9. With ruler draw a line in the north-south and east-west directions perpendicular to each other through the center of the circle as shown in Figure 2.

10. Choose the side that you want as the top, and cut out a small circle centered on one of the lines drawn in step 8, approximately two inches from the edge of the mounted circle. (See Figure 3).

11. Place paper clip through the hole. This will be the handle with which to hold the astrolabe.

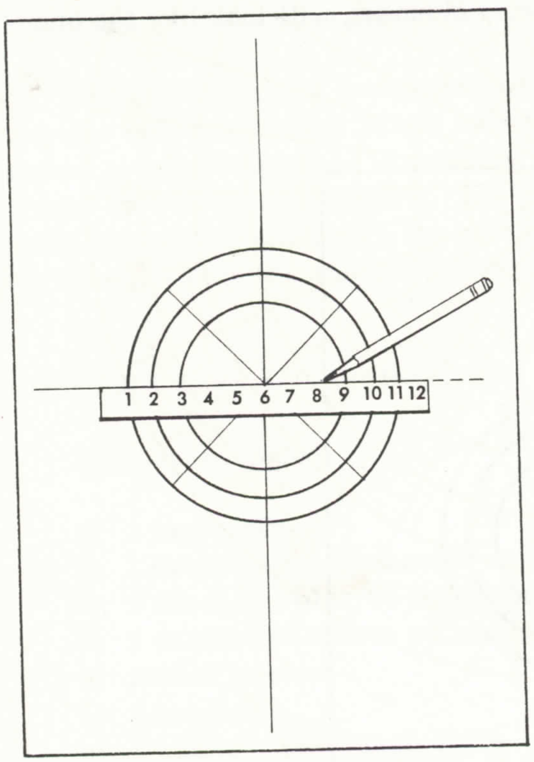


Figure 2. Drawing the perpendicular lines.

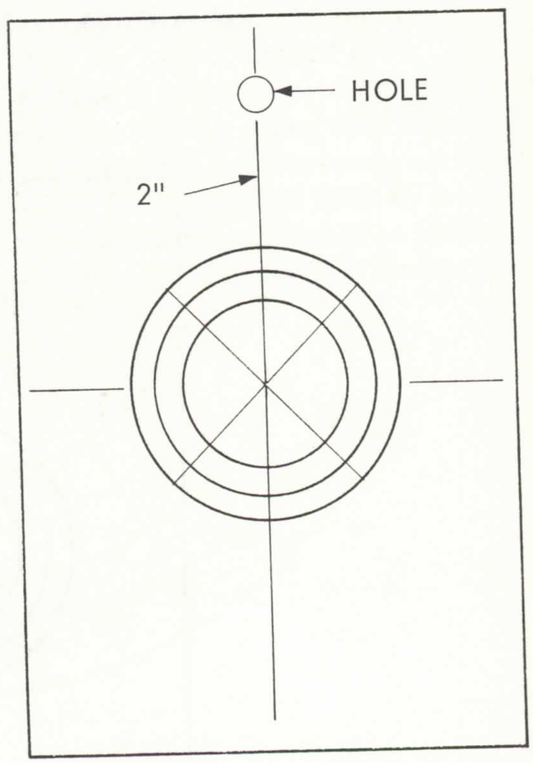


Figure 3. Preparing the hole for the handle.

