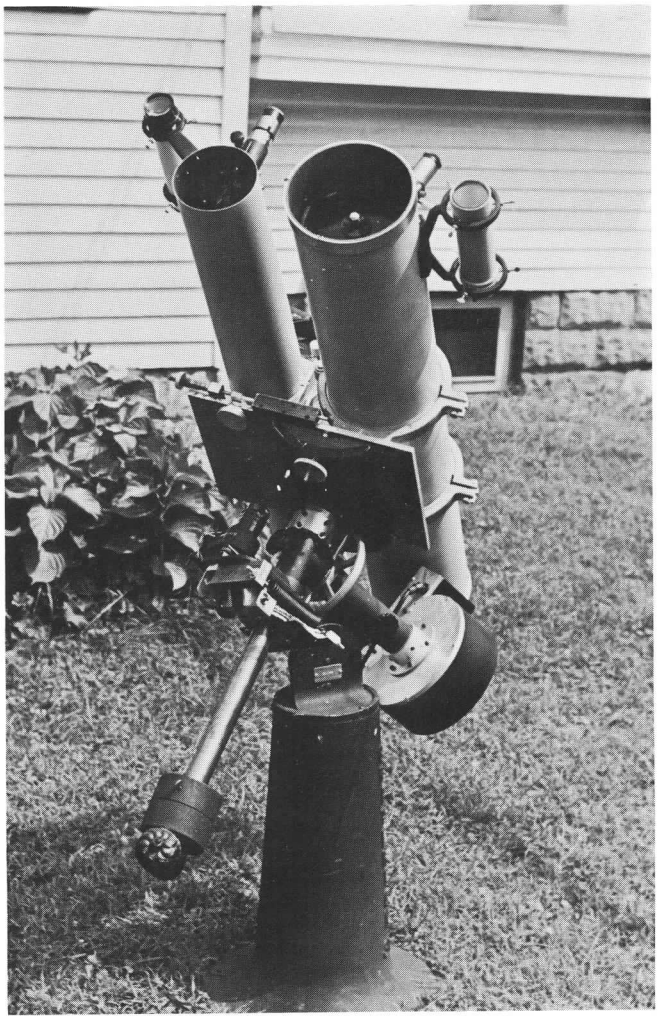
Mechanical Considerations. When considering the utilization of telescopes for astronomical photography. far more attention must be given to the quality of such mechanical items as the mounting, clock drive and optical housings, than to the quality of the optics. Deep sky photographs taken at prime focus would be almost indistinguishable whether 1/20 wavelength optics were used or 1/4 or even 1 wavelength optics were used. Only under perfect seeing conditions when attempting high resolution lunar and planetary photography is there even the slightest difference between 1/20 wavelength and 1/8 or 1/4 wavelength optics. The overwhelming majority of excellent astronomical photographs are taken with equipment that is above average mechanically.

Mountings. A massive and stable mounting is a necessity for both prime focus and high resolution photography. The shafts of both axis should be at least 1/6 the diameter of the objective, and preferably 1/4 its diameter. If brass bushings are used, they should fit the shafts to within one thousandth of an inch. Roller thrust bearings are preferred because of the fact that all lateral motion can be eliminated by tighening the bolt on the shaft that holds the bearing in place. Roller thrust bearings are the type which are used in the axel of most automobiles. When used in telescope mountings, it is extremely difficult not to understress them in terms of lateral and axial thrust, and RPMs. As with other types of bearings, the inner and outer surfaces must be press fit in to the housings and over the shafts. This assures the elimination of lateral motion. There is a great deal of craftsmanship involved in making mountings properly. Even the slightest gap between the bearing and its housing or shaft will result in an annoying jitter especially in the declination axis.



ABOVE: Author's mounting disassembled to show roller thrust bearings.

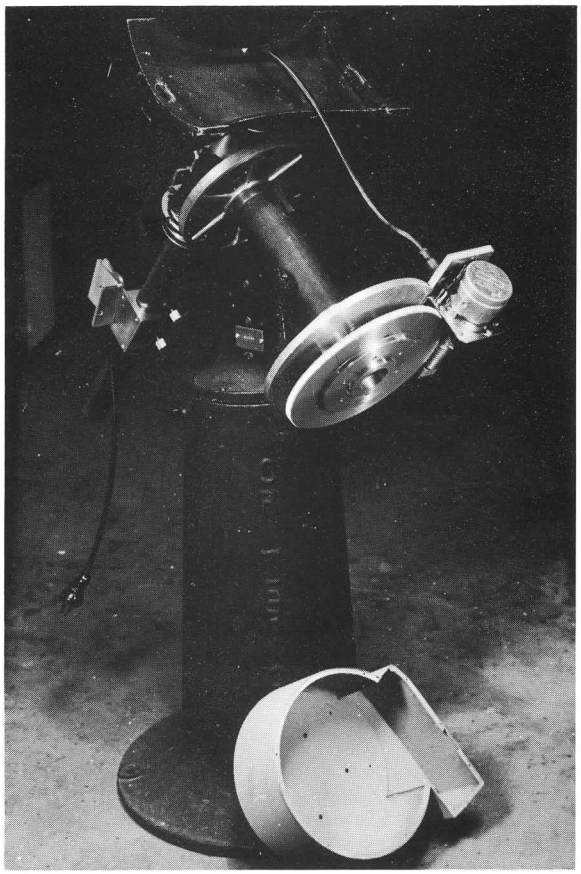
When roller thrust bearings are used the shafts are frequently tapered in order to utilize a large bearing on the upper ends of the axis where the majority of weight and lateral thrust are concentrated. Although the larger bearing is not needed to take the stress, the larger bearing and shaft diameter does add greatly to the rigidity of the mounting. When a mounting is equipped with setting circles, it must have both axis very nearly perpendicular to each other. Otherwise, the reading will not be accurate whenever the mounting is moved considerable distances over the celestrial sphere. The mounting should be perminently mounted on a metal or concrete pier. For maximum stability the center of gravity of the mounting should be situated over a third of the pier. The alignment of the polar axis, while not critical for high resolution photography, is criticial for prime focus photography. The reason for this is the difference in exposure times. High resolution photography generally is limited to exposures of a few seconds. This is not enough time for the drift in either axis to effect resolution. Prime focus photography usually involves exposures of tens of minutes. Thus there is sufficient time for the scene to rotate. The fact that large negatives covering larger angular fields of view are



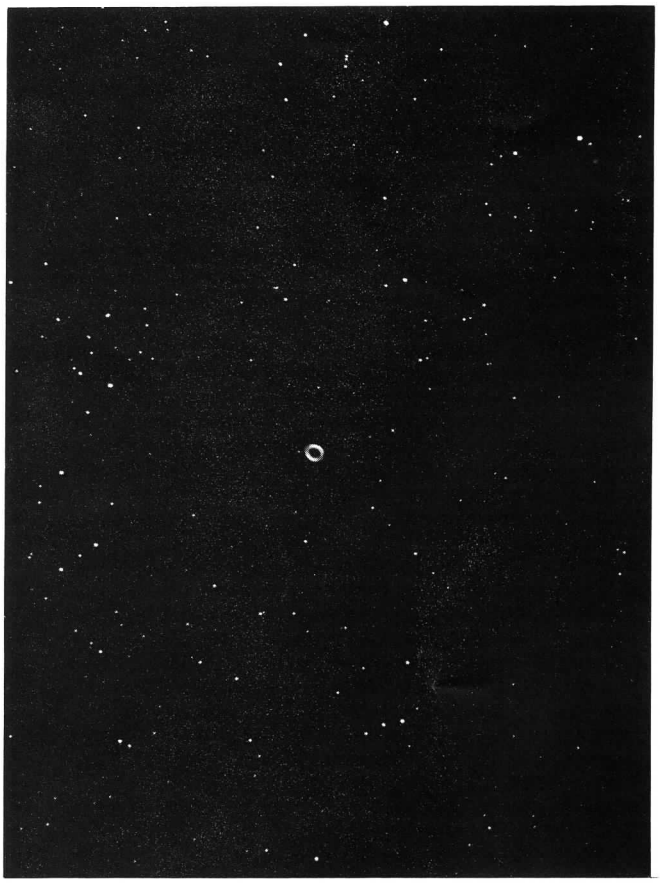
ABOVE: Howard Zeh's 8 inch reflector and 4½ inch f/10 guide scope. Note the glass support for the diagonal to eliminate the spider and thus the diffraction caused by spider arms. Also note that the 8 inch reflector is mounted off center to allow for the weight of the 4½ inch guide scope.

