UNITRON Instructions

2.4" - 3" AND 4" EQUATORIAL REFRACTORS

UNITRON SCIENTIFIC, INC. 66 NEEDHAM STREET, NEWTON HIGHLANDS, MASS.

Instructions *for* UNITRON®

2.4", 3", and 4" Equatorial Refractors

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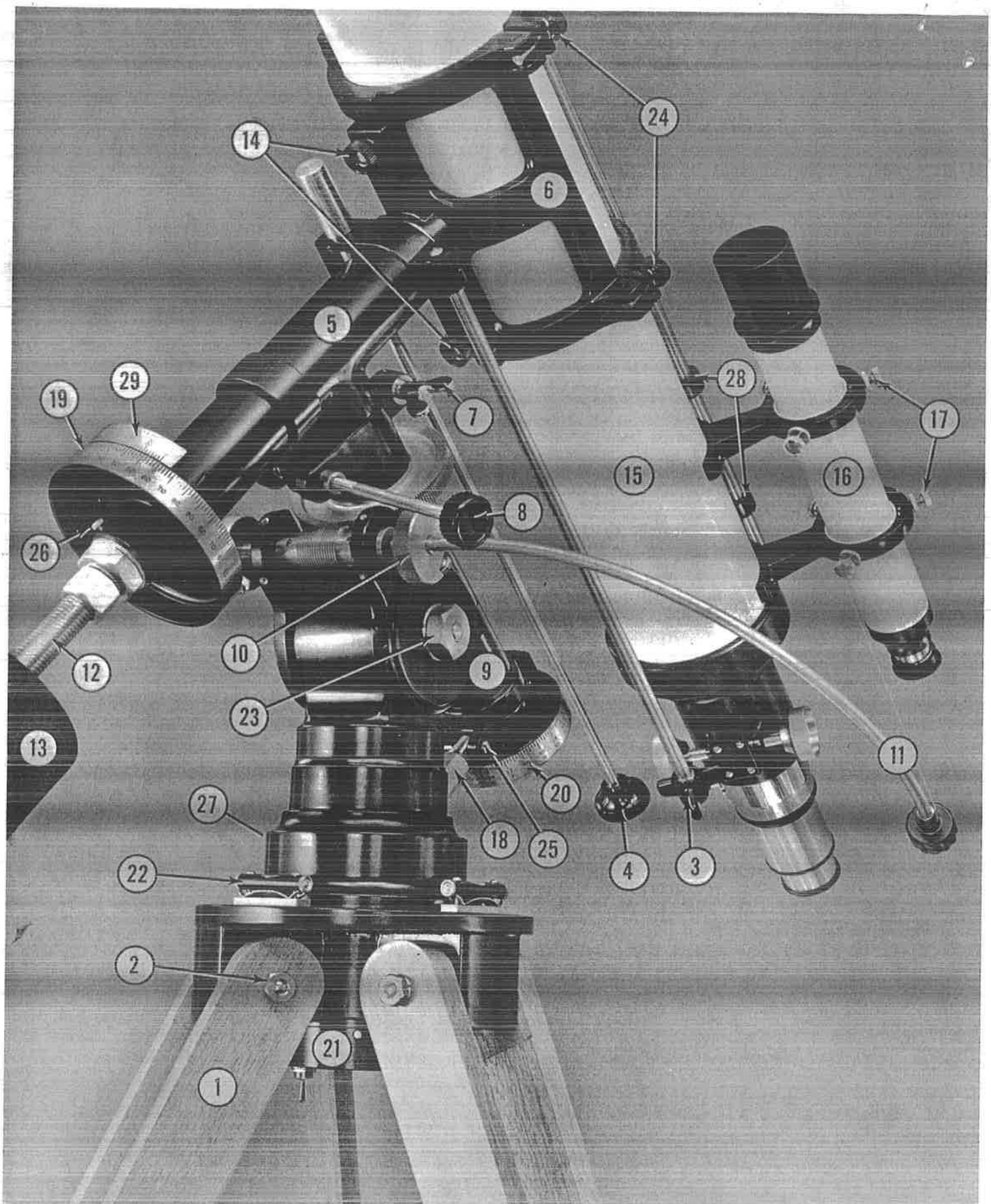

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Fig. 1: UNITRON Equatorial Refractor

1. Tripod legs
2. Tripod leg bolts
3. Declination fast motion clamp rod
4. Declination slow motion control rod
5. Declination axis
6. Cradle
7. Right ascension fast motion clamp
8. Auxiliary right ascension control rod
9. Polar axis
10. Right ascension control knob
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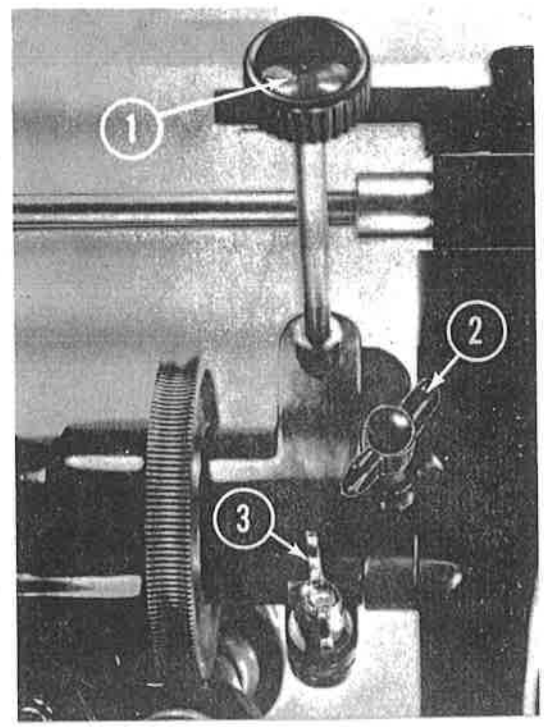
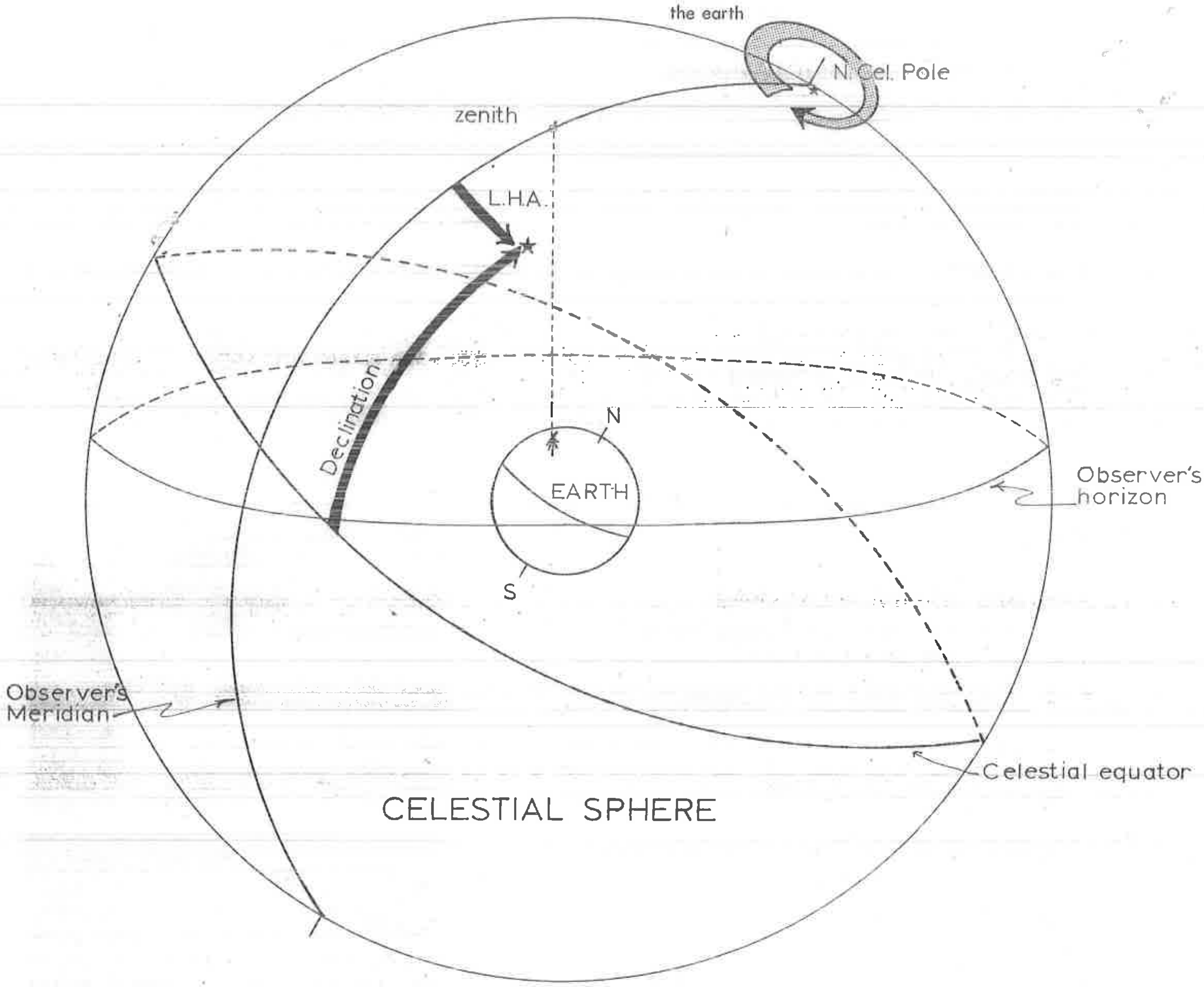
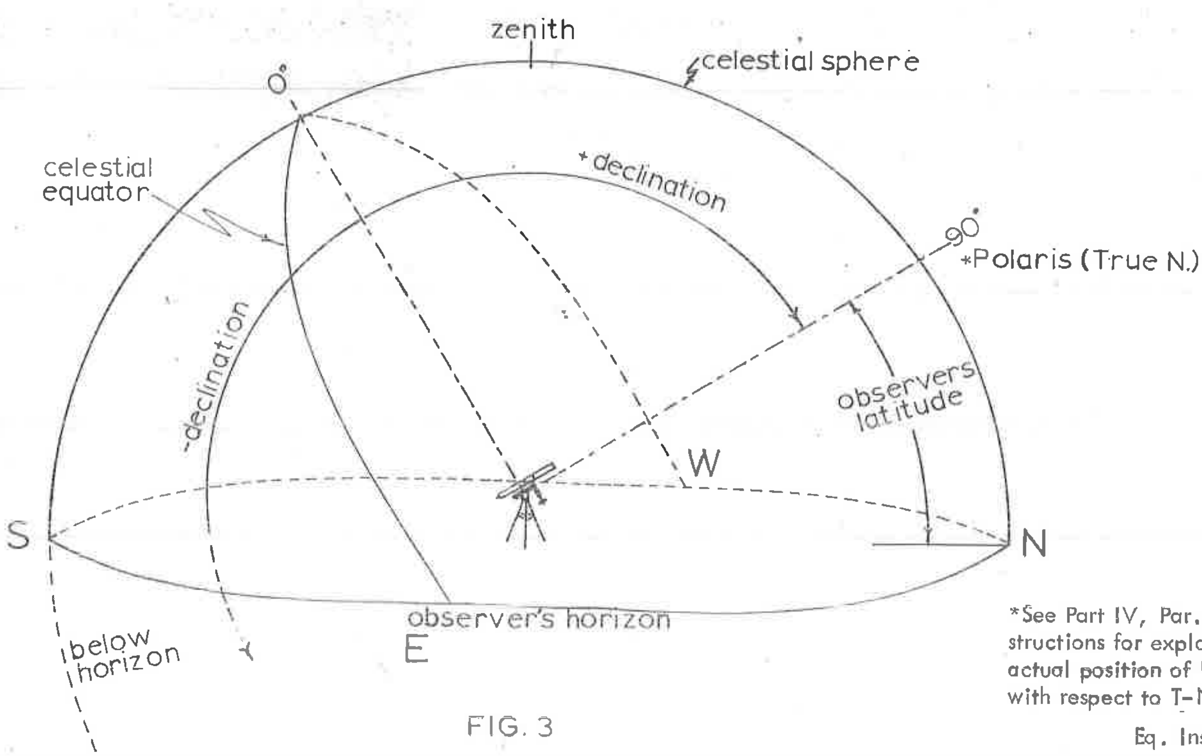