12. Mark circle every 10° and label as shown in Figure 4.

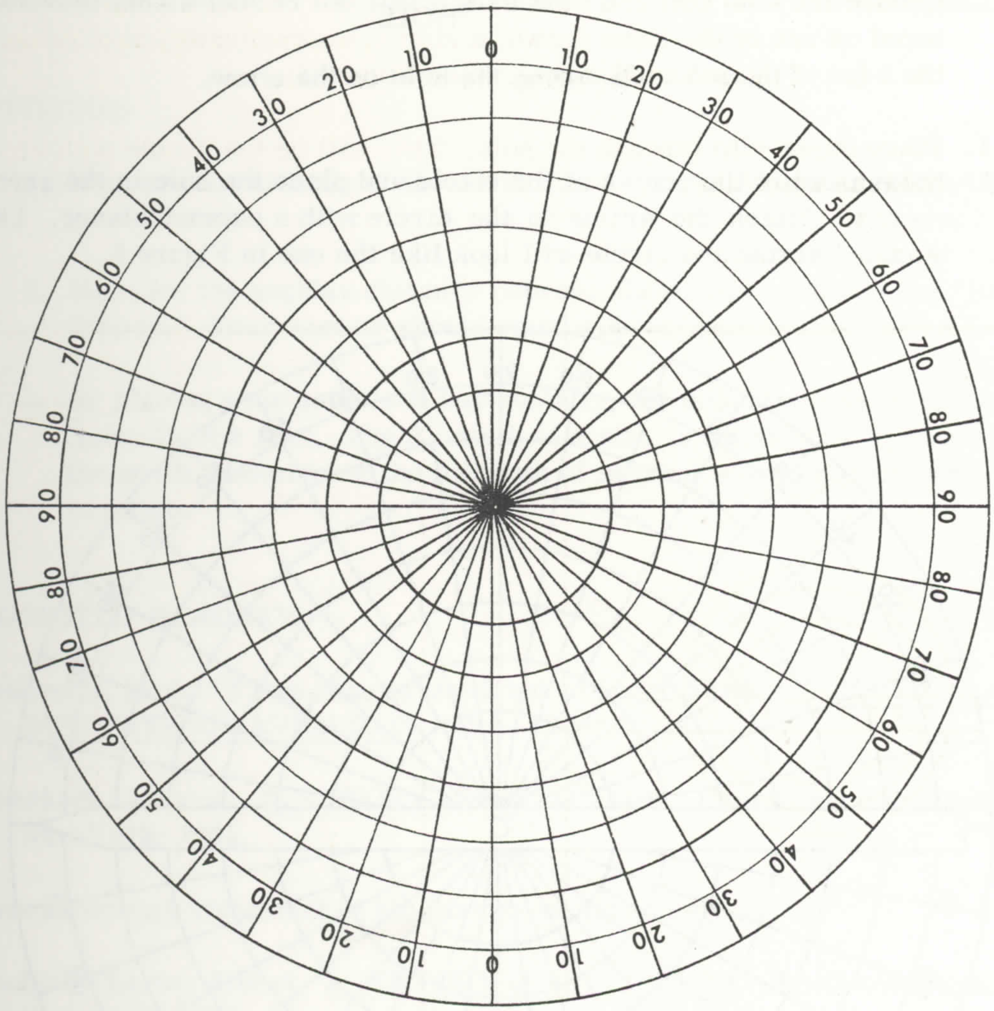


Figure 4. Marking off the circle.

13. Cut out an arrow to mount on circle. The arrow should have a diameter of approximately 1/2 inch for a circle with a 7-inch diameter.

14. Cut out a small hole in the arrow so that the hole is centered and the tip points to the edge of the circle when mounted. (Refer to Figure 5).

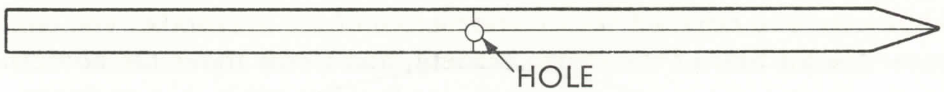


Figure 5. Centering the hole on the arrow.

15. Make a slit in the center of the circle and place the hole in the arrow over it. Attach the arrow to the circle with a paper fastener. The mounted arrow and circle will look like the one in Figure 6.