normally used for prime focus photography and that guide stars several degrees from the object being photographed are used also, contributes to the problem. The alignment of the polar axis should be within ten minutes of arc to completely eliminate the phenomina of sky rotation. The photographic method of alignment is probably the most accurate. Alignment accuracies of a few minutes of arc are easily obtained. Once aligned properly typical corrections in declination should average about 5 arc seconds for every 5 minutes of exposure. Even then this correction is most likely due to tube or optical housing fixture. One reason the photographic method is so accurate is that it involves taking a photograph of Polaris with the same instrument that is being aligned. Since Polaris is only one degree from the celestrial pole, alignment errors of even a few minutes of arc are readily apparent. In general the photographic alignment method is limited by the accuracy achievable in positioning the Polar axis while other methods are usually limited by how accurately setting circles can be read. One item that is surprising about photographic alignment is that differential flexture does not seem to be a problem. It appears that the motion of the telescope in a ten or twenty minute exposure of Polaris is not sufficient to cause such flextures. Screw type adjustments for azimoth and elevation adjustments of the Polar axis are quite helpful and greatly expedite any alignment procedure.

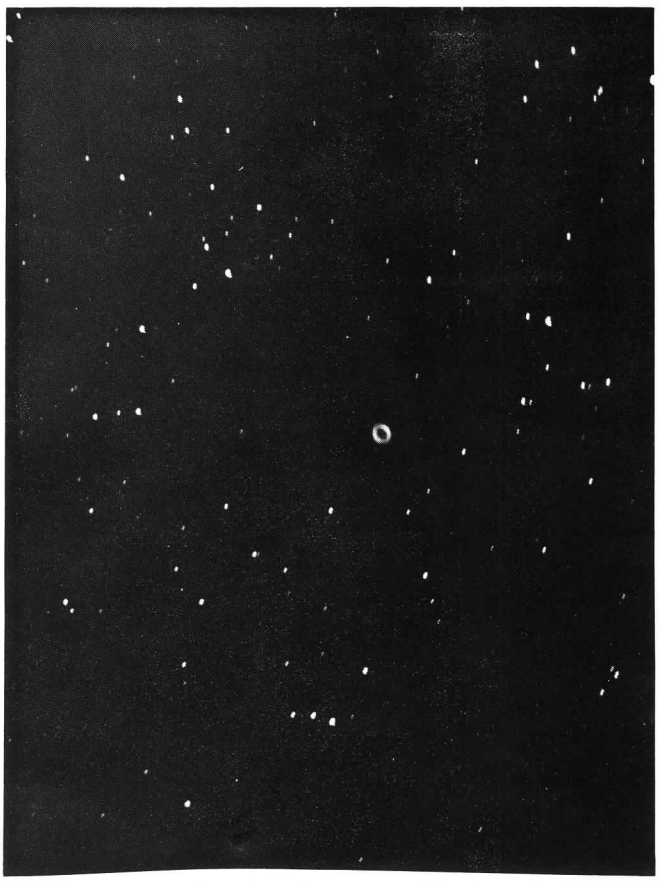
Drives. High resolution photography requires a very smooth clock drive. There should be no short term periodic errors that could tend to smear exposures of several seconds. Prime focus photography requires additional equipment. Both a variable frequency control and a fine manual declination or preferably electric drive are necessary to correct a variety of errors that cause drift in long exposure photographs. A good drive requires accurately cut



ABOVE: Howard Zeh's 8 inch mounting showing a specially designed and built clock drive by Edward R. Byers.



ABOVE: Forty minute exposure of M57, taken on 35mm 4-E film at the prime focus of 12.5 inch f/6 reflector.



ABOVE: Twenty minute exposure of M57. Data same as above except that this photograph was taken with the polar axis aligned visually before more accurate alignment was attempted. Note sky rotation around guide star which is off the photograph to the left.

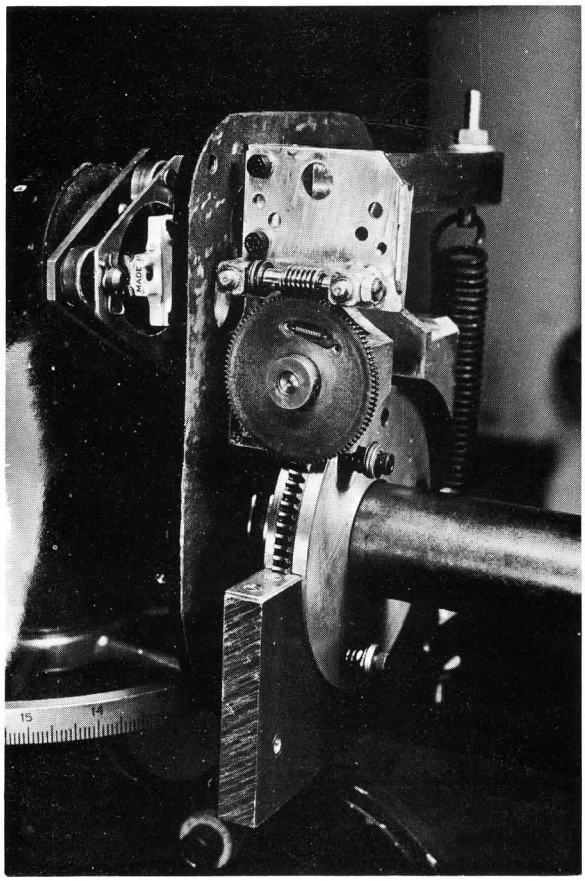
ground and aligned gears and bearings. Fine workmanship is a necessity. Even though drives use syncronious motors and are accurate to within a few seconds, per day, it is the short term periodic error that is the cause of most problems. With a high resolution camera, a good method of evaluating such errors is to offset the polar axis by 30-60 degrees and take a photograph of a bright star. The exposure should be the length of one revolution of the slowest gear in the gear system excluding the last gear which is usually at siderial rate. If the drive were perfectly free of periodic errors, the photograph would show the drift caused by polar axis misalignment as a straight line.

Periodic errors will show up as a corkscrew image. More than one error may be seen, looking like two sign waves of different frequencies added together. By knowing the exposure time and scale of the photograph, the error can be calculated and the gear causing that error isolated. The declination drive should have anti-backlash provisions, because corrections in both directions are frequently needed in the same exposure. Such corrections are usually caused by differential flexture, or temperature difference and although they are frequently in one direction, they do sometimes abruptly change direction in the middle of an exposure. When this happens, it is most helpful to be able to correct this without having to take up the backlash in the gear. Since it is difficult to estimate the amount of backlash, it is quite easy to overshoot when attempting this correction and thus ruin the exposure. In general there are types of gear arrangements for declination movements. One type is similar to the polar axis and involves a worm driven gear with the appropriate reducing gears between the motor and worm, which allows correction motions slow enough to allow corrections of a few arc seconds easily. The other type is a tangent arm, which does not require as many reduction gears.