Fig. 2: Right Ascension Controls - Models 160 and 166

1. Auxiliary right ascension slow motion control knob.
2. Right ascension fast motion control (auxiliary)
3. Right ascension fast motion clamp





*See Part IV, Par. 7 of Instructions for explanation of actual position of Polaris with respect to T-North

FIG. 3

Eq. Inst.

Instructions

UNITRON Equatorial Refractors

PART I: INTRODUCTION

A telescope with an equatorial mounting offers the observer many features not available on the simpler altazimuth models. The advantages of the equatorial mounting result from its ability to be oriented parallel to the earth's axis of rotation. Once the mounting has been oriented, objects can be tracked with one motion only as they revolve about the polar axis; two motions are required for an altazimuth mounting. By using a single control knob only the observer can follow the celestial object in a completely straightforward manner, without danger of "losing" it. Furthermore, since the objects move at a uniform rate, this one motion, the right ascension, can be operated by a clock drive, leaving the operator completely free to concentrate on his observations.

Movements of the mounting correspond to the grid lines normally employed on star charts. These grid lines divide the sky in declination and right ascension in the same manner that latitude and longitude is used on the surface of the earth. Setting circles on the equatorial mounting are provided for both declination and right ascension. Just as the position of a feature on the earth's surface can be specifically located, in terms of latitude and longitude, so can a celestial object be positioned in the sky, in terms of declination and right ascension. This means that objects not familiar to the observer can easily be located by consulting a star chart or ephemeris which will provide the declination and right ascension. This data can then be applied to the setting circles for the time of observation and the telescope pointed toward the object with a considerable degree of accuracy. The advantages of the equatorial mounting render it highly desirable for visual observation and a MUST for astro photography.

In the instructions which follow, detailed information is given on the use of the setting circles and on aligning the telescope with the high degree of precision needed to insure most accurate readings. However, if you are a beginner, do not be misled into thinking that you must understand all of these complexities before enjoying the use of your UNITRON Equatorial Refractor. By making a rough adjustment with respect to the North Star Polaris, you can enjoy the convenience of single-knob tracking: later, as your interest and skill develops, you can use the setting circles to locate celestial objects which are not readily apparent.

Although there are many variations of equatorial mountings available, they all consist of two axes, positioned at right angles to each other. UNITRON refractors are equipped with the German-style mounting which is the most common type and is noted for its adaptability to portable instruments and ease of operation.

Although the apparent movement of the stars, from east to west, results from the revolution of the earth, it is, perhaps, an easier concept for observers previously unfamiliar with the equatorial mounting to visualize the earth as being a fixed point, and the stars as objects fixed on a celestial sphere which revolves approximately once every 24 hours about the earth's axis. Fig. 3 illustrates this concept. A major portion of these instructions will be devoted to the proper orientation and use of the equatorial mounting. A glossary of terms applicable to the orientation and use of equatorial refractors is included at the end of these instructions.

CAUTION: As in the case of any precision instrument, certain skills and equipment are employed in the assembly of your refractor that are generally not available to the amateur observer. We advise the user against attempting any disassembly or adjustment of the objective, eyepieces, or mounting. If, at any time, your instrument requires servicing beyond the maintenance described in these instructions, please communicate with our Instrument Service Department at the address shown on the front of this instruction manual.

In general, these instructions apply to all UNITRON Equatorial Refractors. On the few occasions where there is a variation between equatorial models, the instructions will specify the model number or objective diameter of the instrument referred to.

SEPARATE INSTRUCTIONS: The following components have separate instructions packed with them. If any of the items are supplied as standard equipment with the telescope that you ordered, or were ordered as separate accessories, refer to the instructions which accompany the accessory.

a) Synchronous Motor Drive (2.4", 3" or 4" models)
b) Weight Driven Clock (Models 160 and 166 only)
c) 2.4" Photo-Guide Telescope
d) Astro-Camera, Model 220A
e) UNIHEX Eyepiece Holder
f) DUETRON Double Eyepiece Holder
g) 60mm Eyepiece

PACKING: The major components of all equatorial models are shipped in three separate containers as follows: Optics Cabinet - contains the refractor with eyepieces, sunglass, dewcap, dustcap, cradle, sun-screen apparatus, star diagonal and erecting prism system. (If the UNIHEX eyepiece holder was selected, then this will be in a separate small styrofoam box.) Mounting cabinet - contains the equatorial mounting with control rods, counterbalance rod, counterbalance weight, and the flexible cable. For the Model 128, a 3-piece flat bar assembly is included with the legs for holding the legs in position when the instrument is set up. For 3" and 4" models, a tripod shelf is provided in a separate carton. Tripod legs for 2.4" and 3" models are in a separate carton. For 4" models, they are in a wooden cabinet.

NOTE: All references to illustrations appear as hyphenated numbers in parentheses. The number of the figure is given first followed by the item number in the figure.

PART II: ASSEMBLY

1. ATTACHING THE TRIPOD LEGS: Attach the tripod legs (1-1) to the base of the mounting by using the tripod leg bolts (1-2) packed with the tripod legs. Attach the spreader bar (Model 128) or shelf (3" and 4" models) at the mid-point of the legs to hold the tripod legs in position.

2. INSTALLING THE CONTROL RODS:

A) Declination fast motion clamp (1-3): This rod is identified by the 3-pronged handle and coarse thread. Its purpose is to lock the telescope on the declination axis. When loosened, it permits major changes in the position of the telescope tube, in declination. In some models, a shipping bolt must be removed to permit insertion of this rod. Tighten this rod sufficiently to prevent movement but do not overtighten.

B) Declination slow motion control (1-4): this rod is identified by the round knob and fine thread. The rod should be screwed into a point where turning the rod causes a movement of the cradle around the declination axis. For this rod to act upon the cradle, the declination fast motion clamp must be tightened. This control permits the fine adjustments to be made in declination, while observing.

C) Right ascension fast motion clamp (1-7): This may be a wing screw, as illustrated, or a short rod with 3-pronged handle similar to the declination fast motion clamp. This clamp locks the telescope on the polar axis (1-9). It should be kept tightened except when making major changes in right ascension. Tighten sufficiently to prevent movement over-tightening may result in damage to clamp housing.

D) Auxiliary right ascension control rod (1-8): screw this rod in until it causes a movement of the mounting around the polar axis. The right ascension fast motion clamp must be tight in order for this control to operate properly. This control is used to make fine adjustments in right ascension when a synchronous motor drive is being used with the telescope. (Ordinarily, the right ascension control knob (1-10) would be used for this purpose, but the installation of a synchronous motor drive eliminates the right ascension control knob as a means of manual control. Fine manual adjustments, or corrections, can then be accomplished with the auxiliary right ascension control rod.)

