UNITRON INSTRUMENTS, INC.
Subsidiary of Ehrenreich Photo-Optical Industries, Inc.
175 Express Street, Plainview, N.Y. 11803
Telephone (516) 822-4601

Model 152 4" Equatorial Retractor
INSTRUCTION MANUAL

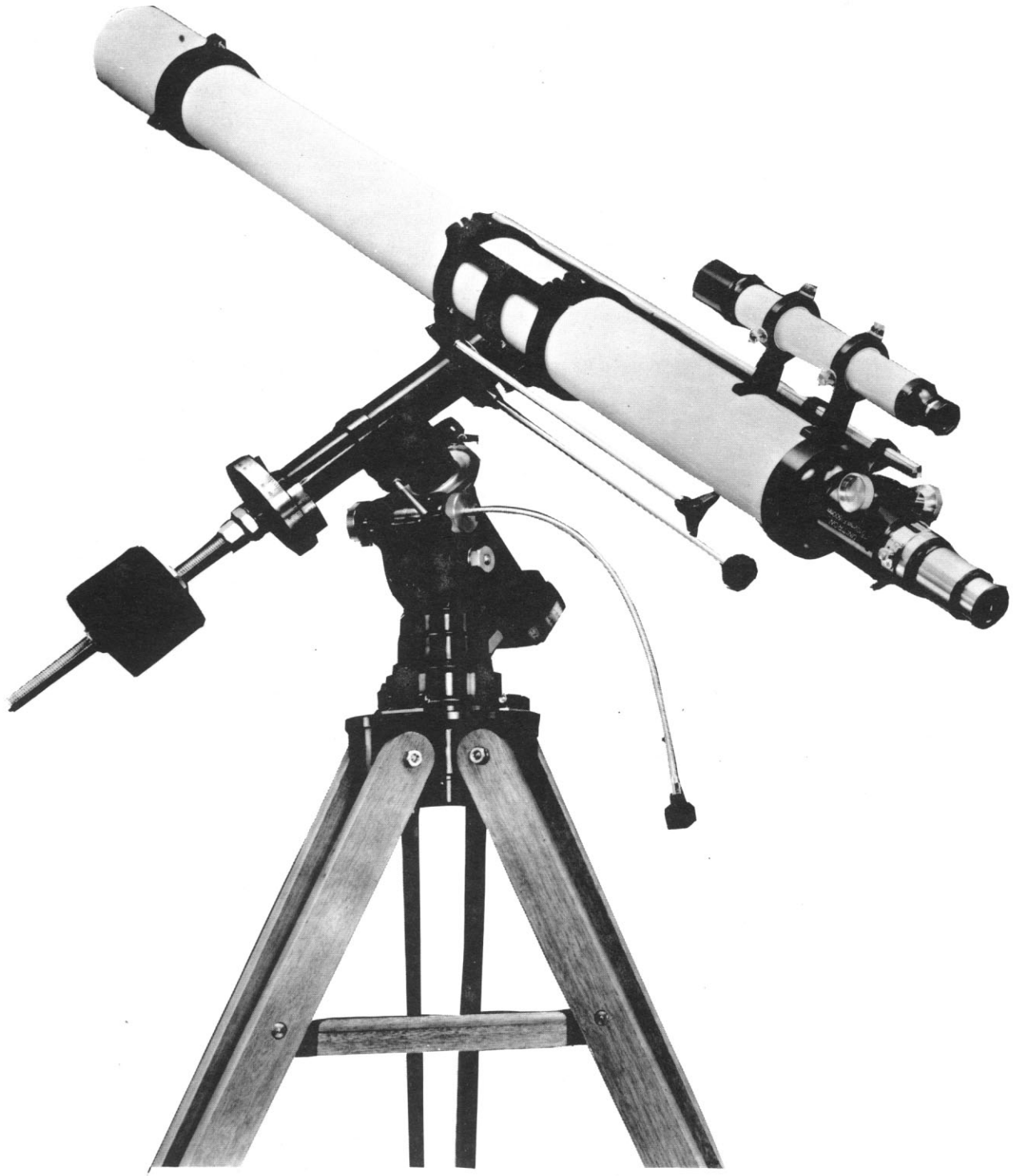


TABLE OF CONTENTS

INTRODUCTION

I. ASSEMBLY

1. Tripod
2. Control rods
3. Counterbalance
4. Optics

II. OPERATION OF OPTICAL SYSTEM

1. Controls
2. Focusing
3. Viewfinder
4. Star Diagonal
5. Terrestrial viewing - erecting prism system
6. Unihex
7. Sunscreen apparatus

III. ORIENTATION OF THE MOUNTING

1. Leveling
2. Balancing
3. Latitude adjustment
4. Setting circles
5. Reading the setting circles
6. Alignment of the polar axis and orientation of the setting circles
7. Precise orientation

IV. USING THE EQUATORIAL MOUNTING

1. Determining local hour angle
2. A simple method for using setting circles

V. CARE OF THE INSTRUMENT

VI. HINTS ON OBSERVING

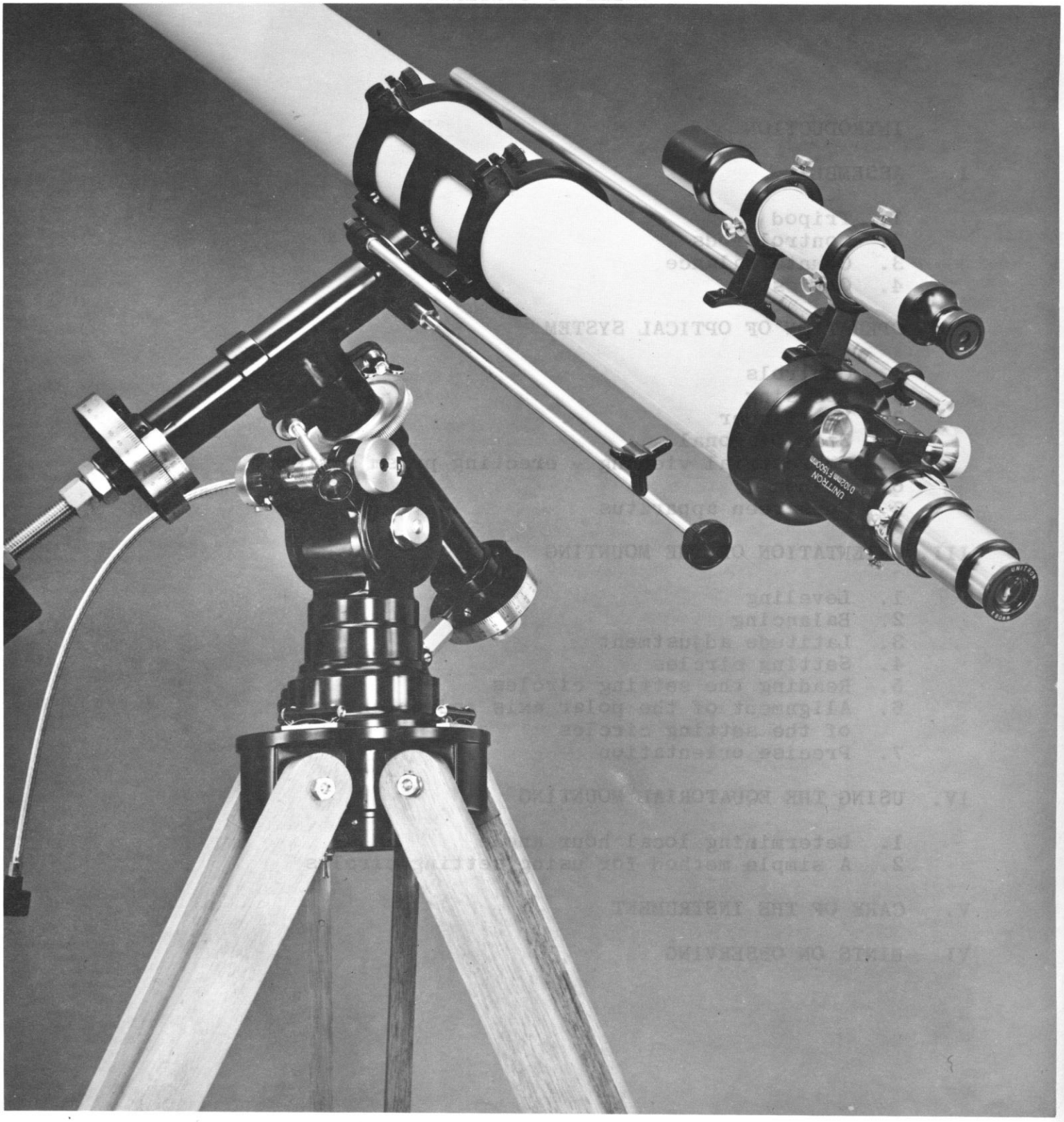
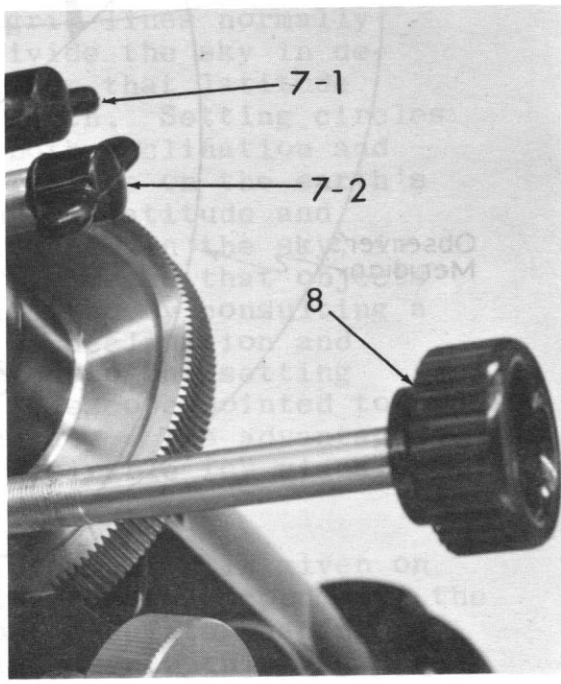