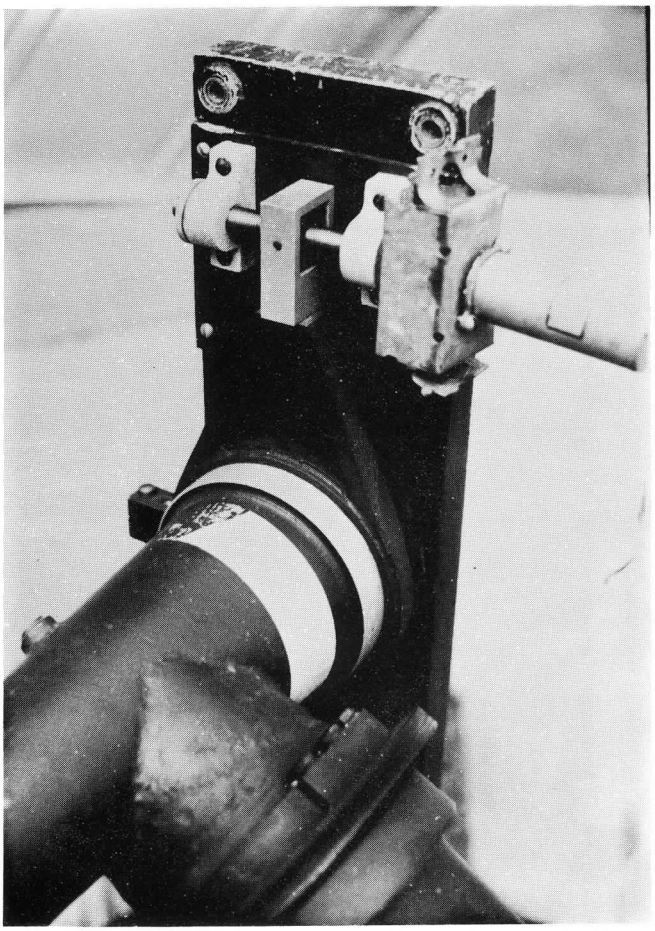
Saddles, Tubes, Mirror and Diagonal Holders.
The rotating tube feature on a telescope is not only a convenient feature by may be a necessity in some cold areas where the rising warm air from the observer's body may be as bad as the worst atmospheric turbulance. By being able to rotate the tube, a person can position himself so that this rising air does not come between the mirror and object, or if there is a slight breeze, downwind of this critical light path.

The most popular and best tube material this author has found is fiberglass. The original tube for my 12 inch reflector was a 15 inch diameter sheet metal tube without insulation. During winter the performance was very poor even after the tube was allowed to cool for several hours. There were always some air currents which appeared as bright ribbons crossing the mirror's surface when viewing an out-of-focus star image. After several minutes of observing, these currents seemed to increase as if the tube was absorbing and transmitting the body's heat into the tube. The next tube, a 16 inch diameter cardboard tube with 3/8 inch walls eliminated these problems but seemed to absorb moisture and flex during long exposures. My current fiberglass tube seems to improve the optical performance and is considerably more rigid. The thick aluminum tube would be even more rigid than the fiberglass tube.

If one's interest was only prime focus photography using a separate guide scope, I recommend two such tubes with cork insulation. Painting metal tubes white on the outside helps prevent heat from being absorbed.



ABOVE: Howard Zeh's anti-backlash declination drive which is spring loaded.

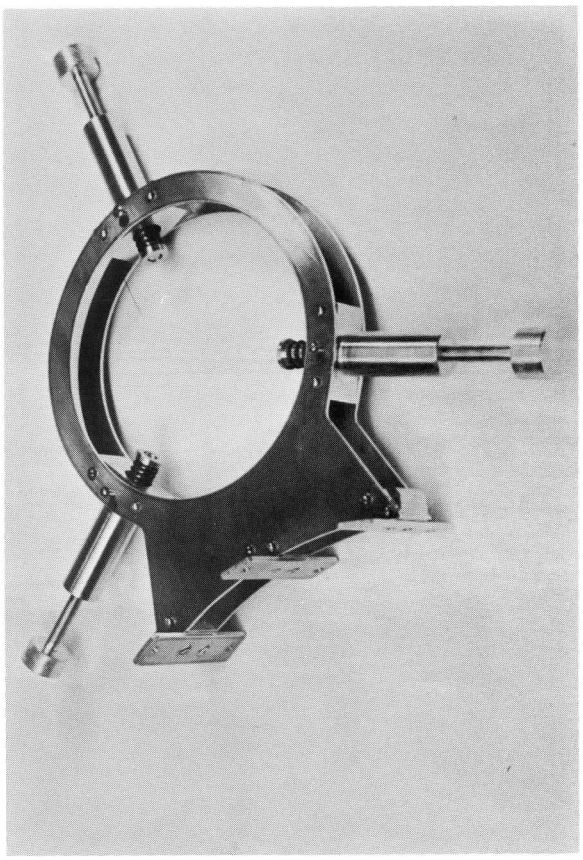


ABOVE: Author's tangent arm declination drive.

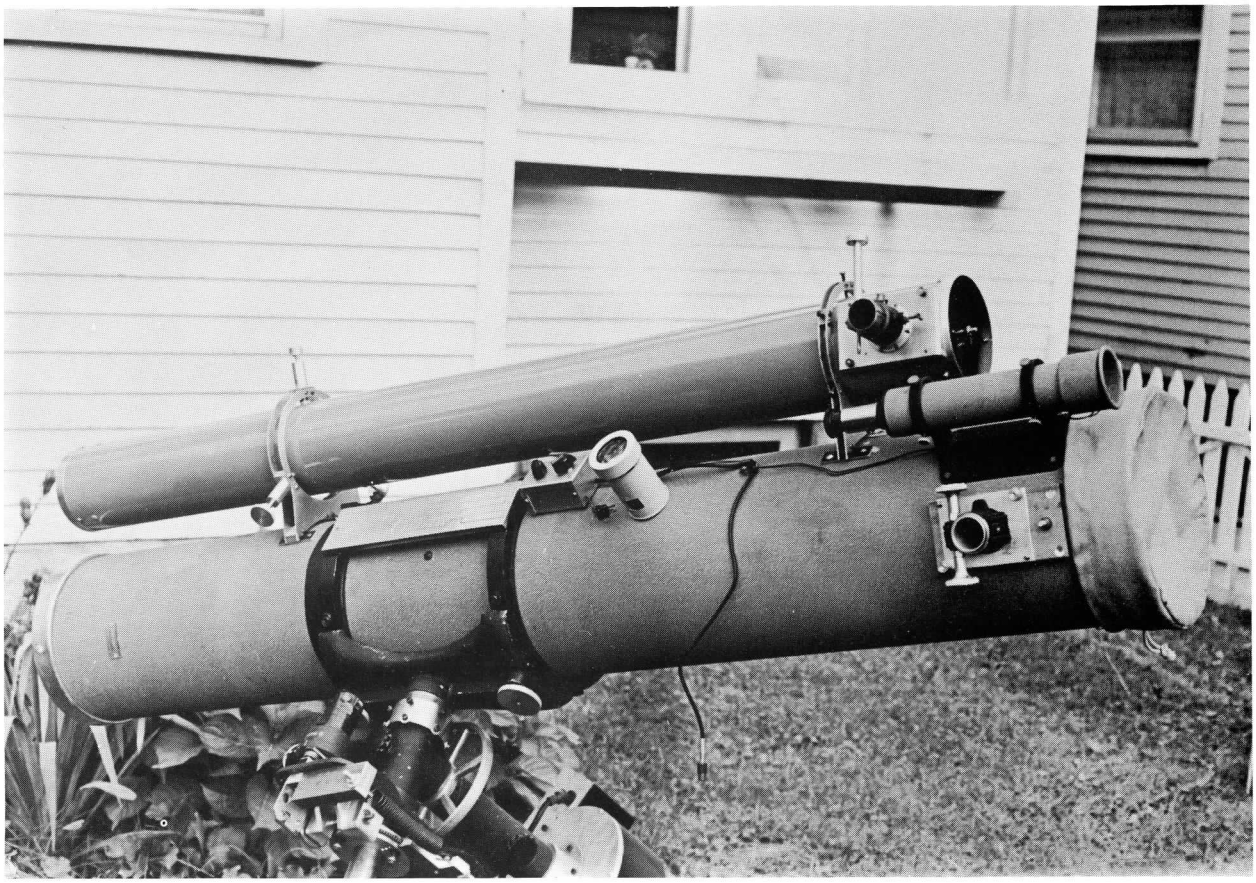
When using the telescope for high resolution photography, a guide scope is useful to monitor the seeing, but its mechanical sturdiness is not as critical as when attempting prime focus photography; then the mechanical sturdiness of the guide scope, the main telescope and all holders of optical components is of major concern because differental flexture or movement of these mechanical parts by as little as one half minute of arc will ruin minutes of perfect guiding. The use of an off-axis guiding system eliminates most of these problems but has the one disadvantage of limiting the area in which a suitable guide star can be found. In addition, once a star is found, it is off axis and exhibits considerable distortion and in most cases does not use the full aperture of the main telescope.