E) Flexible cable (1-11): this is provided to extend the right ascention control to a comfortable position for manual tracking while viewing through the telescope. On all models except the 160 Series, it may be used on either side of the instrument by inserting it into the recessed center of the right ascension hand wheel and tightening the thumbscrew. On the 160 Series, it can be used on the left side only since a gear box replaces

the righthand knob. If a synchronous motor is installed on any of the equatorial mountings, then the flexible cable should be removed as it will create an uneven drag on the motor.

F) For 4" models only (refer to Fig. 2): An added feature on these models is the dual clamping system on the polar axis. In addition to the auxiliary right ascension control rod and the fast motion clamp (2-3), a short wing screw (2-2) is provided. The observer will find that the auxiliary control (2-1) is sometimes difficult to reach when the telescope is pointed in certain directions. By loosening both the clamp screws (2-2) and (2-3) simultaneously, the entire clamping collar may be repositioned about the polar axis. Loosening either clamp individually will permit fast motion about the polar axis.

3. COUNTERBALANCE:

A) Counterweight rod (1-12): screw the end of the rod containing the hexagonal stop nut into the recess at the end of the declination shaft until the stop nut seats against the face of the shaft.

B) Counterweight (1-13): for 2.4" and 3" models, the counterweight threads onto the counterweight rod. In 4" models, the counterweight slides onto the shaft and is held in place by two hexagonal nuts which are screwed down against opposite sides of the weight.

4. OPTICS:

A) Install the refractor tube (1-15) on the mounting by removing the cradle nuts (1-14) and inserting the bolts through the holes on the flat bar at the upper end of the declination axis. Replace and tighten these nuts. Hand tightness is sufficient as the use of pliers is unnecessary and may damage the nuts.

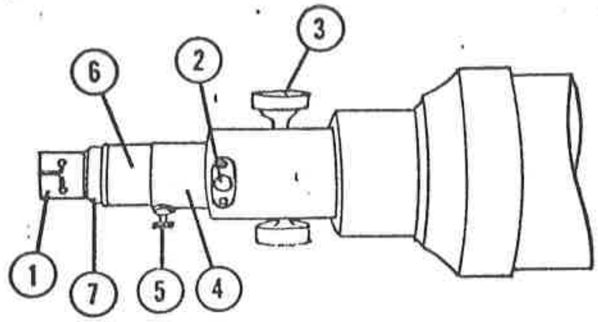
B) Viewfinder (1-16): on the 2.4" models, the viewfinder is shipped mounted in the collimating brackets on the main tube. On 3" and 4' models, the viewfinder is in a separate cardboard carton in the optics cabinet and must be slid into the brackets after backing out all six collimating screws (1-17) to obtain clearance. Instructions for aligning viewfinder are in Part III (3) of these instructions.

C) Dewcap and Dustcap: the dewcap and dustcap are packed separately in the optics cabinet. On the 2.4" model, the dewcap slides over the objective lens. The dustcap, in turn, fits over the end of the dewcap. On the 3" and 4" models, the dewcap screws onto the outer cell over the objective lens and the dustcap slides over the end of the dewcap.

This completes the assembly of the major components of the refractor.

PART III: OPERATION OF OPTICAL SYSTEM

1) FOCUSING: The 2.4" and 3" models are equipped with the Standard rack and pinion focusing mechanism, unless the Deluxe rack and pinion was specified in the order, at extra cost. The 4" models are equipped with the Super rack and pinion. Focusing procedures are the same regardless of the type of rack and pinion except for the use of locking screws on Deluxe and Super models, shown as items (4-2) and (4-5). These must be loosened during focusing and then may be tightened to prevent accidental movement of the mechanism. If the observer is unfamiliar with high powered telescopes, it is desirable to practice focusing the instrument during daylight on a distant object. Select a low power eyepiece and insert it directly in the end of the drawtube (4-1). The magnification, or power, will be determined by dividing the focal length of the eyepiece into the focal length of the objective. The focal length of the eyepiece, in millimeters, is shown on the top of each eyepiece. The focal lengths of objectives are as follows: 2.4" refractor - 900mm; 3" refractor - 1200mm; 4" refractor - 1500mm. To obtain an approximate focus, loosen the fine focus locking screw (4-2) and by turning the fine focus knobs (4-3) move the fine focusing sleeve (4-4) until it is approximately at the center of its total travel. Next, loosen the coarse focus locking screw (4-5) and while sighting through the eyepiece, slowly pull out the drawtube (4-6) until the distant object is as close as possible to being in focus. A sharp focus can then be obtained by adjusting the fine focus knobs (4-3) in the appropriate direction. As eyepieces are changed, a minor adjustment in fine focus will be necessary to achieve maximum resolution.



1. Eyepiece holder
2. Fine focus lock (not on standard R & P)
3. Fine focus knob
4. Fine focus sleeve
5. Coarse focus lock (not on standard R & P)
6. Drawtube (coase focus)
7. Eyepiece holder collar

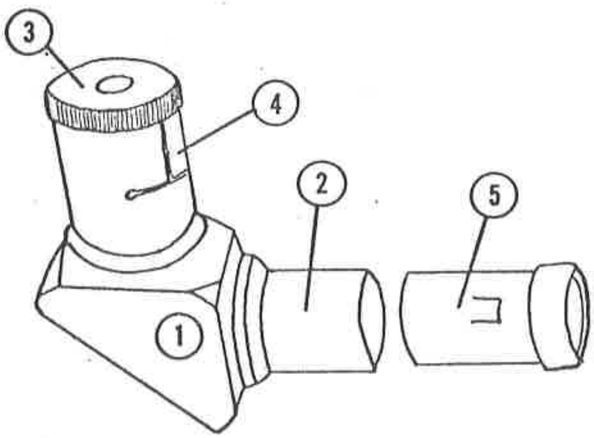
Fig. 4

The Deluxe and Super model rack and pinions have drawtubes with reversible eyepiece holders. The eyepiece holder collar (4-7) can be unscrewed and reversed 180° to provide a 1-1/4" eyepiece holder. The Super rack and pinion features a double drawtube. The inner drawtube is the same type used in the Deluxe rack and pinion while the outer drawtube, of approximately 58mm diameter, permits use of the Super rack and pinion and 60mm widefield eyepiece.

Your instrument has been supplied with either a UNIHEX eyepiece holder or a star diagonal and erecting prism system. If you chose the UNIHEX eyepiece selector, instructions for this accessory are packed in the box with the UNIHEX. If your instrument was equipped with a star diagonal and erecting prism, instructions for the use of the star diagonal are contained in paragraph (2) below.

Use of the erecting prism is discussed in Part VI of these instructions.

2) STAR DIAGONAL & ACHROMATIC AMPLIFIER: (Refer to Fig. 5) The star diagonal (5-1) is a special right angle eyepiece holder designed to permit comfortable viewing regardless of the position of the telescope tube. It is designed for astronomical observation only, as the image viewed when using a star diagonal will be upright, but reversed from right to left. To use the star diagonal, insert the drawtube end (chrome tube without slot) (5-2) into the eyepiece holder of the drawtube. An eyepiece (5-3) is inserted into the eyepiece holder (5-4) of the star diagonal. The telescope is then focused using the same procedure previously outlined. An Achromatic Amplifier (5-5) is supplied as standard equipment with the star diagonal. The Amplifier is a two-element Barlow-type negative amplifying lens. It is located in the drawtube end of the star diagonal and has an appearance similar to an eyepiece, but without marking. When inserted in the optical system it will double the magnification of any eyepiece with which it is used. Use of the Amplifier will provide the higher magnifications desired for lunar and planetary observations.



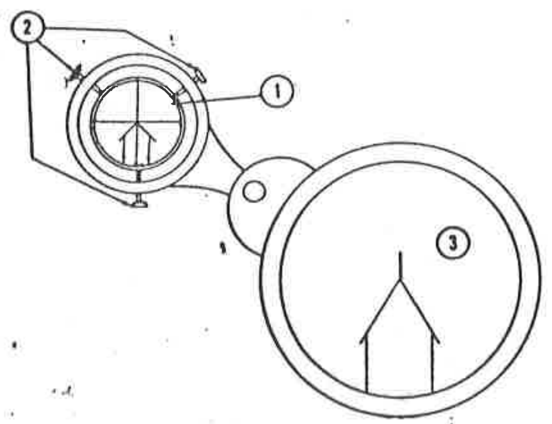
1. Star diagonal
2. Chrome tube
3. Eyepiece
4. Eyepiece holder
5. Achromatic Amplifier

Fig. 5

Use of the Amplifier will, of course, result in a narrowing of the field and a reduction of light passage through the instrument. Consequently, the Amplifier is most useful on bright objects under good "seeing" conditions. The

Amplifier has a friction fit in the star diagonal and can be removed or replaced, as desired by the observer.

3) VIEWFINDER: (Refer to Fig. 6) The viewfinder (6-1) is a low power, widefield telescope which aids in locating objects to be viewed with the main telescope. It is focused by simply moving the eyepiece in or out of the drawtube. The eyepiece has built-in crosshairs which permit an object to be centered in the field of view. Before the viewfinder can be used effectively, its optical axis must be carefully aligned with the optical axis of the main telescope. During daylight hours, select a well defined, distant object, such as a church steeple or flagpole. Using a low power eyepiece center the object in the field of the refractor, as shown in (6-3). By using the collimating screws (6-2) in the viewfinder mounting brackets, move the viewfinder within the brackets until the object is centered in the crosshairs. The optical axes are now close to being parallel. To improve this adjustment, select a well-defined celestial object, such as a prominent star, and repeat the procedure outlined for daylight alignment. Polaris is an excellent choice as its extremely slow apparent movement allows sufficient time for accurate alignment of the viewfinder after the star has been placed in the center of the main refractor field.