UNITRON
6" REFLECTOR

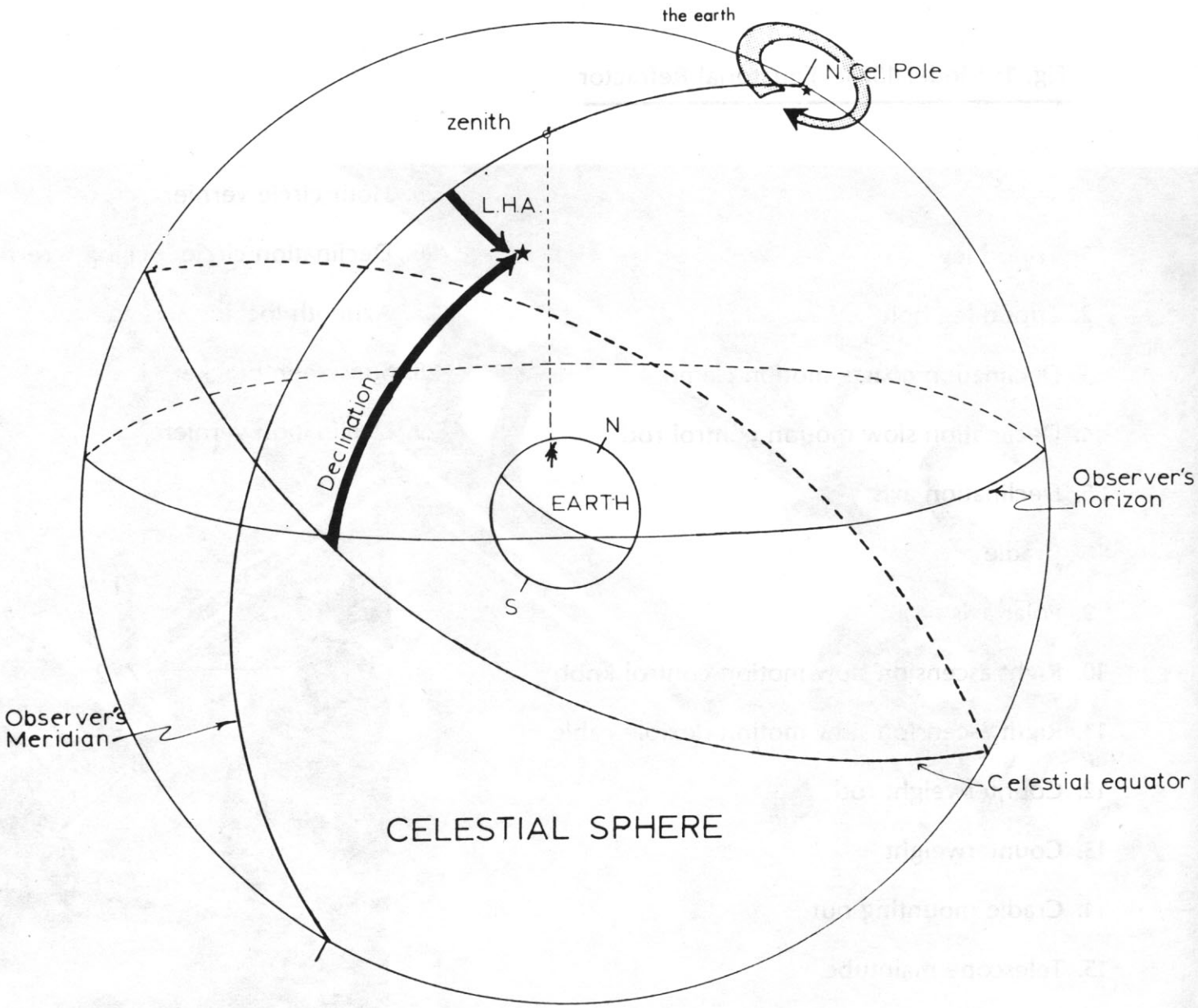
Fig. 1: Model 152 4" Equatorial Refractor

1. Tripod leg
2. Tripod leg bolt
3. Declination coarse motion clamp
4. Declination slow motion control rod
5. Declination axis
6. Cradle
9. Polar axis
10. Right ascension slow motion control knob
11. Right ascension slow motion flexible cable
12. Counterweight rod
13. Counterweight
14. Cradle mounting nut
15. Telescope maintube
16. 10X-42mm viewfinder
17. Viewfinder collimating screw with lock
18. Latitude screw
19. Declination setting circle
20. Hour or right ascension setting circle
21. Shelf illuminator
22. Bubble level
23. Trunnion nut
24. Cradle locking nut
25. Hour circle vernier
26. Declination circle locking screw
27. Azimuth locking screw
28. Sunscreen bracket
29. Declination vernier



Right Ascension Controls

7. Right ascension coarse motion clamp #1: permits rotation of the maintube and R.A. clamp housing. Right ascension coarse motion clamp #2: permits rotation of the maintube independent of the R.A. clamp housing.
8. Auxiliary right ascension slow motion control rod.


the earth
N. Cel. Pole
zenith
L.HA.
Declination
N
EARTH
S
Observer's horizon
Observer's Meridian
Celestial equator
CELESTIAL SPHERE

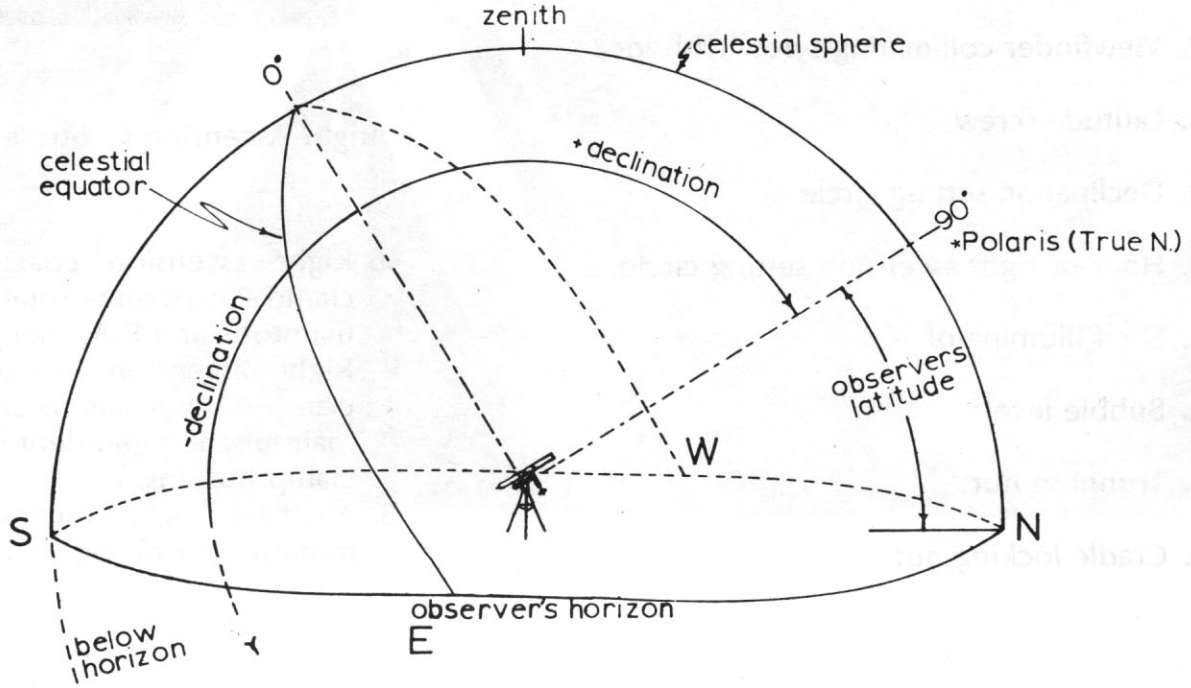

zenith
celestial sphere
0°
celestial equator
*declination
90°
*Polaris (True N.)
-declination
observers latitude
W
S
N
observer's horizon
E
below horizon