One feature you should look for in mirror mounts and diagonal holders is eas of alignment and the ability to lock the alignment in without disruption.

Optical Considerations. Prime focus photography requires only mediocure optics, and the alignment of optical components is not critical. High resolution photography does require 1/4 to 1/8 wavelength but not necessarily perfect optics and the alignment is critical because misalginment results in loss of contrast and detail. The author prefers to do final alignment on Jupiter, observing the inside and outside focus appearance to determine accurate alignment. The expanding out-of-focus image should be symmetrical when the optics are in perfect alignment. Reflectors are useful for narrow (one to two degrees) field of view prime focus photography; one must use either a refractor of Schmidt to photograph wider fields. Small F valve refractors are corrected over a relatively small spectral range, unless three or more elements are used in the objective; whereas small F



ABOVE: Close up of guide scope holder for ease in guide star acquisition.

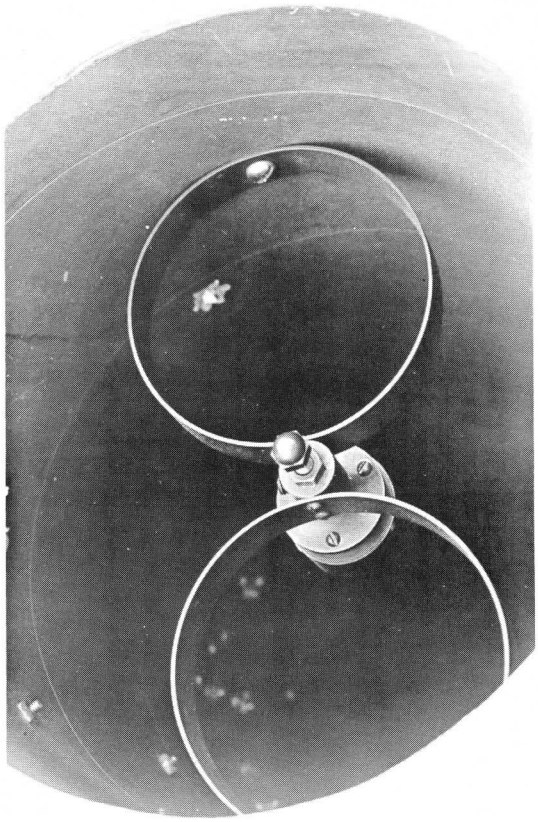


ABOVE: Howard Zeh's 8 inch reflector with 4½ inch F/13.5 guide scope. Note eyepiece holder and guide scope holder assemblies.

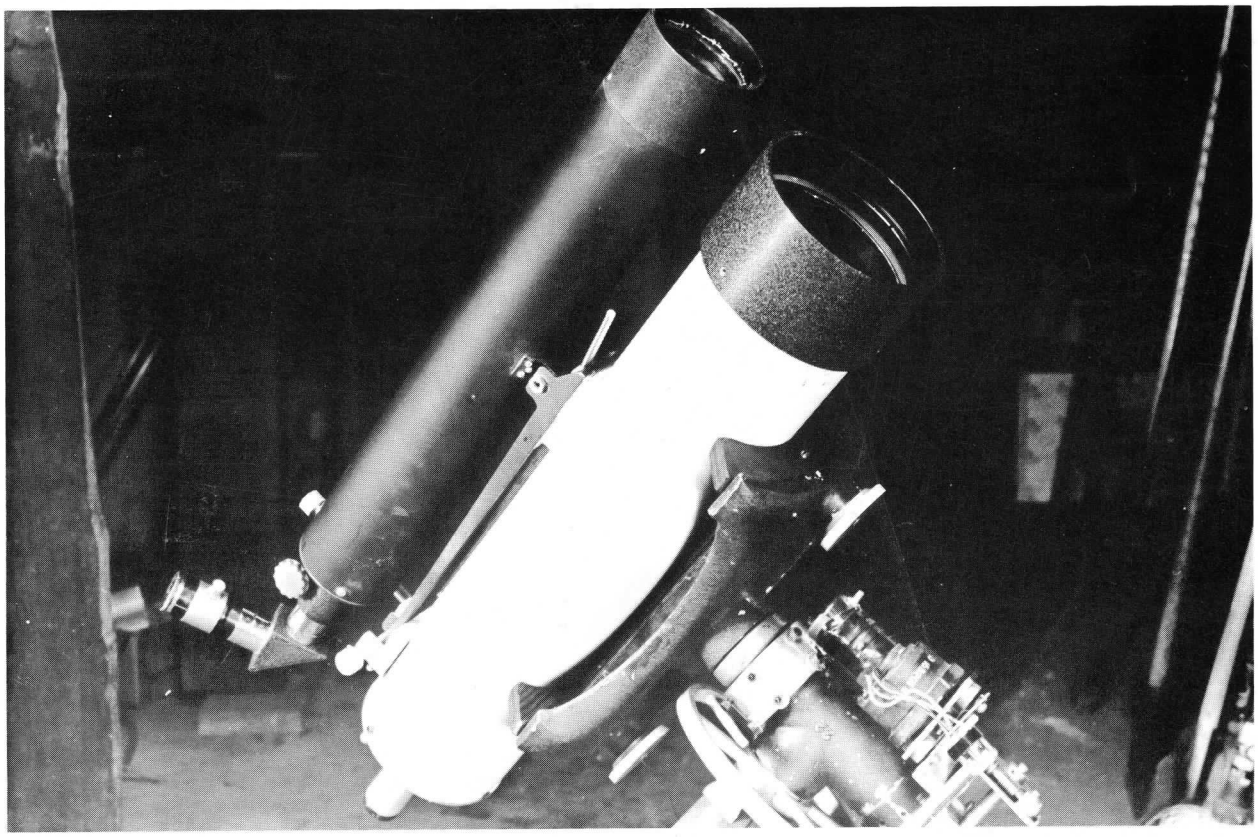
reflectors are quite common and their nature, fully color corrected. Sometimes refractors require color filters for both high resolution and prime focus photography. The refractor has the advantage of the closed tube, thus eliminating the problems of heat currents as previously described, and in addition the absence of a diagonal makes alignment easier and eliminates both the light obstructed and lost in the reflection from the diagonal. Alignment becomes very critical when focal ratios become less than 6. The figure of F/6 and faster mirrors tend to change less with temperature changes than mirrors slower than F/6. In any event high resolution photography should not be attempted unless the temperature of the telescope is in equilibrium with that of the air. This can easily be determined by viewing an out-of-focus stellar image. This image should be very sharp and free of distortions such as air currents and atmospheric turbulance.

The Camera. When used with a telescope, a camera is only a means of holding film and timing the exposure, and sometimes not even the latter. For small F.O.V.s high resolution and prime focus photography, the 35mm camera is the best instrument to use. Plateholders must be removed to focus and the film must be uncovered in preparation for an exposure. These actions can disturb the critical position of the camera when in focus. In addition it is easier to take and develop a larger number of negatives with a 35mm film. Plateholders are necessary for wide F.O.V.s for both prime focus and lunar photography.