1. Viewfinder
2. Collimating screws
3. Refractor

Fig. 6

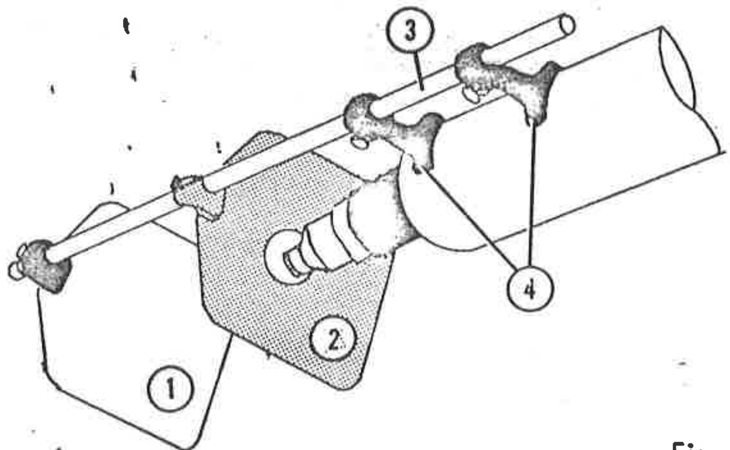
4) SUNGLASS: A sunglass is included with all UNITRON refractors. It will be found attached to the top of one of the eyepieces, generally the 12.5mm, but can be removed by simply loosening the thumbscrew and transferred to the eyepiece of your choice.

Caution

Extreme care must be exercised when using the sunglass. The high magnifications employed in astronomical telescopes produce a concentration of heat at the eyepiece sufficient to crack the sunglass if the telescope is pointed at the sun for longer than a brief period of time. SEVERE EYE DAMAGE CAN RESULT IF THIS OCCURS. When viewing, the instrument should be turned away from the sun at frequent intervals. The viewfinder should be covered to prevent accidental exposure of the naked eye to the sun's rays passing through the viewfinder.

When viewing the sun it is recommended that a solar aperture diaphragm be used in front of the objective. A solar aperture diaphragm is included as a standard component of all equatorial instruments. It is similar in appearance to the dustcap but has a small hole located in the center. Use of the aperture diaphragm reduces the area of objective lens surface that is directly exposed to the sun, and consequently limits the amount of light passing through the instrument. Even when using the solar aperture diaphragm, however, the instrument can be pointed directly toward the sun only for brief periods of time if damage to the sunglass is to be prevented. A safer method of direct viewing involves the use of a Herschel Solar Wedge, available as an extra accessory. The Solar Wedge is similar in appearance to a star diagonal but has a small hinged door which, when opened, permits dissipation of most of the sun's heat before it reaches the eyepiece. The Solar Wedge is used in combination with the sunglass.

5) SUNSCREEN: The safest method of viewing the sun requires the use of a sun projecting screen apparatus, which is included with all equatorial models. When sun projection screens are used, the sun's image is projected on a white metal screen, where it may be viewed safely with the naked eye. This method also has the advantage of permitting several persons to view the projected image simultaneously. Attach the brackets (7-4) to the tube, through the use of the thumbscrews provided in the tube. The rod is inserted through the brackets and the screens locked on the rod. The black screen with the hole in the center is used as a shade to prevent the direct rays of the sun from striking the white screen and "washing out" the image of the sun projected through the telescope. The size of the projected image can be regulated by moving the white screen along the rod. The sun's image can be sharply focused by use of the drawtube and rack and pinion mechanism.



1. Sunscreen
2. Shade
3. Sunscreen rod
4. Sunscreen brackets

Fig. 7

PART IV: ORIENTATION OF THE MOUNTING

The accuracy with which a good equatorial mounting performs is a reflection of the accuracy with which it was oriented and balanced. If the instrument remains set up in one location, then it will be necessary to orient one time only. If it is taken down between observing periods, then, with the exception of the latitude adjustment, the remaining orienting procedure will have to be repeated each time the instrument is set up. Although the procedure may appear to be involved the first time that it is performed, you will find that orientation requires only a short time once you become familiar with the operation of the mounting. A small inexpensive hand level should be acquired to facilitate leveling and orienting the mounting.

1) LEVELING: Level the mounting by reference to the level vials provided on the 4" models (1-22) or by using the hand level on smaller models, placing it on the flat surface of the tripod head. On soft ground, the tripod legs may be pressed into the ground to achieve a level position. On hard surfaces, shims of plywood, masonite, or cardboard can be used to raise the tripod in the appropriate direction to obtain a level position. Lifting and swinging one tripod leg right or left will also accomplish limited leveling of the head.

2) BALANCING:

a) Loosen the right ascension fast motion clamp (1-7) and place the declination axis in a horizontal position. Move the counterbalance weight (1-13) in and out along the counterweight rod (1-12) until the declination axis remains balanced in the horizontal position, unsupported.

b) With the declination axis balanced and locked in the horizontal position loosen the declination locking rod (1-3) and rotate the telescope tube (1-15) to a horizontal position. Loosen the cradle locking screw (1-24) and slide the tube, in the cradle, as necessary to permit balancing. The addition of certain accessories, such as the Astro-Camera, may necessitate the use of auxiliary equipment for balancing the tube. A counterbalance clamp is available for 2.4" and 3" models and a UNIBALANCE assembly is available for the 3" and 4" models. Refer to the list of accessories at the end of these instructions for further information.

Note: It will be found, while observing, that the telescope may seem to be out of balance in certain viewing positions. This results from a displacement of the center of gravity and minor adjustments of the counterweight

and tube position should be made, as necessary. Proper balance is especially important for smooth operation when the synchronous motor drive is used with the mounting. Even for manual operation of the mounting proper balance will reduce gear wear and eliminate "chatter".

3) LATITUDE ADJUSTMENT: The polar axis (1-9) must be inclined to the horizontal plane at an angle equal to the observer's latitude. Your latitude can be determined with sufficient accuracy from any good atlas or topographic map. Cut a triangle out of a piece of cardboard with one angle equal to your latitude. Position the triangle on the polar axis, as shown in Fig. 8 and place the hand level on the upper edge of the cardboard. Turn the latitude screw (1-18) until the hand level bubble is centered. The cardboard triangle can be eliminated if a direct angle reading level is used. Caution: Do not loosen or tighten the trunion nuts (1-23) during this adjustment as these are adjusted at the factory. Over-tightening these will result in damage to the main gears of the mounting. The latitude adjustment is permanent as long as the observer's location remains the same or the latitude screw is not disturbed.

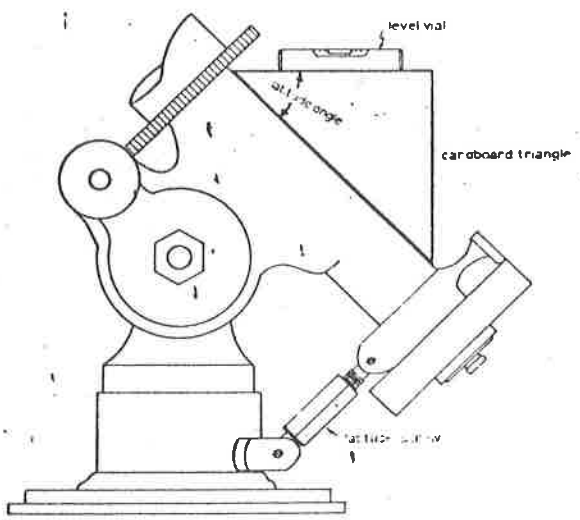


Fig. 8

At the time your instrument is shipped, we check your location and a latitude screw is provided whose range will permit proper setting for your location. Occasionally, you may find that a latitude screw will not provide as much adjustment in one direction, or the other, as you may desire. If you encounter this problem, return the latitude screw to our Instrument Service Department, enclosing a note indicating the latitude at which you are observing. We will forward a replacement screw whose mid-range will be approximately equivalent to your latitude. Also, if you move to a new location where the latitude is not within the tolerance of the screw originally provided with your instrument, new latitude screws are available for $6.50 each, postpaid. When ordering, please be sure to include the latitude of your new location and the model number of your instrument.

4) SETTING CIRCLES: Before proceeding further with the orientation of the mounting, it is necessary that you understand how to read and adjust the setting circles. All UNITRON equatorial mountings are provided with setting circles for both declination and right ascension. Since they are graduated differently, we will discuss them separately.

a) Declination Circles: Declination is measured in degrees, minutes, and seconds of arc. Declination corresponds to latitude on earth and is a measure of the angular distance that a celestial body lies north or south of the celestial equator. Declination is measured from 0° at the celestial equator to +90° at the north celestial pole, and from 0° at the celestial equator to a -90° at the south celestial pole. Since most positions on earth permit the observation of some celestial bodies both above and below the equator, the declination circle (1-19) is graduated from 0° to 90° in both directions.

b) Hour Circles: The hour circle is used to set the local hour angle of a celestial body on the telescope mounting. The hour circle is graduated in hours, minutes and seconds of arc since the local hour angle (and right ascension from which it is derived) is measured in these terms. Right ascension for a celestial body is obtained from a star chart or ephemeris. The right ascension is a measurement on the celestial sphere that corresponds to longitude on the earth's surface. By comparing the right ascension of an astronomical body with the observer's longitude the local hour angle may be determined. The local hour angle is the angular distance between the observer's meridian and the body, measured east or west. It is the local hour angle which is actually used in orienting the telescope. This will be discussed, in detail, in a later paragraph.