FIG. 2

INTRODUCTION

A telescope with an equatorial mounting offers the observer many features not available on the similar 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 the problem of "losing" it. Furthermore, since the stars 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 develop, 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. 2 illustrates this

concept. A major portion of these instructions will be devoted to the proper orientation and use of the equatorial mounting.

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.

The following, packed in wooden cabinets, are included with the Model 152 as standard equipment.

Case 1 - Maintube with coated, achromatic objective of 100mm clear aperture and 1500mm focal length.
- Standard rack and pinion focusing mechanism.
- 10X-42mm viewfinder.
- 5 coated eyepieces - 40mm(38X), 25mm(60X), 18mm(83X), 12.5mm(120X), 9mm(167X) and 7mm(214X).
- Star diagonal with 2X barlow lens (Prod. No. 16519 only).
- Erecting prism system (Prod. No. 16519 only).
- Sun projecting screen set.
- Solar aperture diaphragm.
- Dewcap.
- Dustcap.

Case 2 - Equatorial mounting with coarse and fine motion controls.
- Coarse motion and slow motion control rods.
- Slow motion flexible cable.
- Counterweight rod.
- Counterweight.
- Shelf illuminator

Case 3 - Set of 3 tripod legs

A separate cardboard carton contains the wooden tripod accessories shelf.

If ordered with the Model A Unihex as standard equipment (Prod. No. 16518 only), the Unihex with 2X barlow lens is packaged in a separate cardboard box.

PART I: 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 wooden tripod accessories shelf at the midpoint of the legs to hold the tripod legs in position.

2. INSTALLING THE CONTROL RODS:

A) Declination coarse 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. 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 coarse motion clamp must be tightened. This control permits the fine adjustments to be made in declination while observing.

C) Right ascension coarse motion clamp (1-7): This control is a wing screw, as illustrated. 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 coarse 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 ascension control to a comfortable position for manual tracking while viewing through the instrument. It may be used on either side of the telescope by inserting it into the recessed center of the right ascension hand wheel (1-10) and tightening the thumbscrew. If a synchronous motor is installed, then the flexible cable should be removed as it will create an uneven drag on the motor.

F) Shelf illuminator (1-21): Offers convenient illumination to the tripod accessories shelf. Install the 2 batteries provided into the tube portion and attach the tube to the bulb housing. The completed assembly threads into the underside of the mounting as shown.

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): The counterweight threads onto the counterweight rod.

4. OPTICS:

A) The cradle (1-6), which attaches the telescope to the mounting, is clamped around the maintube (1-15) during shipment. To attach the cradle to the mounting, remove the cradle mounting nuts (1-14) and insert the threaded bolt shafts through the cradle mounting bar as shown. Replace the nuts and tighten them securely by hand. The telescope may be repositioned forward or backward in the cradle by loosening the cradle locking nut (1-24) and positioning the tube as desired.

B) The viewfinder (1-16) is to be installed in the collimating brackets on the maintube. Instructions for aligning the viewfinder are in a later section of this manual.

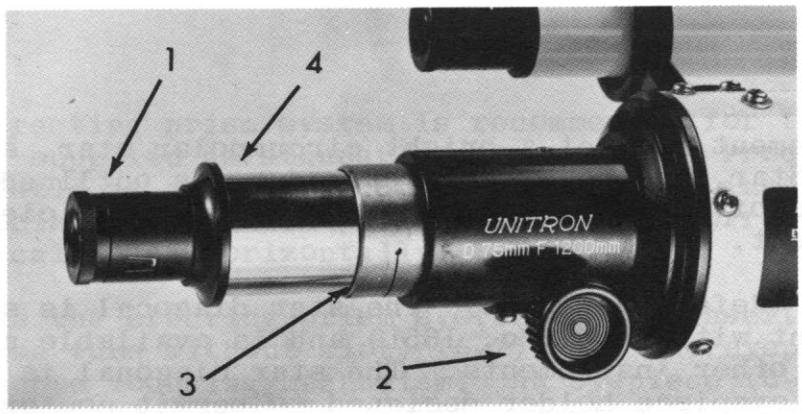
C) The dewcap is packed separately in the optics cabinet and screws onto the outer cell. The dustcap slides over the end of the dewcap and is easily removed for observing.

This conpletes the aseembly of the major components of the refractor.

PART II: OPERATION OF OPTICAL SYSTEM

1) CONTROLS: (Refer to Fig. 1) Both right ascension and declination motions are equipped with coarse and slow motion controls. Major changes in the position of the telescope tube are accomplished by use of the declination coarse motion clamp (1-3) and the right ascension coarse motion clamp (1-7). Once the object to be observed is within the field, the coarse motion clamps should be tightened. Centering can then be accomplished by using the slow motion micrometer screws in right ascension (1-8 or 1-10) and declination (1-4). Tracking is done by using the right ascension flexible control cable (1-11).

2) FOCUSING: (Refer to Fig. 3) The Model 152 refractor is equipped with the Standard Rack and Pinion focusing 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, such as the 25mm, and insert it directly in the end of the drawtube (3-1). To obtain an approximate focus, turn the fine focus knob (3-2) until the fine focusing sleeve (3-3) is approximately at the center of its travel. Then, while sighting through the eyepiece, slowly pull out the drawtube (3-4) 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 knob in the appropriate direction. As eyepieces are changed, a minor adjustment in fine focus will be necessary to achieve maximum resolution.



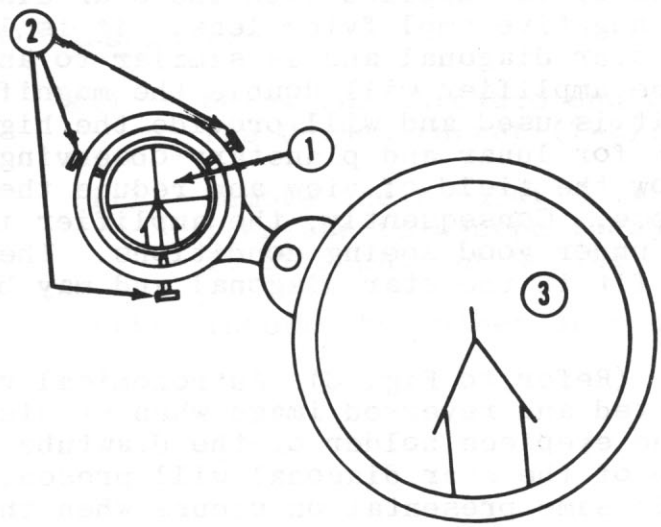
1. Eyepiece holder
2. Fine focus knob
3. Fine focus sleeve
4. Drawtube

Fig. 3

The magnification, or power, of an eyepiece is determined by dividing the focal length of the objective by that of the eyepiece. The eyepiece focal length, in millimeters, is engraved on the top of each ocular. The focal length of the Model 152 is 1500mm. A chart is affixed to the maintube as a handy reference listing the magnification and field of view of each eyepiece when used with the Model 152.

3) VIEWFINDER: (Refer to Fig. 4) The viewfinder 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, 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 flagpole or utility pole. Using a low power eyepiece, center the object in the field of the telescope (4-3). Then, while looking through the viewfinder, adjust the collimating screws (4-2) in the rear mounting bracket, nearest the eyepiece, moving the viewfinder until the object is centered on the crosshairs. This is done by backing off on one of the screws and tightening the others. If exact centering is not possible, adjust the viewfinder as close to exact alignment as possible and repeat the adjustment using the collimating screws on the forward mounting bracket. By adjusting either or both sets of collimating screws, it is possible to achieve the required alignment.