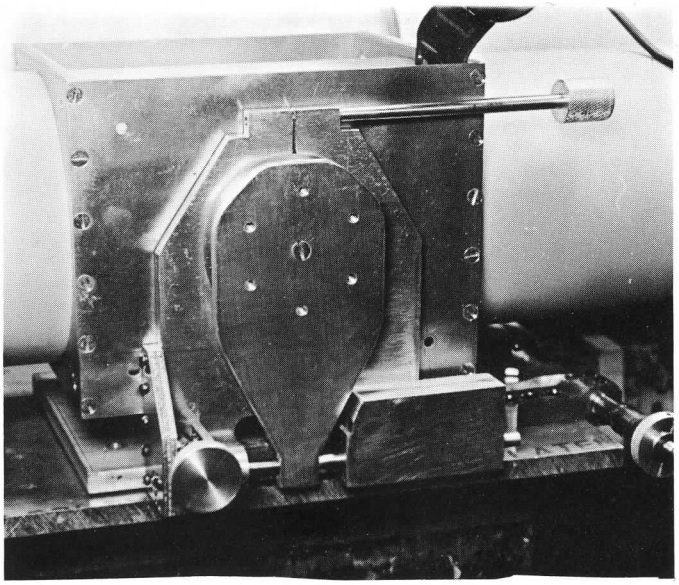
One disadvantage to the 35mm camera is the shutter recoil and mirror slap. Although of no consequence for prime focus photography, the resulting vibration is usually sufficient to effect the resolution if long effective focal lengths are used. This author first used a leaf type of shutter and then suspended the shutter on rubber bands to eliminate all vibrations.



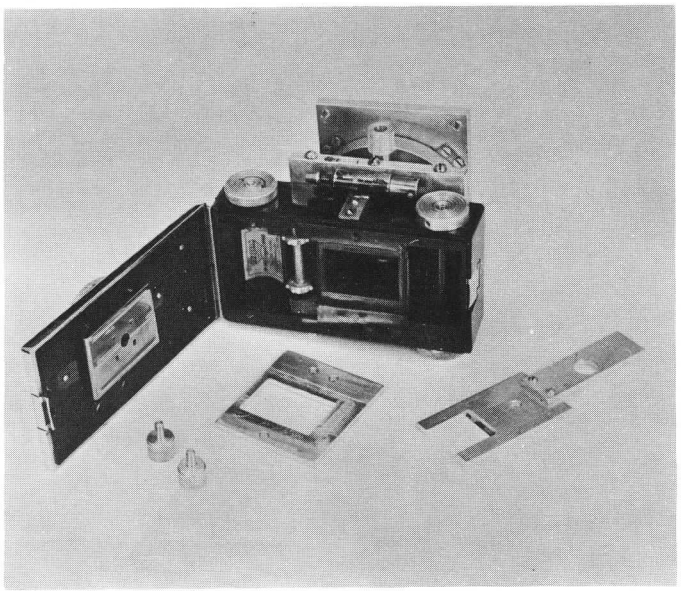
ABOVE: One method Howard Zeh has tried to minimize diffraction effects in long exposures is shown here. This type of diagonal holder eliminates the spides caused by the spiders arms which make bright stars show up as crosses on long exposures



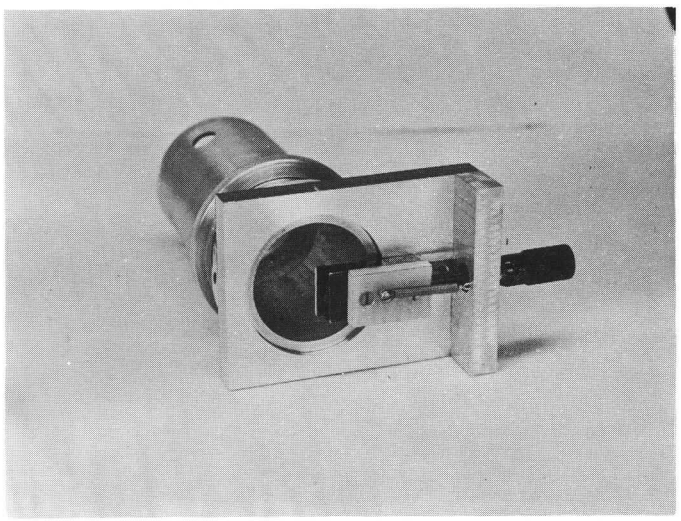
ABOVE: Howard Zeh's 5 inch F/5 refractor and 3 inch F/8 guide scope. Note that the mounting is the same as used with the 8 inch.



ABOVE: Close up of Howard Zeh's off setting system for his 4¼ inch f/10 guide scope, seen with his 8 inch reflector in the photograph on page 3.



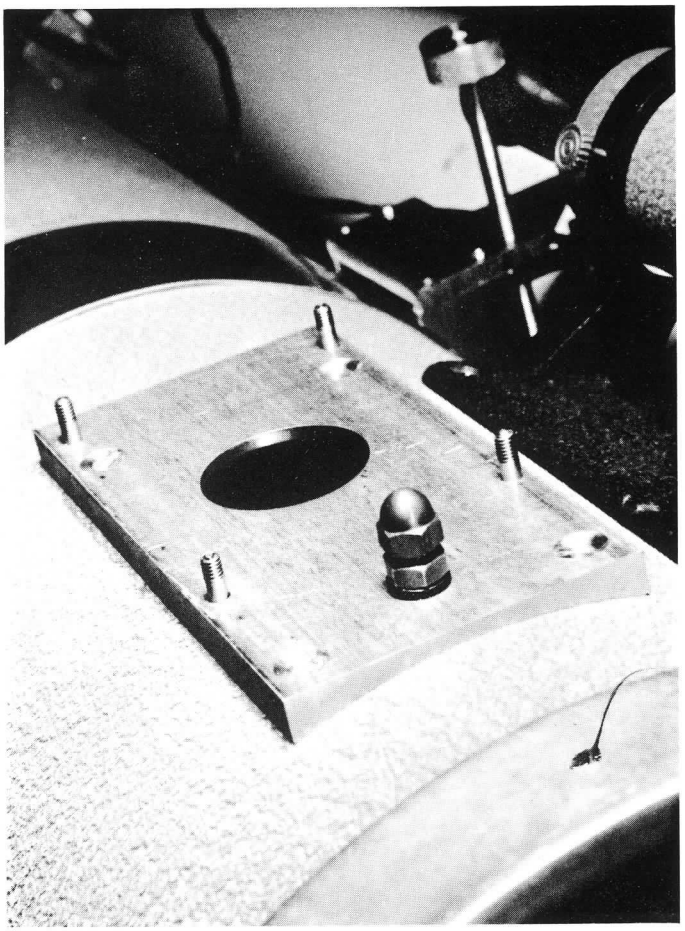
ABOVE: Howard Zeh's camera and knife edge parts for focusing at prime focus.