5) READING THE SETTING CIRCLES: 2.4" Models - On the 2.4" equatorial mounting the setting circles are read through the use of a fixed index. The declination circle is divided into 2° divisions and can be read to an accuracy of approximately 30 minutes with the index, as illustrated in Fig. 9. The hour circle is graduated into ten minute divisions and can be read to approximately 3' with the index as shown in Fig. 9.

Fig. 9

3" and 4" Models - The setting circles on the 3" mountings are graduated into 2° increments in declination and 10^m increments on the hour circle, just as they are on the 2.4" mountings. They are read, however, to a greater degree of accuracy through the use of verniers. Verniers (1-29) are short, graduated scales which replace the single index used on the 2.4" mounting.

Fig. 10 shows sections of the declination circle with vernier scales. Examining the figures, note that there is only one line on the vernier and one line on the main circle which are in coincidence. Examine the setting circle on your instrument and you will find that for any position of the main circle, only one line will be in coincidence with a graduation on the vernier. The value, in arc, of the entire vernier scale is equal to the value in arc between adjacent graduations on the main scale. Since each graduation of the main scale equals 2°, the total length of the vernier is 120' or 2°. The vernier is numbered in both directions from 0' to 120'. The examples in Fig. 10 illustrate how to determine which set of numbers should be referred to.

Example 1 (Fig. 10a). The leftmost line of the vernier is used to determine the main scale reading. In Fig. 10a it falls between 0° and 2°. Referring to the vernier scale, numbered in the same direction as the main scale, coincidence occurs at 90'. Therefore the total declination reading is 1°30' (0° plus 90'=1°30').)

Example 2 (Fig. 10b). The leftmost line of the vernier indicates a reading between 32° and 34°. The vernier is read from right to left (to agree with main scale readings) as 35'. The complete declination reading, then, is 32°35' (32° plus 35').).

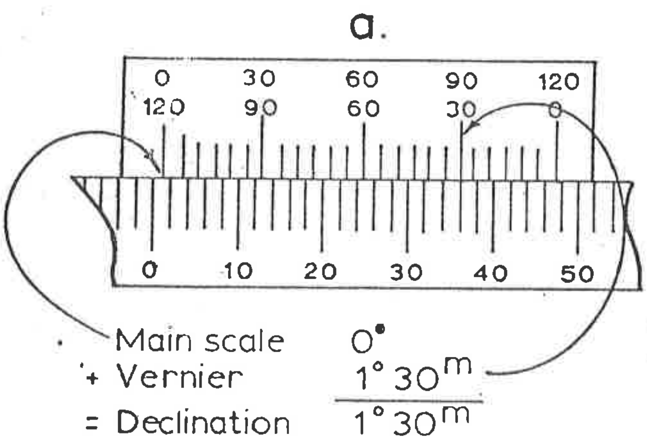


Fig. 10a

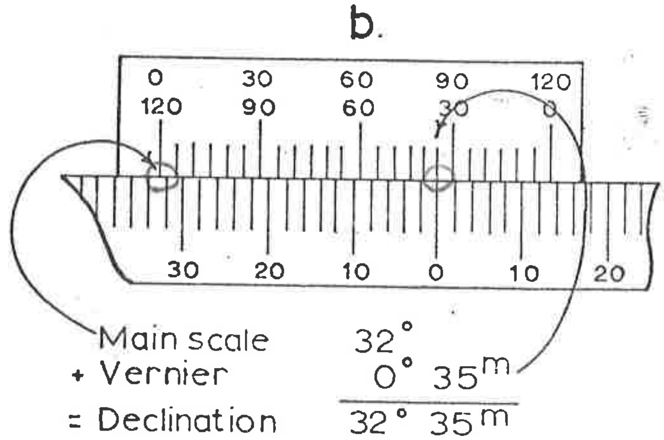
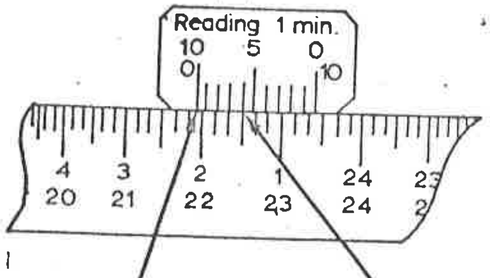


Fig. 10b

The Hour Circle (1-20) is graduated in hours and minutes from 0^h to 24^h in two scales, one clockwise and the other counter clockwise. The scale to be used depends upon whether the object observed lies east or west of the observer's meridian. This will be discussed in greater detail later in the instructions. To read the circle, refer to Fig. 11.



upper 2^h00^m + 06^m = 2^h06^m
lower 21^h50^m + 04^m = 21^h54^m

Fig. 11

If the lower scale is being used the 0 line of the vernier would indicate a reading between 21^h50^m and 22^h00^m. By examining the lines of the vernier from left to right, the 04^m is coincident with a line of the main scale.

If the upper scale of the vernier is being used the 0 line at the left edge of the vernier would be used to determine the main scale reading. In Fig. 11 a reading between 2^h00^m and 2^h10^m would be indicated. In reading the value of the vernier the scale would be read from right to left giving a value of 06^m.

6) ALIGNMENT OF POLAR AXIS AND ORIENTATION OF SETTING CIRCLES:

With the latitude adjustment completed, the polar axis can now be aligned with the earth's axis and the setting circles set, as follows:

a) Place the declination axis in the horizontal position precisely, by placing the hand level on the surface of the shaft housing as shown in Fig. 12. Center the bubble of the level by turning the right ascension slow motion control (1-10) in the appropriate direction.

b) Set the hour circle (1-20) by loosening the locking screw (1-25). Turn the circle until a reading of 0 or 24^h appears opposite the index or 0 line of the vernier.

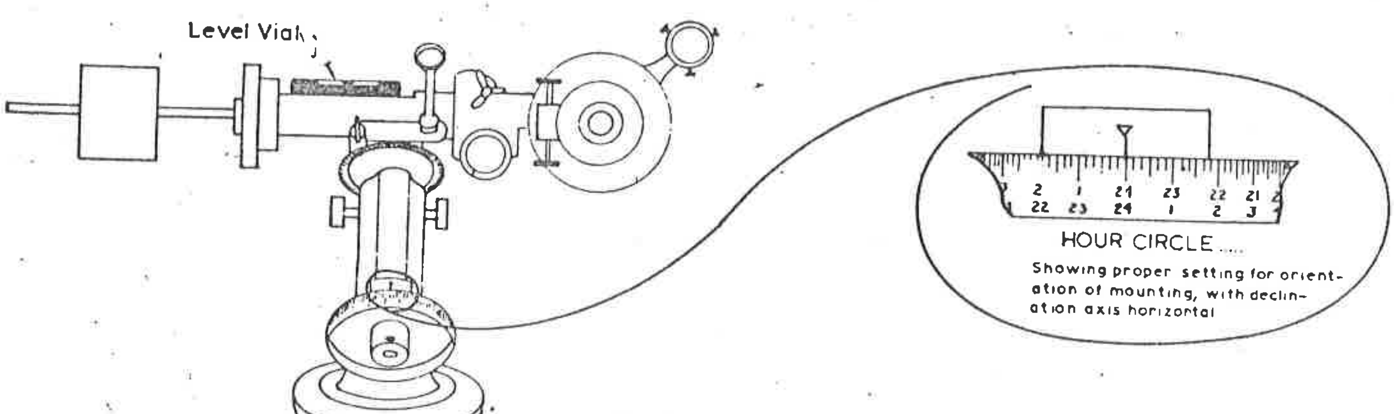


Fig. 12

c) Without disturbing the position of the declination axis, loosen the declination locking rod (1-3) and set the refractor tube approximately horizontal. Place the level on the tube and, using the declination slow motion control (1-4) level the tube precisely. See Fig. 13.

d) Set the declination circle (1-10) by loosening the locking screw (1-26). Set the circle to read the co-latitude (90° - the observer's latitude) of the observer's location.

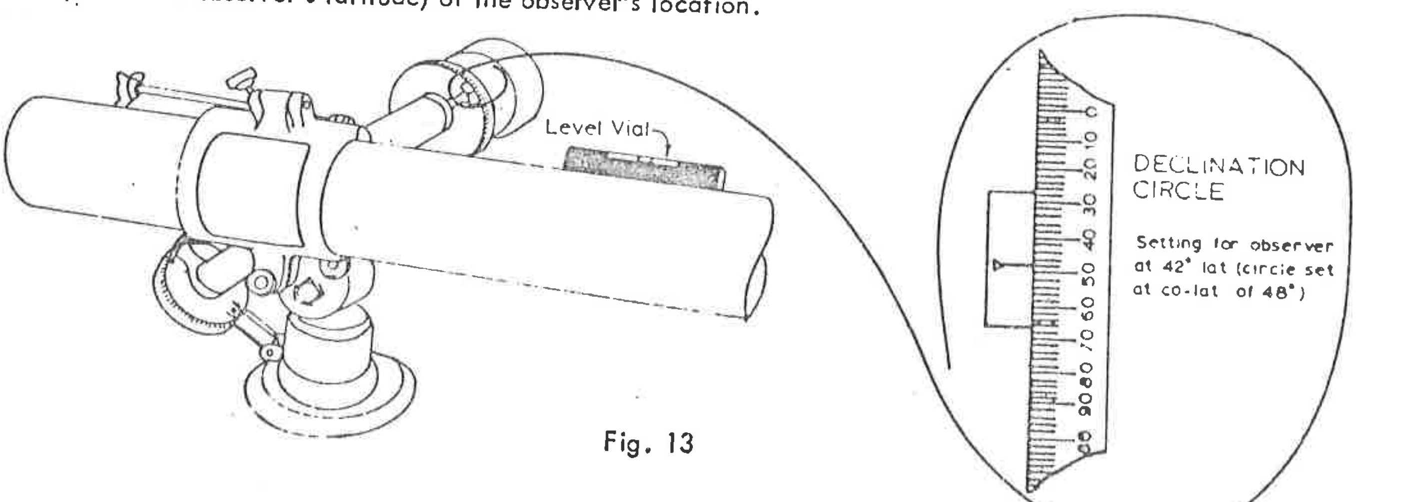


Fig. 13

This completes the orientation of the setting circles. The locking screws on both circles should be tightened and not disturbed again while observing.

e) To complete the orientation of the mounting it is necessary to align the polar axis (1-9) with the earth's axis. This is done by sighting the telescope on Polaris, the north star. Since Polaris revolves in an elliptical orbit around the North Celestial Pole, a slight error in orientation may result unless observations are made at preselected times, which will be discussed in a later paragraph. However, since Polaris is never at a greater angular distance from the Pole than approximately $1^{o}15^{m}$, alignment with Polaris at any instant of time will be sufficiently accurate for most visual observation.