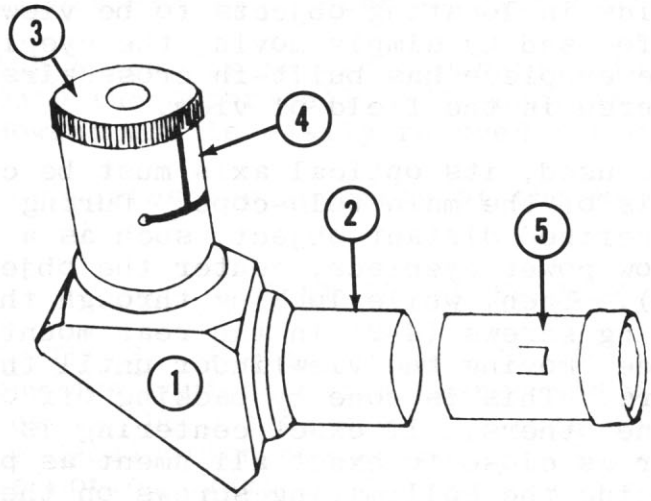
1. Viewfinder field
2. Collimating screws
3. Telescope field

Fig. 4

To improve the alignment, select a bright circumpolar star, such as Polaris, the North Star, and repeat the procedure as outlined. The slow apparent motion of the circumpolar stars allows sufficient time for accurate alignment.

4) STAR DIAGONAL: (Refer to Fig. 5) The star diagonal is supplied as standard equipment with Prod. No. 16519 and is available as an extra accessory for other instruments. The star diagonal is a special right angle eyepiece holder designed to permit comfortable viewing regardless of the position of the telescope tube. Designed for astronomical observations, the image is upright, but reversed left for right.

To use the star diagonal (5-1), insert the coupling tube (chrome tube without slow) (5-2) into the eyepiece holder of the telescope focusing mechanism. An eyepiece (5-3) is inserted in the eyepiece holder (5-4) of the star diagonal. The telescope is then focused using the procedure outlined previously.



1. Star diagonal
2. Coupling tube
3. Eyepiece
4. Eyepiece holder
5. Achromatic amplifier

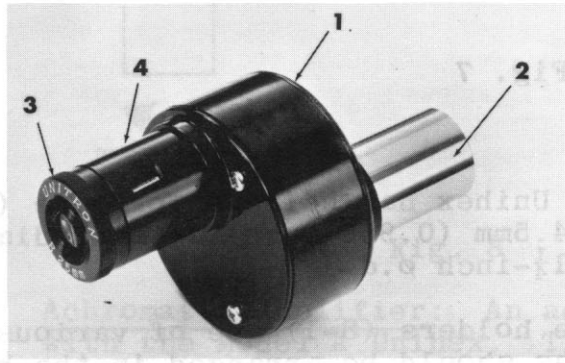
Fig. 5

An achromatic amplifier (5-5) is supplied with the star diagonal. The amplifier is a 2X Barlow negative amplifying lens. It is located in the coupling tube of the star diagonal and is similar to an eyepiece in appearance. Use of the amplifier will double the magnification of any eyepiece with which it is used and will provide the higher magnifications often necessary for lunar and planetary observing. The amplifier will also narrow the field of view and reduce the amount of light reaching the eyepiece. Consequently, the amplifier is most useful on bright objects under good seeing conditions. The achromatic amplifier has a friction fit in the star diagonal and may be removed or replaced as desired.

5) TERRESTRIAL VIEWING: (Refer to Fig. 6) Astronomical refractors normally present an inverted and reversed image when eyepieces are inserted directly into the eyepiece holder of the drawtube. As mentioned previously, use of the star diagonal will present an upright, but reversed, image. This same presentation occurs when the Unihex or Duetron is used.

The erecting prism system is recommended for terrestrial viewing. It is supplied as standard equipment with Prod. No. 16519 and is available as an extra accessory for other instruments. It contains a special prism which presents an image correctly oriented both vertically and horizontally.

To use the erecting prism system (6-1), insert the coupling tube (chrome tube without slot) (6-2) into the eyepiece holder of the telescope focusing mechanism. An eyepiece (6-3) is inserted in the eyepiece holder of the erecting system (6-4). The telescope is then focused using the procedure outlined previously.



1. Erecting prism
2. Coupling tube
3. Eyepiece
4. Eyepiece holder

Fig. 6

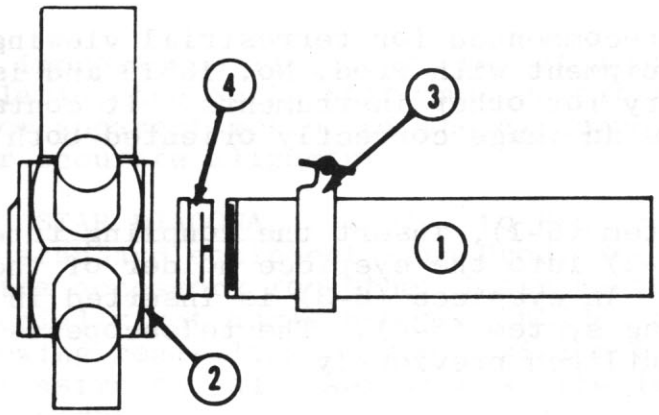
6) MODEL A UNIHEX: (Refer to Fig. 7 and 8) The Model A Unihex is supplied as standard equipment with Prod. No. 16518 and is available as an extra accessory for other instruments. The Unihex is a multiple eyepiece holder which contains a 90^{o} prism to permit comfortable viewing regardless of the position of the telescope tube. It holds six eyepieces simultaneously which permits rapid changes of magnification by simply rotating the turret. This eliminates the inconvenience and possible damage to eyepieces resulting from the use of conventional, single eyepiece holders.

(A) Assembly:

(i) Screw the threaded end of the drawtube (7-1) into the Unihex turret (7-2).

(ii) Remove the regular drawtube (coarse focus sleeve) from the telescope focusing mechanism by sliding it straight out of the fine focus sleeve.

(iii) Insert the Unihex drawtube into the fine focus sleeve.



1. Drawtube
2. Turret
3. Drawtube clamp
4. Achromatic amplifier

Fig. 7

(B) Operation:

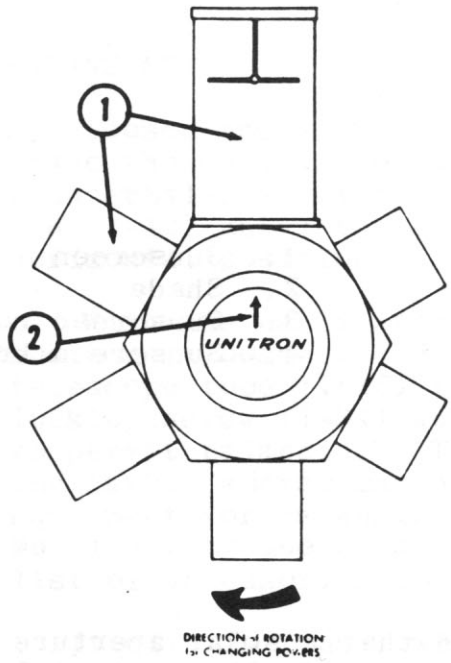
(i) The Model A Unihex has holders for five (5) eyepieces of 24.5mm (0.965-inch) outside diameter and one (1) of $1\frac{1}{4}$-inch ø.d.

(ii) The eyepiece holders (8-1) are of various lengths. The eyepieces should be arranged in the holders in order of focal length with the longest focal length eyepiece in the longest holder. This arrangement will require the minimum adjustment of focus when changing magnification.

(iii) The index arrow (8-2) indicates the position of the prism. The eyepiece holder in line with the index arrow is the one which is in position for viewing. The entire Unihex may be rotated in the fine focus sleeve, thereby repositioning the prism for greatest comfort.

(iv) Focus initially by sliding the entire Unihex in or out of the fine focus sleeve with a low power eyepiece in viewing position. When an approximate focus has been obtained, slide the clamp (7-3) over the fine focus sleeve and tighten the wing nut. This will prevent the Unihex from sliding out of the instrument and will retain the coarse focus position. Refine the focus by using the telescope's fine focus knobs.

(v) To change powers, rotate the turret in a clockwise direction so that the desired eyepiece is in line with the index arrow. Clickstops are provided at each of the six positions, assuring positive alignment of the selected eyepiece with the prism. If the eyepieces have been arranged by focal length, only a minor adjustment of focus will be required.