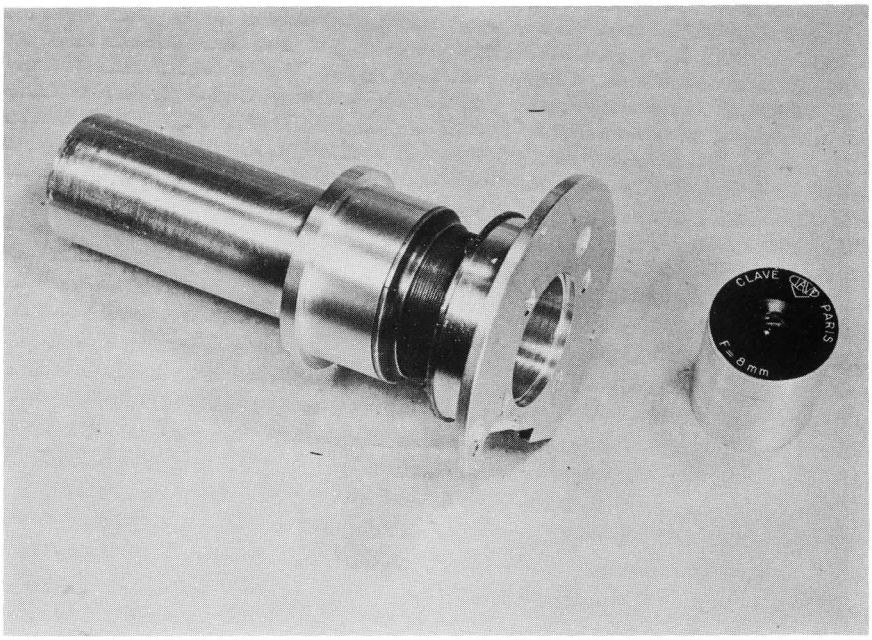
ABOVE: Howard Zeh also uses a dummy camera assembly shown above for prime focus focusing.



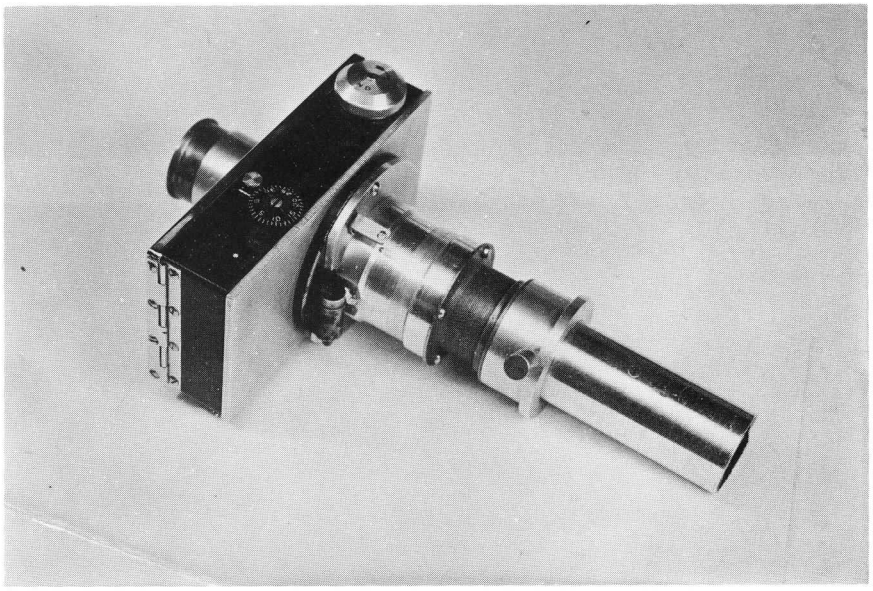
ABOVE; Howard Zeh's 8 inch with demountable thin helical focusser for prime focus photography.



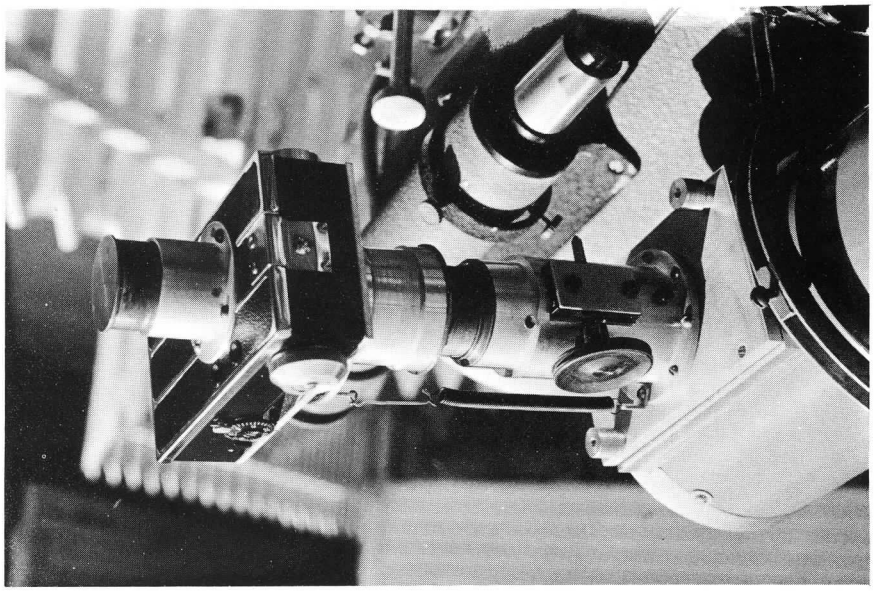
ABOVE: Base for demountable focusser.



RIGHT: Howard Zeh's camera tube assembly. Here is a standard ocular with the tubes outside diameter turned to light press fit the camera tubing.



RIGHT: Camera assembly set up to work at F/112 using the 8mm clave ocular



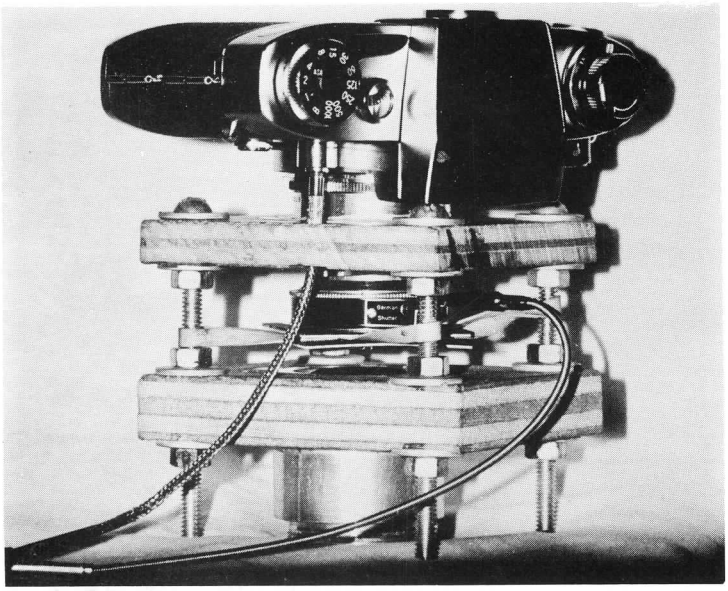
RIGHT: Camera assembly attached to the 4½ inch reflector. Note eyepiece attachment on back of camera for focusing prior to film loading.

With both plateholders and 35mm cameras, the focusing screen ground glass must be positioned to within 1/100 inch of the film plane to assure accurate focus. The film itself must be positioned to within this same accuracy of the image plane for prime focus photography. This positional accuracy represents a resolution of 10 arc seconds based on 12 inch F/6 optics which is a reasonable figure for guiding accuracy. High resolution photography requires that the projecting eyepiece be positioned to within 1/1000 inch because a resolution of 2 arc seconds or less is the desired photographic capability of most medium size telescopes. For extremely accurate focusing in prime focus photography, a knife edge or dummy camera with knife edge may be used. This author has found that the cross checkered focusing screens on 35mm SLRs to be as accurate as knife edge focusing. When a projecting eyepiece is used, it should be of high quality in order to insure good focus over as much of the field as possible, and it must be accurately aligned with regard to the image plane of the objective and film plane of the camera. The use of projecting eyepieces and prime focus photography requires a very smooth and accurate rack and pinion holder since the usual procedure for focusing calls for examination of the image both inside and outside of focus.

The rack and pinion must also have a minimum of backlash in order to prevent vibrations during the focusing procedure and to insure that the position of the camera is maintained once proper focus is achieved, especially if several exposures are to be taken at the same focus.