To locate Polaris refer to Fig. 14. The stars forming the forward edge of the Big Dipper (Ursa Major) point toward the North Star as shown. They are about 5° apart. Polaris is about 30° beyond the edge of the Dipper. (Familiarity with these distances can be helpful as a "yardstick" for estimating other distances on the celestial sphere). As a further check, an imaginary line drawn from Mizar (the star at the bend of the Big Dipper handle) to Ruchbah (the star at the vertex of the widest angle of Cassiopeia, the "Lazy W") will pass through Polaris.

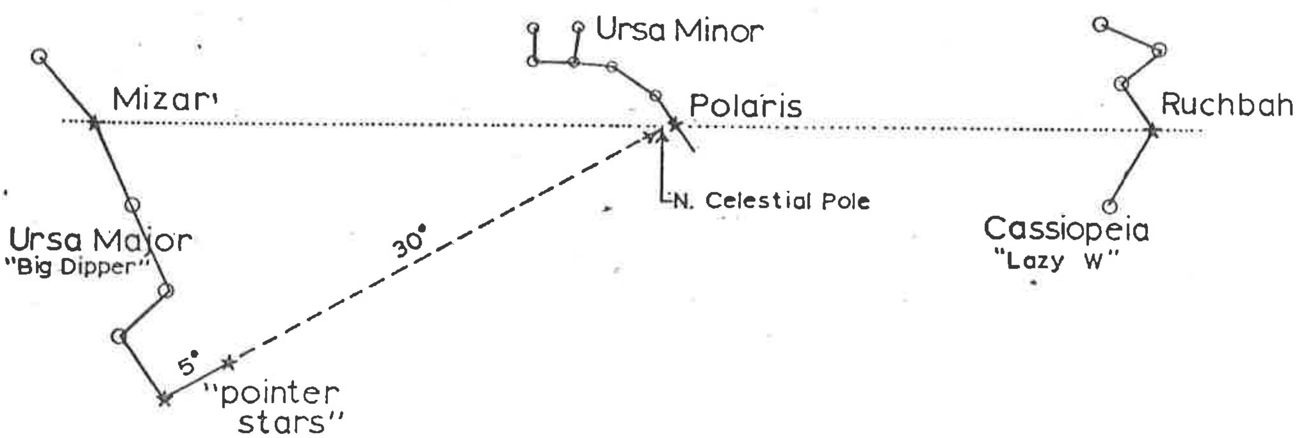
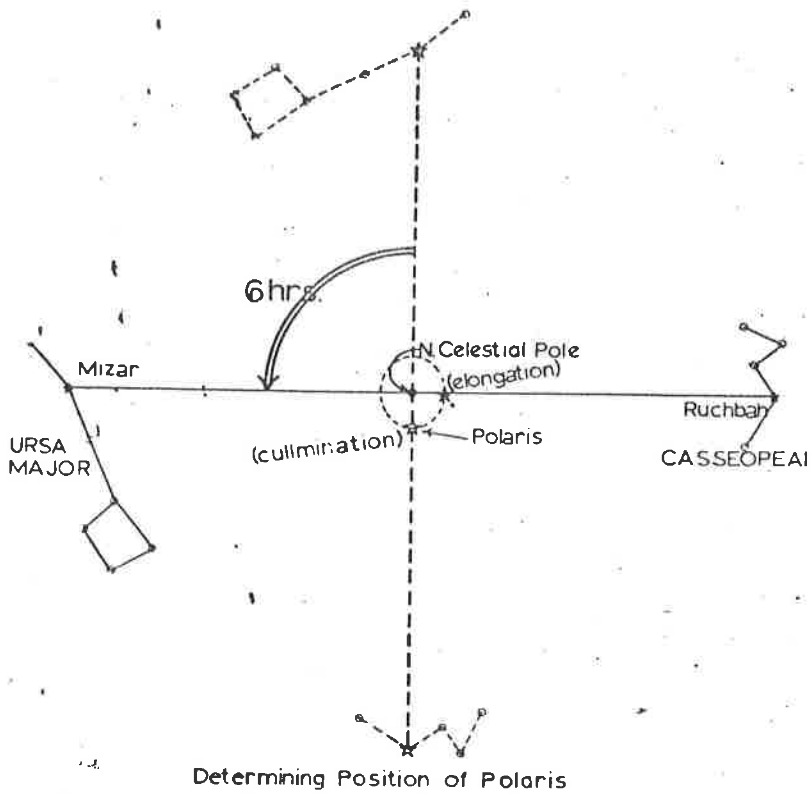


Fig. 14

With the declination axis still in the horizontal position, elevate the tube until the declination circle reads 90°. Loosen the Azimuth locking screw (1-27) and center Polaris in the field by swinging the telescope in Azimuth and raising or lowering by use of the latitude screw (1-18). Retighten the Azimuth locking screw. Upon completion of the orientation on Polaris all subsequent movement of the telescope tube will be accomplished with the declination and right ascension controls only. Do not change t' . orientation of the setting circles or loosen the Azimuth locking screw.

7) <u>PRECISE ORIENTATION:</u> If a more precise alignment of the Polar Axis with the North Celestial Pole is desired for visual observation or especially, for astrophotography, the following procedure should be followed. The imaginary line between Mizar and Ruchbah can be used to determine the position of Polaris with respect to the North Celestial Pole. For accurate setting of the latitude adjustment Polaris should be observed in either eastern or western elongation. For accurate pointing of the Polar Axis in azimuth, Polaris should be observed at upper or lower culmination. Since one revolution of Polaris about the North Celestial Pole occurs approximately every 24 hours, the star is alternately at elongation or culmination every six hours. Reference to Fig. 15 will indicate the relationship of Polaris to the pole with respect to Mizar and Ruchbah. The refractor should be equipped with a crossline eyepiece e.g. the UNITRON 9mm achromatized symmetrical eyepiece with crossline, listed in our accessory sheet. (In 3 and 4" Photo Equatorial Models the 9mm crossline eyepiece is a component of the 2.4" Photo Guidescope and can be transferred to the main telescope for the purpose of orientation.)



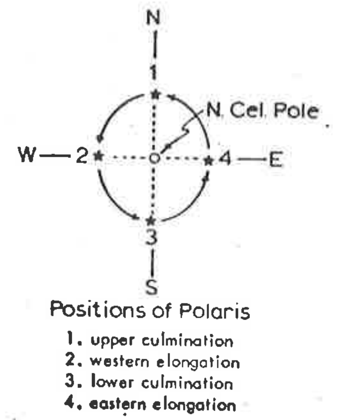


Fig. 15

Latitude - observe Polaris on the horizontal crossline of the eyepiece at eastern or western elongation, with the declination axis locked in the horizontal position. Loosen the locking screw (1-26) and set the declination circle to read 90°. (The declination of the North Celestial Pole.)

Azimuth - observe Polaris on the vertical crossline of the eyepiece, at upper or lower culmination by loosening the Azimuth locking screw (1-27) and moving the tube horizontally. Relock the screw. Set the Hour Circle to read 0^h or 24^h. The mounting is now precisely oriented.

The following table is useful in determining the times at which upper or lower culmination and eastern or western elongation will occur.

CULMINATIONS & ELONGATIONS OF POLARIS 1967 LOCAL MEAN TIME

	8 PM	9 PM	10 PM	11 PM	MID-NIGHT	1 AM	2 AM	3 AM
UC	Dec. 22	Dec. 6	Nov. 21	Nov. 6	Oct. 22	Oct. 7	Sept. 22	Sept. 17
WE	Mar. 21	Mar. 6	Feb. 19	Feb. 4	Jan. 20	Jan. 5	Dec. 22	Dec. 7
LC	June 22	June 7	May 22	May 7	Apr. 22	Apr. 7	Mar. 22	Mar. 7
EE	Sept. 22	Sept. 7	Aug. 23	Aug. 7	July 23	July 9	June 23	June 8

Time of event for dates in between those shown in chart can be determined by subtracting 4^m per day. For example, Upper Culmination, from the chart, occurs at 8:00 PM on Dec. 20. On Dec. 21 U.C. would occur at 7:56 and on Dec. 22 at 7:52, etc. The apparent position of Polaris for 1967 is as follows:

R.A. 2^h01^m Dec. + 89°07 Mag.: 2.1

PART V: USING THE EQUATORIAL MOUNTING

The data necessary to point the telescope at a given celestial object is the declination and right ascension. This information can be obtained from several sources e.g. star charts, ephemerides, and current periodicals.