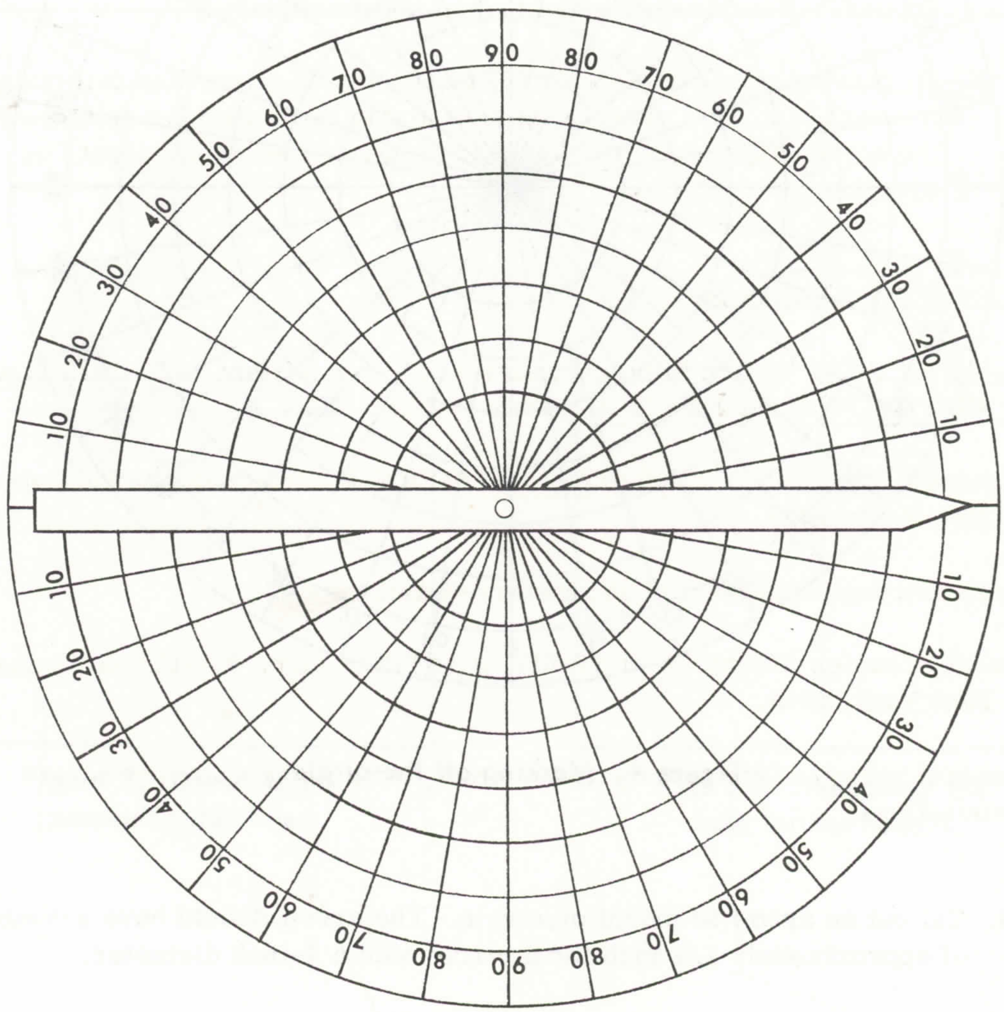


Figure 6. Mounted arrow and circle.

16. Attach two needles to sight with one at the tip of the arrow and the other at the rear.

After you have finished your construction of the astrolabe, you can use it to determine the altitude of the stars, planets, and moon above the horizon.

ACTIVITIES

1. Measure the altitude of the north star, Polaris. Your answer will be your latitude.

2. Measure the angular distance between the pointer stars of the "Big Dipper." Your answer should equal approximately 5°.

3. By placing your astrolabe horizontally, the observer can determine the Azimuth of a star. The Azimuth of a star is its angular distance from the north. Determine the Azimuth of several stars or planets as practice.

SUGGESTED READINGS

Moskowitz, Saul. "From Simple Quadrant to Space Sextant." JOURNAL of the INSTITUTE of NAVIGATION. 12:3, 192-200, 1965.

Pannekoek, Antoine. A HISTORY of ASTRONOMY. Interscience Publishers, New York, 1961.

A very thorough treatment of the history of astronomy.

Reichen, Charles Albert. A HISTORY of ASTRONOMY. Hawthorne Books, Inc., New York, 1963.