In general, with regard to high resolution photography, one should be able to photograph more than can be viewed on the focusing screen; if not something is wrong, such as the alignment of the film plane projecting eyepiece and focal plane; misposition of the focusing screen with respect to the film plane; or shutter vibration. With regard to the guiding eyepiece used for prime focus photography, I recommend at least two times magnification per inch of focal length of the camera and preferably twice that. Guiding error should be no more than 10 arc seconds with a camera focal length of 50 inches. The type of cross hair eyepiece this author prefers is the illuminated reaticle. This type presentation is that of lighted corss haris with almost no back-graound illumination.

Robert C. Price



ABOVE: Author's high resolution camera using a shutter suspended by rubber bands to eliminate shutter vibration. Cover Photograph taken using this camera, 8mm ocular enclosed in 2 inch O.D. tubing at bottom.

Astrophotography for August-September

Lyra and Cygnus

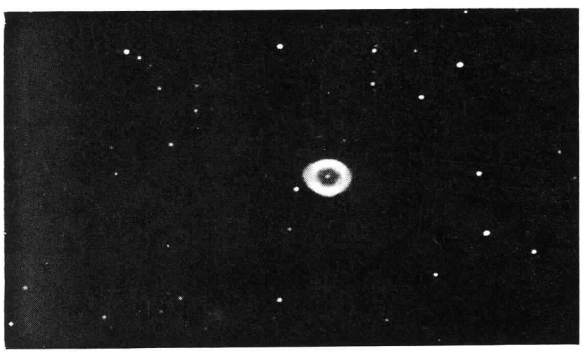
Lyra is one of the best known and most easily located constallations. It is characterized by Vega and four other stars composing a trapazoid. Figure 1 encompasses almost the entire constallation. Although Lyra is lacking in number in photographic objects, the famous Ring Nebula (M57) located at R.A. $18^h51^m.7$ Decl. $+32^o 58^m$ makes up for this lack of quantity. Also located in Lyra and just off the bottom and slighty left of center of Figure 1 is M56, an 8th magnitude Globular cluster 5 minutes in diameter located at R.A. $19^h14^m.6$ Decl. $+30^o 05'$.

The Ring Nebula is approximately 9th magnitude and a little over one minute in diameter. I have tried many films and exposure times using my 10 inch F/7 reflector. Fine grain films, such as Plus-X appear to be well suited to this planetary nebula because its small size requires considerable enlargement. With Plus-X I find that an exposure of 40 minutes is necessary to fully reveal the ring and bring out the central star which is 15th magnitude. Faster films such as Tri-X require only about a 10 minute exposure but do not enlarge as well as the finer grain films.

Color films such as GAF 500 easily reveal the red and yellow colors in exposures as short as 20 minutes. Finer grain films such as Kodachrome II just bearly reveal the nebula in 40 minute exposures. I think the optimum might be about two hours with Kodachrome X, but as yet I have not attempted this.

Cygnus is deeply embeded in the nebulosity of the Milky Way. Richard Berry's photograph, figure 2 clearly shows this nebulosity. The well know cross shape of Cygnus, shown in figure 3, is located in the Southwest corner of the constallation which is about three times larger in area than shown in figure 3. The two most outstanding nebula in Cygnus are well known by their shapes, the North American and the Veil Nebula. The North American Nebula (NGC7000) is located a few degrees east of Deneb at R.A. 20^h57^m Decl. $+44^o.1$. The Veil Nebula has two components located at R.A. $20^h54^m.3$ Decl. $30^o32'$ and R.A. $20^h54^m.6$ Decl. $30^o 32'$. Both these nebula are difficult objects because their low surface brightness requires long exposures and clear skies. Both nebula are red and photograph best with red sensitive emulsions such as 103aF, used with red filters. I have had some success using GAF 500 color film and a guided 50mm F/1.4 and 135mm F/3.5 telephoto lense. Ten minute exposures at F/1.4 and 40 minute exposures at F/3.5 reveal both the North American Nebula and the Veil Nebula, however, the colors are not vivid enough to be brought out well in enlargements.

John Phillips



ABOVE: R.C. Price's 40 minute exposure of M57 taken with his 12.5 reflector on IV-E film developed in FG-7 (9% sodium sulphite solution) at 75°F for 6 minutes/



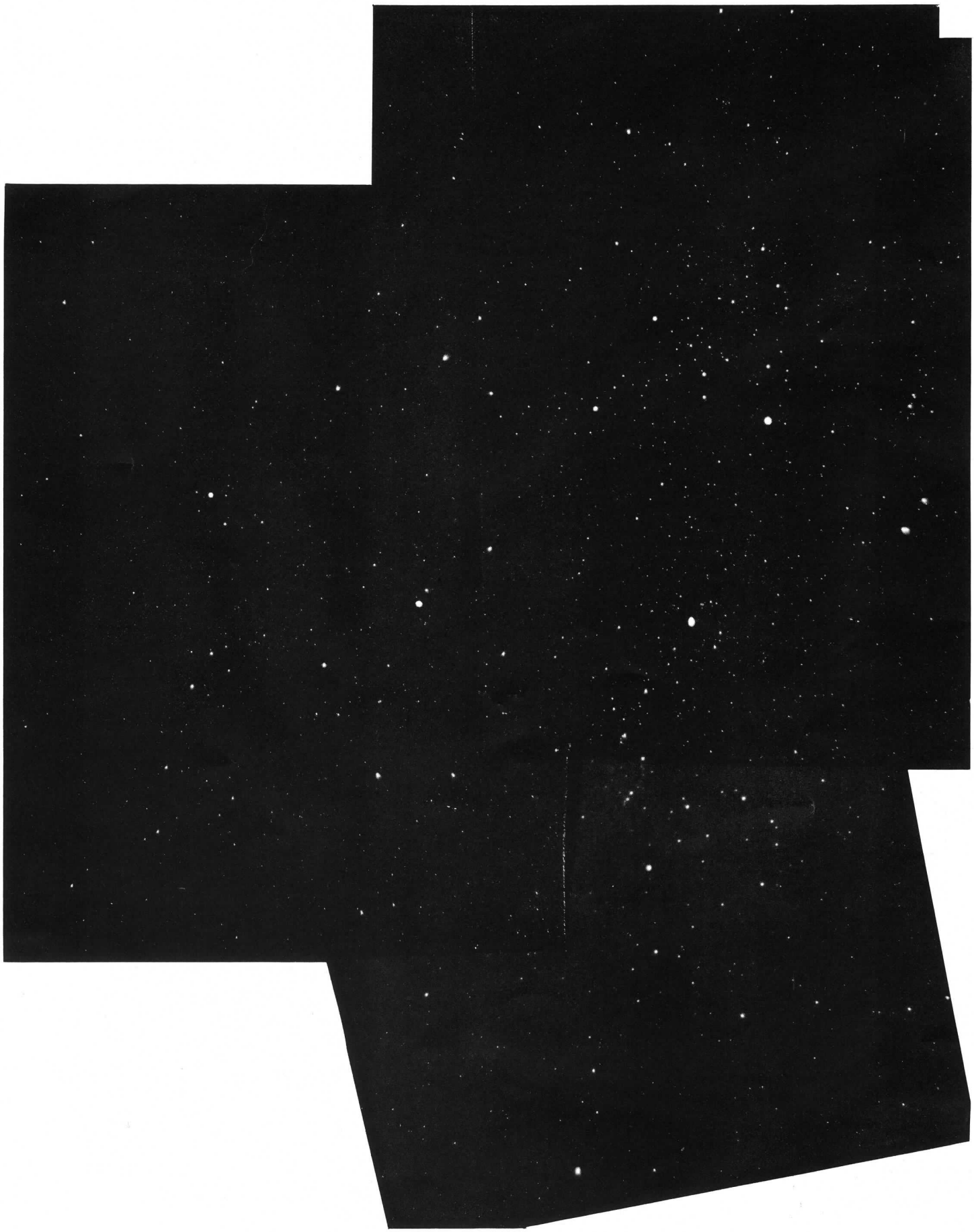
RIGHT: Howard Zeh took this 5 minute exposure of the North American Nebula with a 105mm lens at F/4 and a 35mm camera. He used 103aF film. The bright star in the top center is Deneb.