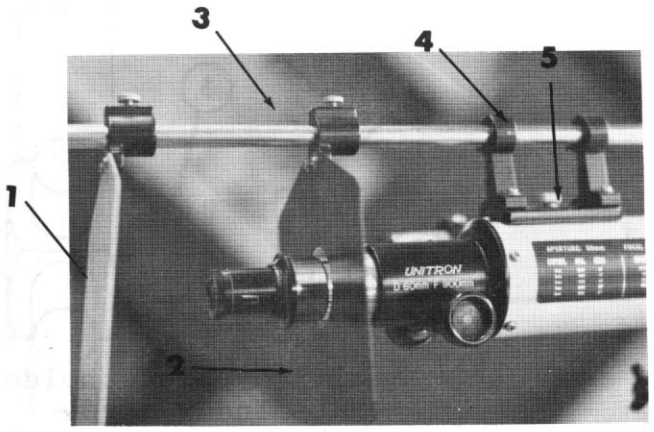
1. Eyepiece holder
2. Index arrow

Fig. 8

(C) Achromatic Amplifier: An achromatic amplifier is supplied with the Model A Unihex. The amplifier is a 2X Barlow negative amplifying lens. Use of the amplifier will double the magnification of any eyepiece with which it is used and will provide the higher magnifications often necessary for lunar and planetary observing. The amplifier will also narrow the field of view and reduce the amount of light reaching the eyepiece. Consequently, the amplifier is most useful on bright objects under good seeing conditions.

When in use, the achromatic amplifer (7-4) is inserted into the threaded end of the Unihex drawtube. It may be inserted and removed by a "pulling-twisting" motion.

7) SUNSCREENS: (Refer to Fig. 9) The safest method of viewing the sun requires the use of a sun projecting screen apparatus which is supplied with all equatorial models. When sun projection screens are used, the sun's image is projected onto a white metal screen (9-1) where it may be viewed safely with the naked eye. This method has the advantage of permitting several persons to view the projected image simultaneously. The black plate with the hole in the center (9-2) is used as a shade to prevent the direct rays of the sun from striking the white projection screen and "washing out" the image. The hole is large enough to permit the passage of the drawtube and eyepiece. The size of the sun's image can be regulated by moving the white screen along the rod. Sharp focus is achieved by use of the telescope's focusing mechanism.



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

Fig. 9

When viewing the sun, it is recommended that a solar aperture diaphragm, supplied as a standard component of all equatorial models, be used. Similar in appearance to the dustcap, the aperture diaphragm has a small hole cut in the center. Use of the solar aperture diaphragm reduces the area of the objective lens surface that is directly exposed to the sun and, consequently, limits the amount of light entering the telescope. Even when using the aperture diaphragm, however, the telescope should be pointed away from the sun at frequent intervals. This will prevent the buildup of excessive heat inside the telescope and optical components which may damage the objective and eyepieces. The viewfinder objective should also be covered in order to prevent accidental exposure to the focused rays of the sun passing through the finder eyepiece.

PART III: 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 using a commercially available hand level, 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 coarse 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 balancing equipment for balancing the tube. This may be accomplished on the Model 152 by use of a Unibalance assembly. Refer to the catalog and list of accessories 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. 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. 10 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.

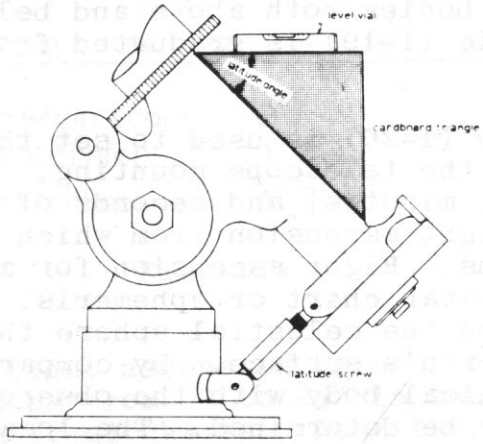


Fig. 10

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.

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 $7.50 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^{o} at the celestial equator to $+90^{o}$ at the north celestial pole, and from 0^{o} at the celestial equator to -90^{o} 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^{o} to 90^{o} in both directions.

b) Hour Circles: The hour circle (1-20) 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: The setting circles may be read with a great degree of accuracy through the use of verniers, which are short graduated scales adjacent to the circles. The hour circle is divided into units of 10 minutes and can be read to 1 minute by vernier. The declination circle is divided into units of 2^{o} and may be read to 5 minutes by vernier.

Fig. 11 shows a section of the declination circle and vernier. Examining the figures, note that there is only one line on the vernier and one line on the main circle which are in coincidence. 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 is 2^{o}, the total length of the vernier is also 2^{o}, or 120'. The vernier is numbered in both directions from 0' to 120'. The leftmost line of the vernier is used to determine the main scale reading.

In Fig. 11a, the leftmost line of the vernier falls between 0^{o} and 2^{o}. Referring to the vernier scale numbered in the same direction as the main scale, note that coincidence occurs at 90'. The total declination reading, therefore, is $0^{o}+90'=1^{o}30'$.

In Fig. 11b, the leftmost line of the vernier indicates a reading between 32^{o} and 34^{o}. The vernier is read from right to left so as to agree with the main scale reading. Coincidence occurs at 35'. The complete declination reading, then, is $32^{o}+35'=32^{o}35'$.

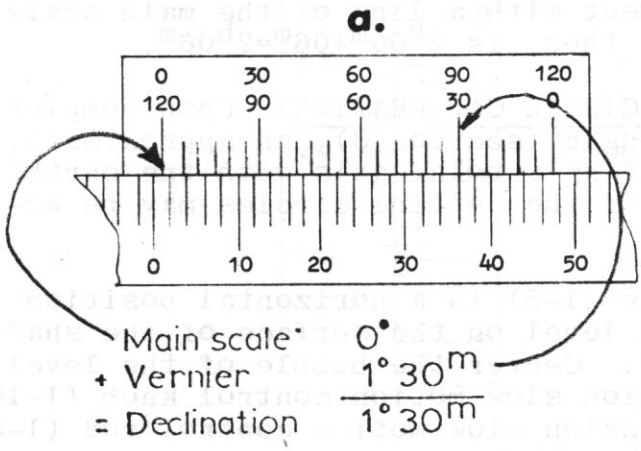


Fig. 11a

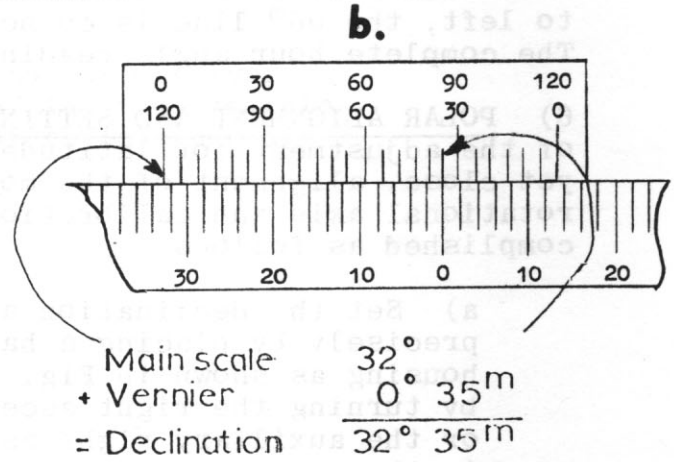
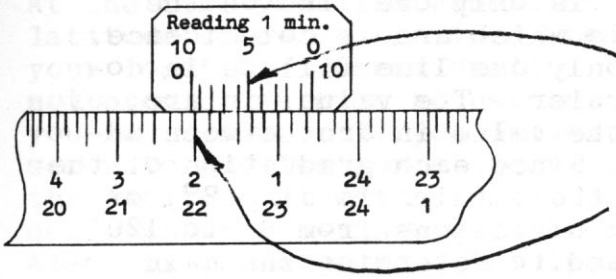


Fig. 11b

The right ascension or hour circle is graduated in hours and minutes from 0^{h} to 24^{h} in scales, one clockwise and the other counter-clockwise. Read the upper scales of the setting circle and the vernier for objects lying east of the meridian: read the lower scales for objects west of the meridian. The leftmost line of the vernier is used to determine the main scale reading.