A general survey of the history of astronomy with many excellent color reproductions.

THE TELESCOPE

There have been numerous books and articles written on the subject of the telescope. There still exists, however, a lack of understanding of the telescope. Many students feel that the most important aspect of a telescope is its ability to magnify. This is not so, as the reader will soon learn.

There are three important points to be considered when discussing the telescope or a pair of binoculars. They are: 1) light gathering power, 2) resolving power, and 3) magnifying power. Knowledge of each is important for a clear understanding of these optical tools.

Since most persons have access to a pair of binoculars, these will be used to describe some of the characteristics of a telescope. The only major difference between a telescope and a pair of binoculars is that the image in a telescope appears inverted or upside down, while this is not so with binoculars. Binoculars have an erecting prism inside them to make the images appear upright to the observer.

"These binoculars are 7×50," or "7×35," are just two examples of how the salesman introduces a pair of binoculars to a prospective customer. What do these numbers mean? In both cases, the number 7 states the magnification factor of the binoculars. The second numbers, 50 or 35, represent the diameter of the objective in millimeters. The large lens in the front of the binoculars is called the <u>objective</u>. There are approximately twenty-five millimeters in one inch. Therefore, the 50 millimeter objective has a diameter of <u>two inches</u>. In the refracting telescope, the large glass lens in the front of the telescope serves as its objective, while in the reflecting telescope the mirror serves this purpose. In all discussions of the telescope it is very important to know the size of the objective, and it is usually stated in inches.

On a dark night, the pupil of the eye is approximately 1/5 of an inch in diameter. Therefore, the 50mm or 2-inch objective lens of the binoculars is 10 times (5×2) wider than the eye opening. The light gathering power of a telescope refers to the amount of light the objective lens or mirror gathers compared to the amount of light that enters the pupil of the eye. To determine the light gathering power of the binoculars, first calculate how many times larger the objective is than the pupil opening of the eye. It has already been stated that the 50mm objective lens is 10 times wider than the eye opening. The next step in determining the light gathering power of any telescope or pair of binoculars is to square the number of times the particular instrument is larger than the eye opening. Thus, the 50mm binoculars gathers 100 times (10×10) as much light as does the eye on a dark night. A hundred-inch telescope will gather 250,000 times $(5\times 2)^2$ more light than the eye.

The binoculars in this discussion magnify 7 times. Thus, the image will appear 7 times wider and taller through the binoculars than it does to the unaided eye. A hundred power magnification telescope will make the image appear 100 times taller and wider to the observer. Even though the telescope or binoculars gather more light than the eye, using a large magnification will reduce the brightness of an image since the light is being spread out over a much larger area.

This is compensated for in "opera glasses." The "opera glasses", which gather more light than the eye, have a low magnification. This results in the images not being as widely spread out. Therefore, using this type of optical instrument will make the objects appear brighter than they normally do to the unaided eye, but with very little magnification. It is best when observing through a telescope to always use the lowest magnifying power that delivers the most satisfactory image. The reader should now understand why.

The resolving power of a telescope refers to how close a pair of objects can be to each other, and be seen as two by the observer. As an example, headlights on a car seen in the distance appear as one light, and yet, as the car approaches one is able to detect two headlights. The telescope or binoculars permit a person to distinguish clearly between the points whose separation is less than the least angle the eye can detect. To clarify this, do the following exercise:

> Take a book and see how far the reader can get from the book and still be able to read it. As the reader gets farther from the book, a point will be reached where the angular separation of the upper and lower parts of the letters is less than the resolving power of the eye, and the observer can no longer read the print. At this point take a pair of binoculars and see if the book can be read.

The ability to separate objects which are very close together also depends on the size of the objective. The larger the objective of a telescope or pair of binoculars the greater its resolving power.

In making observations the larger the telescope, the better. This point should now become evident from the preceding information. No telescope with less than a three-inch objective diameter is good to use for astronomical studies, and to do any real serious work at least a six-inch telescope should be used. For a person who is beginning to learn how to use the telescope, the refractor type is probably best, considering the cost and the less likelihood of damage.