RIGHT: Figure 1. John Phillips took this 30 minute exposure of Lyra with a 12" F.L. F/2.5 AERO-EKTAR lense. The 4"x5" sheet of Tri-X film covers a $17^{o}x23^{o}$ field.



ABOVE: Figure 2. Richard Berry used his 24 inch F.L. F/7 TESSAR lense for this photograph of the area of the North American Nebula. The one hour exposure was on 8"x10" Royal-X-Pan sheet film which was developed 10 minutes in DK-50. This reproduction is a one-to-one enlargement of his 8"x10" contact print.



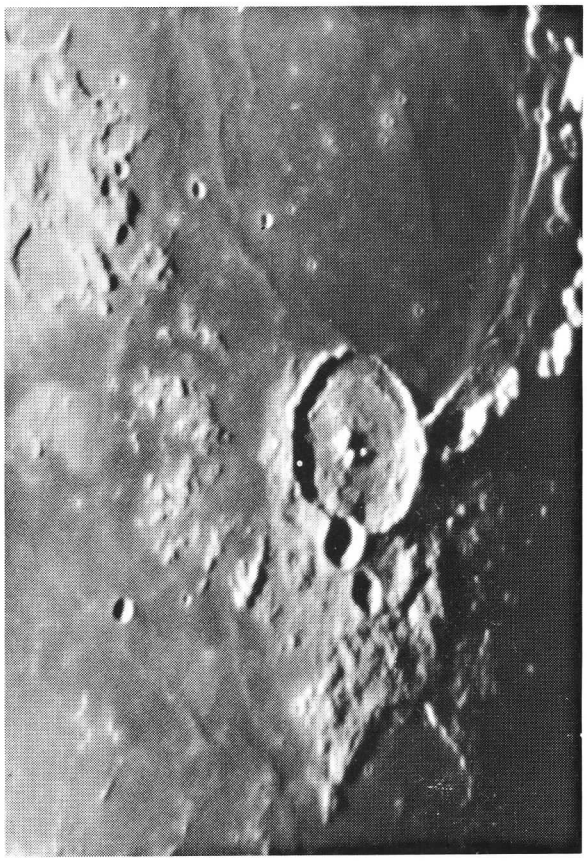
ABOVE: Figure 3. John Phillips combined three contact prints of Cygnus to produce this mosaic showing the well known cross that marks this constallation. Each exposure was 30 minutes on Tri-X 4"x5" sheet film using a 12 inch F.L. F/2.5 AERO-EKTAR lense.



ABOVE: Eugene Harlan took this one hour exposure of the North American Nebula with his 6 inch F/6 refractor. He used a 103a-E $3\frac{1}{4}$"x$4\frac{1}{4}$ plate.

Jovian Photography

Although Jupiter has just reached opposition to the Sun and crosses the meridian before midnight, it is unfavorably placed for photography because it is low in Capricornus.



Martian Photography

During August and September, Mars will grow in apparent diameter from 13 to 21 seconds of arc More important, however, is that it will be well placed for photography, being from +7 to +11 degrees in declination as it moves from Pisces into Cetus and then into Aries. Mars will reach opposition on October 25. This opposition will be one of the best for photography given Mars' diameter and altitude.

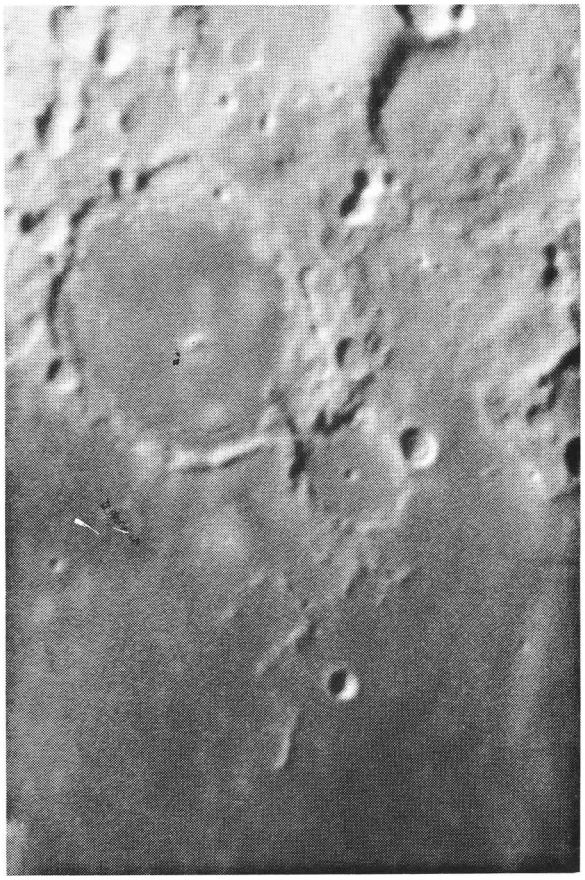
Editor's note:

A special article on Martian photography will featured in the October-November issue.

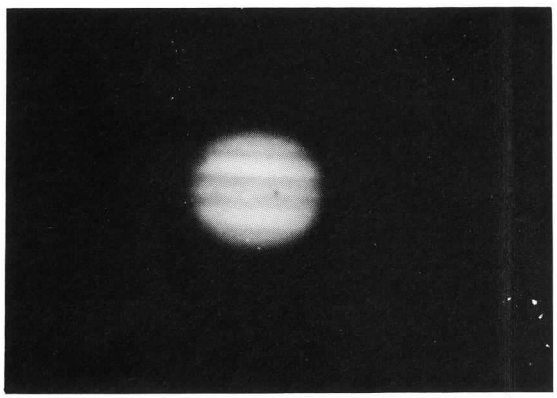
Lunar Photography

The last quarter Moon will be well placed for photography in August while both the last quarter and gibbous Moon will be well placed in September. In general I consider the Moon well placed for photography whenever it is +10 degrees in declination when it crosses the Meridian. This fall the last quarter and gibbous Moon will meet this criteria.

Ralph Proctor



ABOVE: H.F. Zeh



ABOVE: Jupiter photographed by Howard F. Zeh with his 8-inch reflector. Four second exposure at F/80 on VTE film.

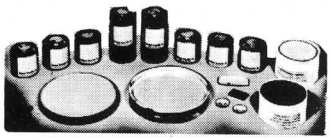
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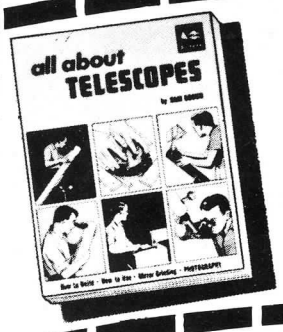
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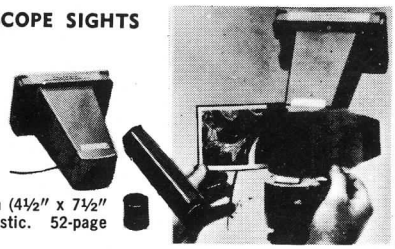


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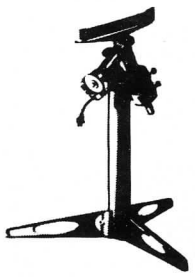
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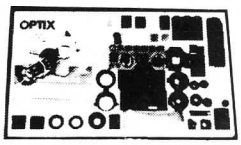
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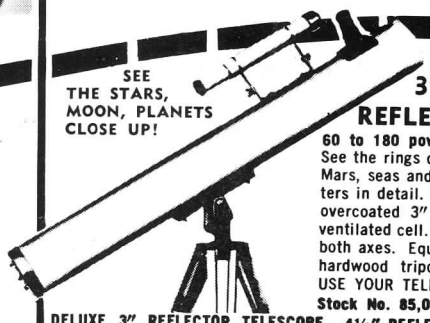




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