Fig. 12 shows a section of the hour circle and vernier. Examining the figure, note that there is only one line on the vernier and one line on the main circle which are in coincidence. For any position on 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 on the main scale is 2^{m}, the total length of the vernier is also 2^{m}.



upper $2^h\ 00^m + 06^m = 2^h\ 06^m$

lower $21^h\ 50^m + 04^m = 21^h\ 54^m$

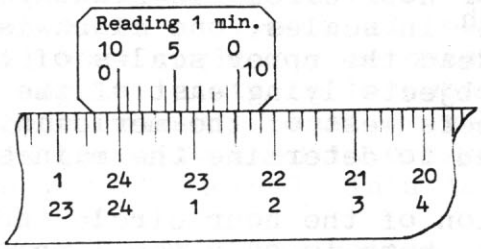
Fig. 12

If the lower scale of the setting circle is being used, the left-most 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 line is coincident with a line of the main scale. Therefore, the complete hour angle reading is $21^h50^m+04^m=21^h54^m$.

If the upper scale of the setting circle is being used, the 0 line at the left edge of the vernier would indicate a reading between 2^h00^m and 2^h10^m. By examining the lines of the vernier from right to left, the 06^m line is coincident with a line of the main scale. The complete hour angle reading, then, is $2^h00^m+06^m=2^h06^m$.

6) POLAR ALIGNMENT AND SETTING CIRCLE CALIBRATION: Upon completion of the adjustment for latitude angle (section 3), an approximate, yet close, alignment of the mounting's polar axis with the earth's rotational axis and calibration of the setting circles may be accomplished as follows:

a) Set the declination axis (1-5) in a horizontal position precisely by placing a hand level on the surface of the shaft housing as shown in Fig. 13. Center the bubble of the level by turning the right ascension slow motion control knob (1-10) or the auxiliary right ascension slow motion control rod (1-8) in the appropriate direction.



HOUR CIRCLE

Showing proper setting for orientation of mounting, with declination axis horizontal.

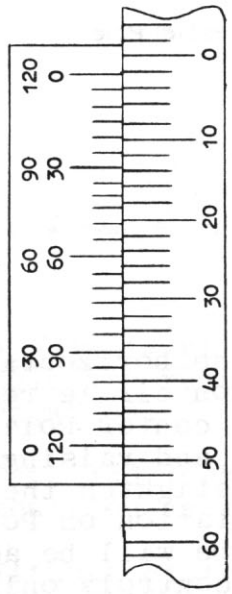
Fig. 13

b) Set the hour circle (1-20) by loosening its locking screw, as well as the locking thumbnut at the base of the polar axis

(1-9), and rotating the circle until a reading of 24^h coincides with the leftmost 0 line of the vernier as in Fig. 13.

c) Without disturbuing the position of the declination axis, loosen the declination coarse motion clamp (1-3) and set the refractor tube approximately horizontal. Place the level on the telescope tube and center the bubble by turning the declination slow motion control rod (1-4) in the appropriate direction.

d) Set the declination circle (1-19) by loosening its locking screw (1-26) and turning the circle until the co-latitude (90^o minus the observer's latitude) coincides with the leftmost line of the vernier as in Fig. 14.



DECLINATION CIRCLE

Setting for observer at 42^0 latitude (circle set at co-latitude of 48^0)

Fig. 14

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

e) To complete the orientation of the mounting it is necessary to align the polar axis 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 pre-selected times, which will be discussed in a later paragraph. However, since Polaris is never at a great angular distance from the Pole, alignment with Polaris at any instant of time will be sufficiently accurate for most viaual observation.

To locate Polaris refer to Fig. 15. The stars forming the forward edge of the Big Dipper (Ursa Major) point toward the North Star as shown. They are about 5^o apart. Polaris is about 30^o 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.

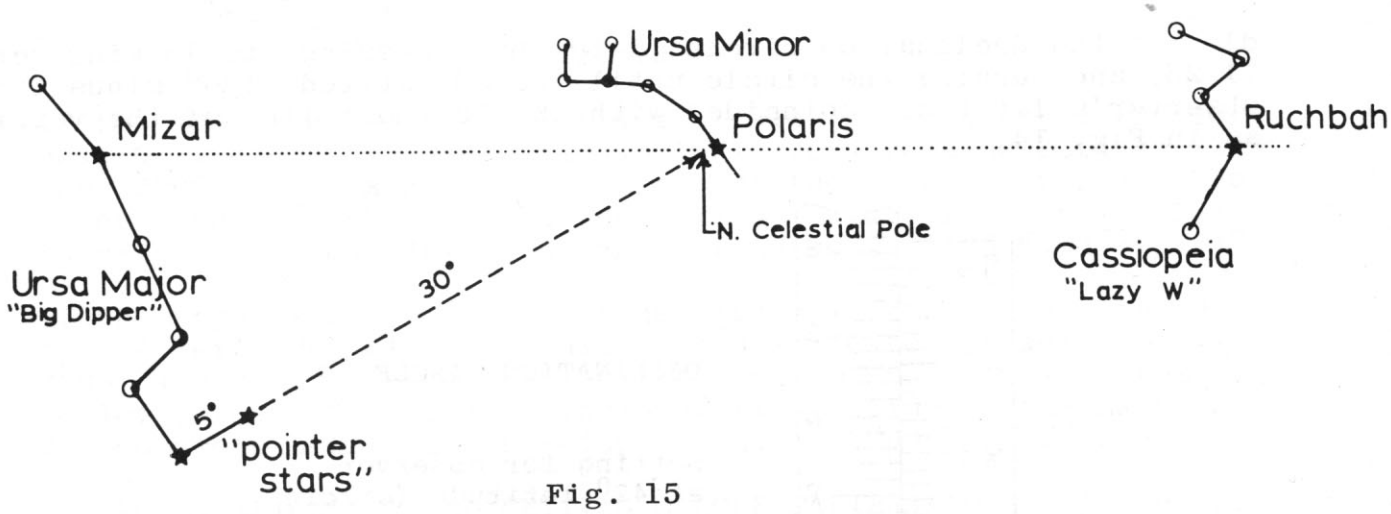
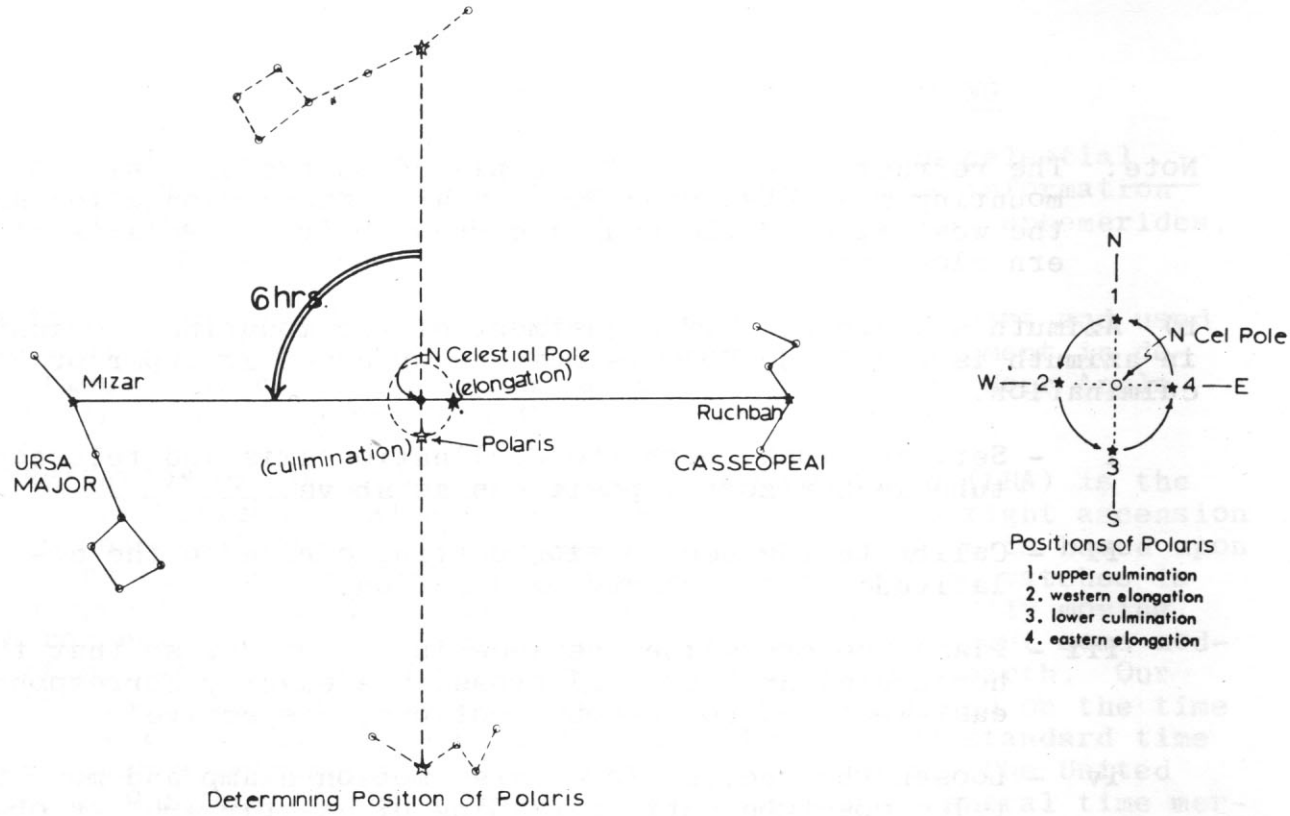


Fig. 15

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 the orientation of the setting circles or loosen the Azimuth locking screw.