The declination can be taken directly from the star chart and used on the declination setting circle to orient the instrument in declination. The right ascension is converted to Local Hour Angle which can be used on the Hour Circle of the instrument.

DETERMINATION OF LOCAL HOUR ANGLE: Local Hour Angle (LHA) is the difference between Local Sidereal Time (LST) and the right ascension of the celestial object to be observed. Sidereal Time is based upon the stars but the time which appears on our clocks and watches is based upon the sun. Furthermore, since we are constantly moving with respect to the sun, time based upon the sun, without some modification, would be different for every point on the earth. Our watch time is actually a local standard time (ST) based on the time zone in which we live. The earth is divided into 24 standard time zones, each approximately 15° of longitude in width. The United States spans four of these zones. Each zone has a central time meridian which is the line of longitude passing through the center of the zone. They are shown in Table I.

	Central Time Meridian
Eastern Standard Time Zone (EST)	75°
Central Standard Time Zone (CST)	90°
Mountain Standard Time Zone (MST)	105°
Pacific Standard Time Zone (PST)	120°

Table I

The first step in determining sidereal time requires us to convert our watch time, Eastern Standard Time (EST) to the Local Mean Time (LMT) for our location. Determine your longitude from an atlas or map to the nearest 1/4° (15^m). If you are located west of your central time meridian, add four minutes for each degree of longitude (1^m per 1/4°). If you are east subtract four minutes per degree.

This is a constant for a given location and can be recorded on Table II (page 13) for reference. On each occasion that sidereal time is to be determined apply this constant to the local standard time to determine local mean time.

EXAMPLE

The following example is based on an observer located in Boston, Massachusetts whose watch is operating on Eastern Standard Time. (Note: An appropriate correction must be applied when Daylight Saving Time is in effect to correct to the standard time of the zone before determination of local mean time.)

Example: Observer's location: Boston, Mass., Eastern Standard Time Zone,
longitude $71°03^m$ (use as 71° to nearest 1/4°)

E.S.T. (watch time): 8: P.M.

Date: August 14th

Central time meridian (from Table I) = 75°

SIDEREAL TIME EQUIVALENT TO 8 P.M. (2000HRS.) LOCAL MEAN TIME

DAY	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	DAY
1	$2^h 45^m$	$4^h 48^m$	$6^h 38^m$	$8^h 40^m$	$10^h 39^m$	$12^h 41^m$	$14^h 39^m$	$16^h 41^m$	$18^h 44^m$	$20^h 42^m$	$22^h 44^m$	$0^h 42^m$	1
2	2 49	4 52	6 42	8 44	10 43	12 45	14 43	16 45	18 48	20 46	22 48	0 46	2
3	2 53	4 56	6 46	8 48	10 46	12 49	14 47	16 49	18 51	20 50	22 52	0 50	3
4	2 57	5 00	6 50	8 52	10 50	12 53	14 51	16 53	18 55	20 54	22 56	0 54	4
5	3 01	5 04	6 54	8 56	10 54	12 57	14 55	16 57	18 59	20 58	23 00	0 58	5
6	3 05	5 07	6 58	9 00	10 58	13 01	14 59	17 01	19 03	21 02	23 04	1 02	6
7	3 09	5 11	7 02	9 04	11 02	13 05	15 03	17 05	19 07	21 06	23 08	1 06	7
8	3 13	5 15	7 06	9 08	11 06	13 08	15 07	17 09	19 11	21 09	23 12	1 10	8
9	3 17	5 19	7 10	9 12	11 10	13 12	15 11	17 13	19 15	21 13	23 16	1 14	9
10	3 21	5 23	7 14	9 16	11 14	13 16	15 15	17 17	19 19	21 17	23 20	1 18	10
11	3 25	5 27	7 18	9 20	11 18	13 20	15 19	17 21	19 23	21 21	23 24	1 22	11
12	3 29	5 31	7 22	9 24	11 22	13 24	15 22	17 25	19 27	21 25	23 27	1 26	12
13	3 33	5 35	7 25	9 28	11 26	13 28	15 26	17 29	19 31	21 29	23 31	1 30	13
14	3 37	5 39	7 29	9 32	11 30	13 32	15 30	17 33	19 35	21 33	23 35	1 34	14
15	3 41	5 43	7 33	9 36	11 34	13 36	15 34	17 37	19 39	21 37	23 39	1 38	15
16	3 45	5 47	7 37	9 40	11 38	13 40	15 38	17 40	19 43	21 41	23 43	1 41	16
17	3 49	5 51	7 41	9 43	11 42	13 44	15 42	17 44	19 47	21 45	23 47	1 45	17
18	3 53	5 55	7 45	9 47	11 46	13 48	15 46	17 48	19 51	21 49	23 51	1 49	18
19	3 56	5 59	7 49	9 51	11 50	13 52	15 50	17 52	19 55	21 53	23 55	1 53	19
20	4 00	6 03	7 53	9 55	11 54	13 56	15 54	17 56	19 58	21 57	23 59	1 57	20
21	4 04	6 07	7 57	9 59	11 57	14 00	15 58	18 00	20 02	22 01	0 03	2 01	21
22	4 08	6 11	8 01	10 03	12 01	14 04	16 02	18 04	20 06	22 05	0 07	2 05	22
23	4 12	6 14	8 05	10 07	12 05	14 08	16 06	18 08	20 10	22 09	0 11	2 09	23
24	4 16	6 18	8 09	10 11	12 09	14 12	16 10	18 12	20 14	22 13	0 15	2 13	24
25	4 20	6 22	8 13	10 15	12 13	14 15	16 14	18 16	20 18	22 16	0 19	2 17	25
26	4 24	6 26	8 17	10 19	12 17	14 19	16 18	18 20	20 22	22 20	0 23	2 21	26
27	4 28	6 30	8 21	10 23	12 21	14 23	16 22	18 24	20 26	22 24	0 27	2 25	27
28	4 32	6 34	8 25	10 27	12 25	14 27	16 26	18 28	20 30	22 28	0 31	2 29	28
29	4 36		8 29	10 31	12 29	14 31	16 30	18 32	20 34	22 32	0 34	2 33	29
30	4 40		8 32	10 35	12 33	14 35	16 33	18 36	20 38	22 36	0 38	2 37	30
31	4 44		8 36		12 37		16 37	18 40		22 40		2 41	31

TABLE 2

Difference between longitude and central time meridian:

$$75^\circ - 71^\circ = \underline{4^\circ}$$

Time correction: $4^\circ \times 4^m = 16^m$ (to be subtracted from E.S.T. since Boston is east)

$$8{:}00\ \text{P.M. (E.S.T.)} - 16^m = 7^h44^m\ \text{(L.M.T.)}$$

The local mean time just determined must then be converted to sidereal or star time (ST). This is very easily accomplished by referring to Table 2, which gives the sidereal time equal to 8:00 P.M. Local Mean Time for each day of the year. In actual use we suggest that you reset your wrist watch or clock for the sidereal time. Since the difference between standard time and sidereal time varies only about 4^m per day, this setting will be sufficiently accurate for use throughout an evening of observing.

Example continued:

Entering Table II for August 14th we find that 8:00 PM LMT = 17^h33^m sidereal time. (Since sidereal time is measured from 0^h to 24^h, 12^h should be subtracted from any reading determined from Table II which exceeds 12^h to permit setting on a standard wrist watch dial). At 7:44 PM (EST), the Boston time equivalent to 8:00 (LMT), the observer's watch should be set to read 5^h33^m (17^h33^m - 12^h00^m). The sidereal time can then be read directly for the balance of the evening by simply taking the watch time plus twelve hours. Hence, at 9:00 PM (EST) the sidereal time would be 18^h49^m (6^h49^m read from the watch plus 12^h).

We stated earlier that the Local Hour Angle which will be set on the Hour Circle of the equatorial mounting is the difference between Sidereal Time and right ascension. If the Boston observer wishes to view the globular cluster, M13, in Hercules, a star chart would indicate the declination as $+36^\circ32^m$ and the right ascension as 16^h40^m.

To point the telescope at this object at 9:00 PM (EST) loosen the declination lock rod (1-3) and swing the telescope tube until a reading of $+36^\circ32^m$ (estimated as closely as graduations will permit) appears on the declination circle.

Final adjustment should be made with the declination slow motion control rod (1-4). Next, determine the Local Hour Angle (LHA) by taking the difference between the right ascension (RA) and the sidereal time:

$$18^h49^m\text{(ST)} - 16^h40^m\ \text{(RA)} = 2^h09^m\ \text{(LHA)}$$

If the RA is <u>greater</u> than ST then the LHA is <u>East</u> of the observer's meridian

If the RA is <u>less</u> than ST then the LHA is <u>West</u> of the observer's meridian.

In this case the RA being less, M-13 lies 2^h9^m West of the observer's meridian. The Hour Circle would read as shown in Fig. 16.

Loosen the RA clamp (1-7) and swing the objective end of the tube toward the West until the Hour Circle reads 2^h9^m as shown in Fig. 16.