7) PRECISE ORIENTATION: The preceding alignment procedure is accurate enough for most visual observations. However, a more precise alignment of the polar axis with the North Celestial Pole is required for accurate visual observations and, especially, for astrophotography. The imaginary line between Mizar (zeta Ursae Majoris) and Ruchbah (delta Cassiopeiae) can be used to determine the location of Polaris with respect to the North Celestial Pole. For accurate refinements of the latitude angle adjustment, Polaris should be observed at eastern or western elongation. Should adjustment in azimuth be necessary, 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 North Star is alternately at elongation and culmination every 6 hours. Reference to Fig. 16 will indicate the relationship of Polaris and the North Celestial Pole to Mizar and Ruchbah. During the alignment procedure, the telescope should be equipped with a crossline eyepiece, e.g. the Unitron 9mm achromatised symmetrical eyepiece with crossline or the 10X eyepiece "borrowed" from the viewfinder.



Determining Position of Polaris

Fig. 16

a) Latitude Adjustment - if refinements in the adjustment of latitude angle are required, observe Polaris at eastern or western elongation.

i - Set, and lock, the declination axis in a horizontal position as in the previous alignment method.

ii - Without disturbing the positions of the declination axis, loosen the declination coarse motion clamp and set, and lock, the refractor tube in a precisely horizontal position.

iii - Set the co-latitude of the observing location on the declination setting circle.

iv - Place the crossline eyepiece in the eyepiece holder so that the horizontal and vertical crosslines exactly correspond to east-west and north-south motions, respectively.

v - Loosen the declination coarse motion clamp and move the telescope tube until the declination setting circle reads $+90^{o}$ exactly.

vi - While looking through the eyepiece, turn the latitude screw (1-18) until Polaris falls exactly on the horizontal crossline of the eyepiece. Since Polaris is on the declination of the North Celestial Pole ($+90^{o}$) when at elongation, the latitude angle of the polar axis will be properly set.

Note: The refractor tube should be placed on the east side of the mounting when observing Polaris at eastern elongation and on the west side of the mounting when observing Polaris at western elongation.

b) Azimuth Adjustment - if adjustment of the mounting's orientation in azimuth is required, Polaris must be observed at upper or lower culmination.

i - Set, and lock, both the declination axis and telescope tube in horizontal positions as above.

ii - Calibrate the declination setting circle to the co-latitude of the observing location.

iii - Place the crossline eyepiece in its holder so that the horizontal and vertical crosslines exactly correspond to east-west and north-south motions, respectively.

iv - Loosen the declination coarse motion clamp and move the telescope tube until a reading of exactly $+90^{o}$ is obtained on the declination setting circle.

v - Without disturbing the orientation of the declination axis, set the hour circle to a reading of 6^{h} or 18^{h} (they share the same graduations on the setting circle.)

vi - Loosen the right ascension coarse motion clamp (1-7) and turn the mounting about the polar axis until the hour circle reads exactly 24^{h}.

vii - If Polaris does not lie exactly on the vertical crossline of the eyepiece, loosen the azimuth locking screw (1-27) and turn the entire mounting until the proper alignment is obtained.

Note: Read the upper scale of the hour circle if moving the mounting in "step vi" from east to west. Read the lower scale if moving the mounting from west to east.

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

CULMINATIONS AND ELONGATIONS OF POLARIS

1980 LOCAL MEAN TIME

	8 PM	9PM	10 PM	11 PM	MID-NIGHT	1 AM	2 AM	3 AM
UC	Dec. 23	Dec. 8	Nov. 23	Nov. 7	Oct. 23	Oct. 9	Sept.24	Sept.9
WE	Mar. 25	Mar. 10	Feb. 22	Feb. 8	Jan. 25	Jan. 9	Dec. 24	Dec. 9
LC	June 24	June 8	May 24	May 9	Apr. 24	Apr. 9	Mar. 25	Mar. 10
EE	Sept.24	Sept. 9	Aug. 24	Aug. 9	July 25	July 11	June 25	June 9

Time of event for dates in between those charted can be determined by subtracting 4^{m} per day.

PART IV: USING THE EQUATORIAL MOUNTING

The data necesssry 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^{o} 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 1.

	Central Time Meridian
Eastern Standard Time Zone (EST)	75^{o}
Central Standard Time Zone (CST)	90^{o}
Mountain Standard Time Zone (MST)	105^{o}
Pacific Standard Time Zone (PST)	120^{o}

Table 1

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 $\frac{1}{4}^{o}$ (15^{m}). If you are located west of your central time meridian, add four minutes for each degree of longitude (1^{m} per $\frac{1}{4}^{o}$). If you are east subtract four minutes per degree.

This is a constant for a given location and can be recorded on Table II 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

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

DAY	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	DAY
1	2^h46^m	4^h48^m	6^h39^m	8^h41^m	10^h39^m	12^h42^m	14^h40^m	16^h42^m	18^h44^m	20^h43^m	22^h45^m	0^h43^m	1
2	2 50	4 52	6 43	8 45	10 43	12 46	14 44	16 46	18 48	20 46	22 49	0 47	2
3	2 54	4 56	6 47	8 49	10 47	12 49	14 48	16 50	18 52	20 50	22 53	0 51	3
4	2 58	5 00	6 51	8 53	10 51	12 53	14 52	16 54	18 56	20 54	22 57	0 55	4
5	3 02	5 04	6 55	8 57	10 55	12 57	14 56	16 58	19 00	20 58	23 00	0 59	5
6	3 06	5 08	6 58	9 01	10 59	13 01	15 00	17 02	19 04	21 02	23 04	1 03	6
7	3 10	5 12	7 02	9 05	11 03	13 05	15 03	17 06	19 08	21 06	23 08	1 07	7
8	3 14	5 16	7 06	9 09	11 07	13 09	15 07	17 10	19 12	21 10	23 12	1 11	8
9	3 18	5 20	7 10	9 13	11 11	13 13	15 11	17 14	19 16	21 14	23 16	1 15	9
10	3 22	5 24	7 14	9 16	11 15	13 17	15 15	17 17	19 20	21 18	23 20	1 18	10
11	3 26	5 28	7 18	9 20	11 19	13 21	15 19	17 21	19 24	21 22	23 24	1 22	11
12	3 30	5 32	7 22	9 24	11 23	13 25	15 23	17 25	19 28	21 26	23 28	1 26	12
13	3 34	5 36	7 26	9 28	11 27	13 29	15 27	17 29	19 32	21 30	23 32	1 30	13
14	3 38	5 40	7 30	9 32	11 31	13 33	15 31	17 33	19 35	21 34	23 36	1 34	14
15	3 41	5 44	7 34	9 36	11 34	13 37	15 35	17 37	19 39	21 38	23 40	1 38	15
16	3 45	5 48	7 38	9 40	11 38	13 41	15 39	17 41	19 43	21 42	23 44	1 42	16
17	3 49	5 51	7 42	9 44	11 42	13 45	15 43	17 45	19 47	21 46	23 48	1 46	17
18	3 53	5 55	7 46	9 48	11 46	13 49	15 47	17 49	19 51	21 50	23 52	1 50	18
19	3 57	5 59	7 50	9 52	11 50	13 52	15 51	17 53	19 55	21 53	23 56	1 54	19
20	4 01	6 03	7 54	9 56	11 54	13 56	15 55	17 57	19 59	21 57	0 00	1 58	20
21	4 05	6 07	7 58	10 00	11 58	14 00	15 59	18 01	20 03	22 01	0 04	2 02	21
22	4 09	6 11	8 02	10 04	12 02	14 04	16 03	18 05	20 07	22 05	0 08	2 06	22
23	4 13	6 15	8 06	10 08	12 06	14 08	16 07	18 09	20 11	22 09	0 11	2 10	23
24	4 17	6 19	8 09	10 12	12 10	14 12	16 10	18 13	20 15	22 13	0 15	2 14	24
25	4 21	6 23	8 13	10 16	12 14	14 16	16 14	18 17	20 19	22 17	0 19	2 18	25
26	4 25	6 27	8 17	10 20	12 18	14 20	16 18	18 21	20 23	22 21	0 23	2 22	26
27	4 29	6 31	8 21	10 24	12 22	14 24	16 22	18 24	20 27	22 25	0 27	2 26	27
28	4 33	6 35	8 25	10 27	12 26	14 28	16 26	18 28	20 31	22 29	0 31	2 29	28
29	4 37		8 29	10 31	12 30	14 32	16 30	18 32	20 35	22 33	0 35	2 33	29
30	4 41		8 33	10 35	12 34	14 36	16 34	18 36	20 39	22 37	0 39	2 37	30
31	4 44		8 37		12 38		16 38	18 40		22 41		2 41	31

TABLE 2

zone before determination of local mean time.)