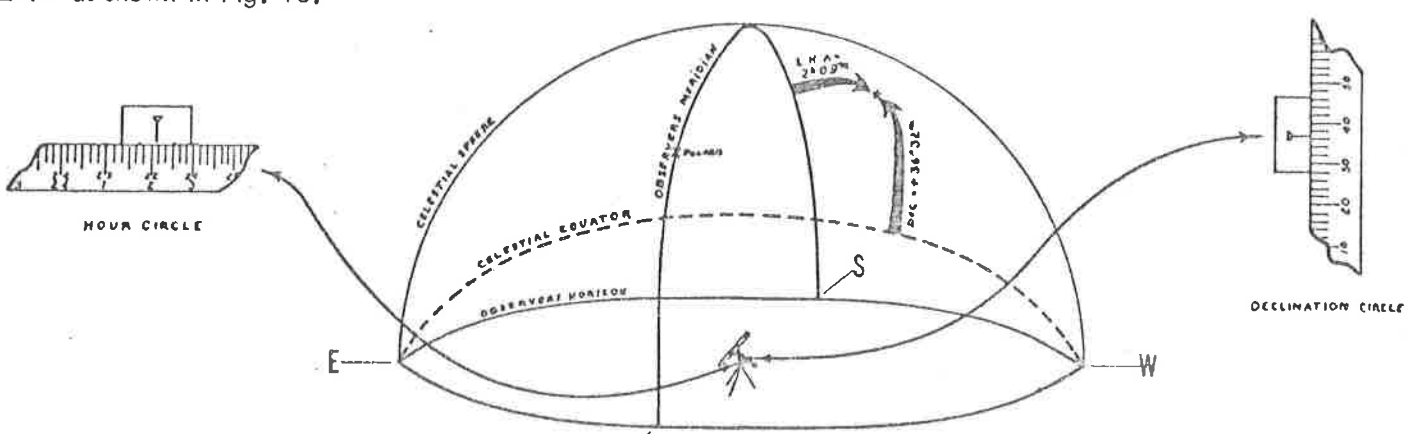


Fig. 16

Once the object has been acquired in the field of view then it may be continuously tracked by turning the RA handwheel (1-10) manually or by a synchronous motor or mechanical drive. This same procedure may be used for locating bright objects during the daytime, such as planets, during certain seasons of the year. If the mounting has been previously oriented, the declination and RA may be determined from an ephemeris and applied to the setting circles to permit location of an object that would be invisible to the naked eye.

PART VI: TERRESTRIAL VIEWING

Astronomical refractors normally present an inverted and reversed image when the eyepieces are inserted directly into the eyepiece holder of the drawtube. As mentioned previously the use of the star diagonal will present an upright image, but it will still be reversed from right to left. This same presentation also occurs with the UNIHEX eyepiece holder.

The erecting prism system is recommended for terrestrial viewing. If it was not supplied as a standard component of your telescope, it can be obtained as an extra accessory. The erecting prism system contains a special prism which presents an image oriented correctly both vertically and horizontally. The erecting prism is inserted directly into the eyepiece holder of the telescope drawtube. Any selected eyepiece, from 4mm to 25mm total length, can then be inserted in the eyepiece holder of the erecting prism. Focusing is accomplished in the normal manner.

Although an altazimuth-type mounting is generally preferred for terrestrial observation, the equatorial mounting can be made to function as an altazimuth mounting, for terrestrial use, by locking the declination axis in the horizontal position. Horizontal movements of the tube can be made by loosening the azimuth locking screw. Vertical changes can be made by using the declination controls.

PART VII: CARE OF THE INSTRUMENT

Your UNITRON telescope has been constructed of the finest materials available and, with proper care, will give a lifetime of service. It is a precision instrument and should be handled with care. When not in use, the telescope and accessories are fully protected by the wooden carrying cases.

The objective lens has been treated with a special coating for maximum light transmission and Image brilliance. Excessive and incorrect cleaning of the lens and the eyepieces may damage the delicate optical surfaces. Do not rub or polish the lens but, instead, gently remove any dust particles with a camel's hair brush, lens tissue, or hand blower. Frequent cleaning is unnecessary. The objective lens has been assembled at the factory with great care and should never be taken apart. The dustcap should be kept on the telescope except when you are actually observing.

Moving parts of the telescope mounting should be occasionally lubricated to insure smooth operation. A light film of machine oil is preferred. Parts should be wiped free of dust before applying. Tighten the nuts on the bolts which fasten the tripod legs to the mounting whenever necessary to insure proper rigidity.

PART VIII: HINTS ON OBSERVING

1) Use the telescope outdoors. Window glass and the air currents in a heated room will spoil the clarity of the image.

2) As mentioned previously, astronomical telescopes invert and reverse the image as seen with the naked eye. Therefore, star maps must be turned upside down when comparing them with a telescopic view. In addition, the diagonal flips the image, again, from left to right. This corresponds to looking at a star map in a mirror.

3) Use the viewfinder first to locate the general region of the object. Always start out with lower powers in the main telescope. After you have found the object, it is possible to use higher power eyepieces in the main telescope, with their more limited fields of view. The highest power eyepieces will perform to best advantage only under favorable atmospheric conditions and, therefore, it is very often the lower and medium powers which will give the most satisfactory views.

4) A useful adjunct to observing will be an atlas or an almanac.

PART IX: WARRANTY

All UNITRON Refractors and Accessories are fully guaranteed for workmanship and performance. Should any component be found faulty as a result of a manufacturing defect, replacement will be made without charge.

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GLOSSARY

1) Almanac: A book or table containing a calendar of days, months and years, to which astronomical data and various statistics are often added, such as time of rising and setting of the sun and moon, changes of the moon, eclipses, hours of high and low tide, etc.

The most important one in America is the AMERICAN EPHEMERIS AND NAUTICAL ALMANAC.

2) Altazimuth: The earliest type of mounting devised for astronomical telescopes: the telescope can be rotated both in altitude (i.e., about a horizontal axis) and in azimuth (i.e., about a vertical axis), and can be used to determine the altitude and azimuth of a celestial object.

3) Celestial equator: The great circle on the celestial sphere cut by the plane of the Earth's Equator extended. A great circle is one whose plane passes through the center of a sphere.

4) Culmination: The culmination or transit of a celestial body is the passage of that body across the meridian of the observer. Every celestial body will have two culminations; passage across the upper arc of the meridian is upper culmination or upper transit, and passage across the lower arc is lower culmination or lower transit.

5) Declination: The declination of a celestial body is the angular distance from the celestial equator measured along the hour circle of the body. Declination is given a positive sign when the body is north of the celestial equator and negative when south. Declination corresponds to latitude on the Earth.

6) Ecliptic: The great circle cut on the celestial sphere by the plane of the Earth's orbit. If we could look past the Sun and see the stars, we would see the Sun and stars moving slowly across the sky. The Sun would gain slightly on the stars each day. The Earth is assumed to be stationary, so the ecliptic is assumed to be the path of the Sun instead. This ecliptic intersects the celestial equator at two points at an angle of about 23-1/2°.

7) Elongations: The elongations of a celestial body are two points in its apparent orbit at which the bearing from the observer's meridian is the greatest. A star is said to be at eastern elongation when its bearing is a maximum to the east and at western elongation when its bearing is a maximum to the west.

8) Ephemeris (plural: ephemerides): A list or table of the computed positions which a celestial body occupied or will occupy on certain dates; these computations are made on the ground of observations that have determined the elements of the orbit.

The American Ephemeris and Nautical Almanac is published every year by the United States Government. It is a book containing tables of the positions of the sun, moon, planets and some stars at frequent intervals through the year. It gives data concerning eclipses, and other facts that are useful to astronomers and navigators. England, France, Spain, Germany and other countries publish such annuals.

9) Equinoxes: The two points where the ecliptic intersects the celestial equator. The point where the Sun crosses the celestial equator from south to north is called the vernal equinox or first point of Aries. The other point is called the autumnal equinox and is diametrically opposite the first point. The equinoctial points move slowly westwood along the ecliptic at a rate of about 50 seconds a year. As a result, all the fixed stars gradually change their positions with respect to the Equator and the vernal equinox.

10) Horizon: The great circle cut on the celestial sphere by the extension of the plane of the observer's horizon.

11) Hour angle: The hour angle of a celestial body is the angle at the celestial poles between the plane of the meridian of the observer and the plane of the hour circle of the star. Stated simply, the hour angle is the angle at the pole between the observer's meridian and the meridian (hour circle) of the celestial body. This angle is similar to differences in longitude on the earth's surface. It is measured westward from the observer's meridian (counterclockwise looking from the Earth to the north celestial pole). It is generally considered as an arc measured along the celestial equator toward the west and may be expressed in time or arc.

12) Hour circle: Any great circle on the celestial sphere that passes through the celestial poles.

13) Latitude: The angular distance measured at the center of the earth, 0° to 90°, north or south of the Equator.

14) Longitude: The angular distance measured at the center of the earth, from 0° to 180°, east or west of the meridian of Greenwich which is used by most nations as the prime or initial meridian.

15) North and south celestial poles: The points where the prolonged polar axis of the Earth intersects the celestial sphere.

16) Oberver's meridian: The great circle on the celestial sphere which passes through the celestial poles and the observer's zenith.

17) Right ascension: The right ascension of a celestial body is the arc of the celestial equator measured from the vernal equinox eastward (clockwise when looking from the Earth to the north celestial pole) to the hour circle of the body. It is measured in units of time from 0 to 24 hours. Right ascension compares with longitude on the Earth.

18) Solstices: Two points on the ecliptic midway between the equinoxes. When the ecliptic is north of the celestial equator the midpoint is called the summer solstice and occurs about June 21st; when the ecliptic is south of the celestial equator, this midpoint is called the winter solstice and occurs about December 21st. It is easily seen, then, that the solstices occur when the Sun is at its greatest distance north or south of the Equator.

19) Zenith and nadir: The two points where the oberver's plumb line intersects the celestial sphere. The zenith is the point directly overhead and the nadir is the point directly underneath.

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