Example: Observer's location: Boston, MA, Eastern Standard Time Zone, longitude $71^{o}03^{m}$ (use as 71^{o} to nearest $\frac{1}{4}^{o}$)

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

Date: August 14th

Central time meridian (from Table 1) = 75^{o}

Differences between longitude and central time meridian:

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

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

8:00 P.M. (E.S.T.) - $16^{m} = 7^{h}44^{m}$ (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 P.M. LMT = $17^{h}33^{m}$ 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 P.M. (EST), the Boston time equivalent to 8:00 (LMT), the observer's watch should be set to read $5^{h}33^{m}$ ($17^{h}33^{m} - 12^{h}00^{m}$). 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 P.M. (EST) the sidereal time would be $18^{h}49^{m}$ ($6^{h}49^{m}$ 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 $+36^{o}32^{m}$ and the right ascension as $16^{h}40^{m}$.

To point the telescope at this object at 9:00 P.M. (EST) loosen the declination rod (1-3) and swing the telescope tube until a reading of $+36^{o}32^{m}$ (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 (ST) - 16^h40^m (RA) = 2^h09^m (LHA)

If the RA is greater than ST then the LHA is East of the observer's meridian.

If the RA is less than ST then the LHA is West 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.

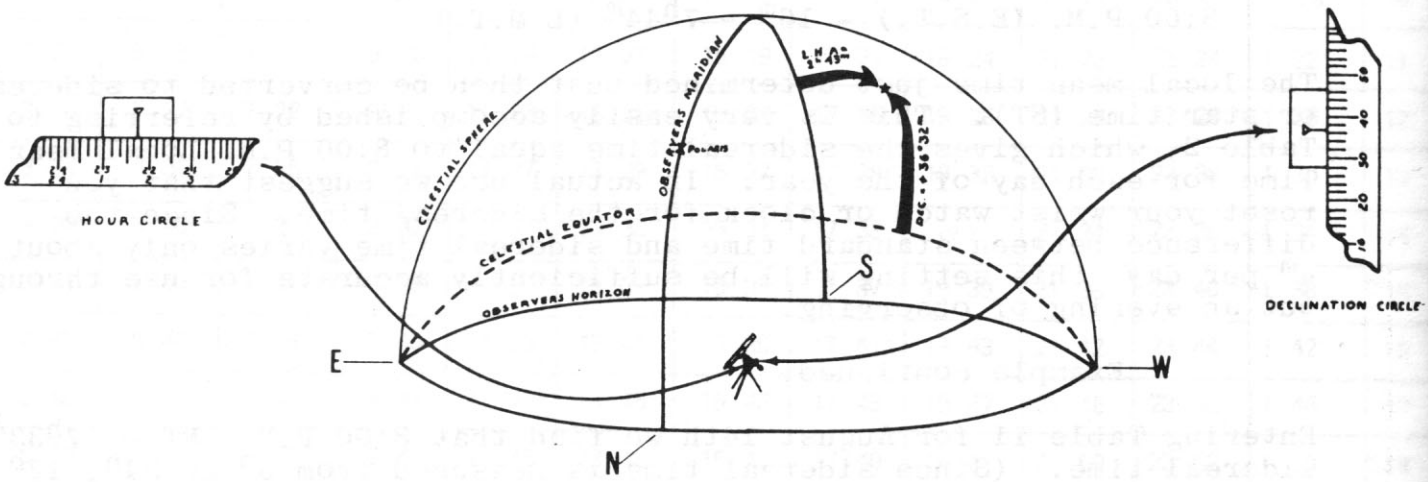


Fig. 17

Once the object has been acquired in the field of view 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.

2) A SIMPLE METHOD FOR USING SETTING CIRCLES: This method, somewhat simpler than the preceding one, is based upon the fact that all objects except the sun and moon move across the sky at the same rate. Therefore, the change in hour angle for one star represents the change for all others.

Begin by choosing a "clock" star whose motion will serve as a base for all others. This should be a third magnitude star near the celestial equator easy to locate and whose right ascension and declination are listed in a table. Two such stars are alpha Aquarius

and delta Aquila.

Move the telescope in declination until the declination circle attains the appropriate setting. Then, move the telescope in right ascension until the clock star is centered in the field. Move the right ascension setting circle to the correct reading for the clock star and clamp the circle in place. Finally, set a clock or wrist watch on 12: this will keep sidereal time. Though not exact, this sidereal clock will be off only 10 seconds per hour, which is sufficiently accurate for most observing programs.

To locate another object, begin by looking up its right ascension and declination. Move the telescope in hour angle until the setting circle reads the object's right ascension plus the time read from the sidereal clock. Lastly, set the telescope on the star's declination. The star should not be centered in the field of view.

PART V: 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 should be covered or returned to their storage containers.

The objective lens has been coated with a special film for maximum brillance of the image. Avoid touching optical surfaces with your fingers, as the trace of oil this leaves greatly reduces optical performance. Excessive and incorrect cleaning of the objective lens and eyepieces may damage the delicate optical surfaces.

If cleaning does become unavoidable, you can gently wipe off dust or dew with a freshly laundered handkerchief or soft linen cloth, using as little pressure as possible. To remove smears or grease, after gently brushing particles from the lens surface, moisten lens cleaning paper or soft linen cloth with lens cleaner. Rub the surface gently and dry with cleaning paper or cloth. Frequent cleaning is unnecessary.

If, on a particularly damp night the telescope becomes heavily dewed, it is advisable to let the instrument stand for a while in a heated room before packing it away in its cabinet. On looking through the telescope, if you see specks of dirt superimposed on the image, this dirt is not on the objective but on the eyepiece lens furthest from your eye. Simply remove the eyepiece and brush the surface clean with a camel's hair brush or clean, soft linen cloth.

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, and the eyepieces should be kept in the box, when you are not 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 screws which fasten the tripod legs to the mounting whenever necessary to insure proper rigidity.

PART VI: 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 powers 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. A good rule of thumb is that the highest useful magnification is approximately equal to 50-60 times the objective's aperture in inches. However, on nights of exceptionally good seeing, this may be as high as 100 times the aperture.

(4) In comparing what you see through your telescope with a star chart, it is very helpful to know the diameter of the field of view for each of your eyepieces and for your finder. If this information is not already at hand, it is easily found. Select any star near the celestial equator--such as one of the bright stars in Orion's Belt--and time how long it takes to drift centrally across the field of view, as the telescope remains stationary. Divide this interval in seconds of time by 4, and the result is very nearly the angular diameter of the field in minutes of arc. Specific data pertaining to fields of view may be found on the enclosed specification sheet.

(5) Averted vision is an additional aid in looking for very dim objects, such as the fainter satellites of Saturn. Turn your glance so that you are looking out of the corner of your eye, while still fixing your attention on the spot to be searched. This method takes advantage of the greater sensitivity of the outer portion of the retina, as compared with its central area.

(6) A useful adjunct to observing will be an atlas or an almanac. A star atlas will be of assistance in locating double stars, clusters, etc. Two excellent atlases, Norton's or Skalnate Pleso, are available from the Sky Publishing Corp., 49 Bay State Road, Cambridge, MA 02138.

For the sun, moon, and planets, refer to the "Observer's Handbook" of

the Royal Astronomical Society of Canada, 124 Merton Street, Toronto, Ontario, Canada.

PART VII: 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. Fill out and mail the return portion of the warranty card that you received with your telescope. Keep the other part for your records.

UNITRON

EXCELLENCE BY DESIGN

UNITRON INSTRUMENTS, INC. 175 Express Street, Plainview, N.Y. 11803, U.S.A. • (516) 822-4601

Printed in U.S.A.