ACTIVITY

Materials Needed:

a) mirror
b) ruler
c) light

Directions:

1. Tape ruler to mirror.

2. With your head approximately 1 foot from the mirror, measure the diameter of the pupil opening of the eye.

3. Vary the amount of light shining on your eye. Determine how this affects the size of the eye's pupil.

SUGGESTED READINGS

Baker, Robt. H. ASTRONOMY. D. Van Nostrand Company, Inc., Princeton, New Jersey. 1964.

Eastman, F. Jack, Jr. "The Telescope, its Principles and Use." GRIFFITH OBSERVER, July, 1965.

Mehlin, Theodore G. ASTRONOMY. John Wiley & Sons, Inc., New York, 1961.

Table 1

Apparent Location of the Sun in the Constellations of the Zodiac Throughout the Year	
Date	Location of Sun
January 1	Sagittarius
February 1	Capricornus
March 1	Aquarius
April 1	Pisces
May 1	Aries
June 1	Taurus
July 1	Gemini
August 1	Cancer
September 1	Leo
October 1	Virgo
November 1	Libra
December 1	Scorpius

The summer solstice occurs after the vernal equinox on or around June 22. It is at this time that the sun is in its northern-most position; it is 23-1/2° north of the equator. After this date, the sun begins to move south. On or near the date of September 23, the sun appears again at the position of the equinox. The position of the earth in its orbit at the time of the autumnal equinox is at the intersection of the celestial equator and the ecliptic in the constellation Pisces, while the sun appears to be located in the constellation Virgo.

In the preceding, reference was made to the apparent position of the sun; however, in reality it is the position of the sun in the starry background as seen from earth. The sun is standing still, but appears to move because of the earth's motion around it.

The sun appears to continue its eastward journey through the stars and is found at the winter solstice about December 22. At this time the sun appears to be 23-1/2° south of the earth's equator. After the winter solstice the sun appears to move northward to return to the vernal equinox.

The length of the seasons vary in the northern hemisphere as shown in Table 2. The reason for the difference in the number of days in each season is due to the earth's position in the orbit about the sun. The nearer the earth is to the sun, the faster it moves; likewise, the farther it is from the sun, the slower it moves. During the winter months, the earth is nearer the sun and completes this season faster. Near July 1 the earth is traveling 18 miles a second in its orbit while on about January 1 when it is much nearer the sun, it is traveling 18.64 miles a second. This means in the course of one day's time in January the earth travels 55,300 more miles than on July 1.

The earth's orbit is slightly elliptical. The sun is not at the center of this elliptical orbit, but is slightly removed from it by a distance of 1,500,000 miles.

In its journey around the sun, the earth's axis is always pointed in the same direction with reference to the stars, but not with reference to the sun. In June the northern axis is pointed to the sun, while in December it is the southern axis which points to the sun. The plane of the earth's equator is tipped 23-1/2° from the plane of the earth's orbit. This inclination of the earth's axis is the major factor in producing the seasons.

Table 2

LENGTHS OF THE SEASONS VARY

Season	Length in Days
Spring	92.9
Summer	93.6
Autumn	89.7
Winter	89.0

STAR POSITIONS

When locating the stars, the astronomer speaks in terms of right ascension and declination. The star's declination is its angular distance above or below the celestial equator (celestial equator — described elsewhere). This measurement is comparable to latitude measurements on the surface of the earth. Locations on the earth's surface are designated as being either north or south of the equator. A (+) sign is used to locate a star north of the celestial equator, and a (-) sign if the star is south. "+20°" locates a star 20° north of the celestial equator.

On the earth's surface longitude locations are made by referring to the prime meridian. Countries and cities are located east or west of the prime meridian with "distances" stated in degrees. In the sky the "prime meridian" is the vernal equinox. The right ascension of a star is the angular distance of the star from the vernal equinox measured toward the east along the celestial equator. The reader should refer to Figure 2.

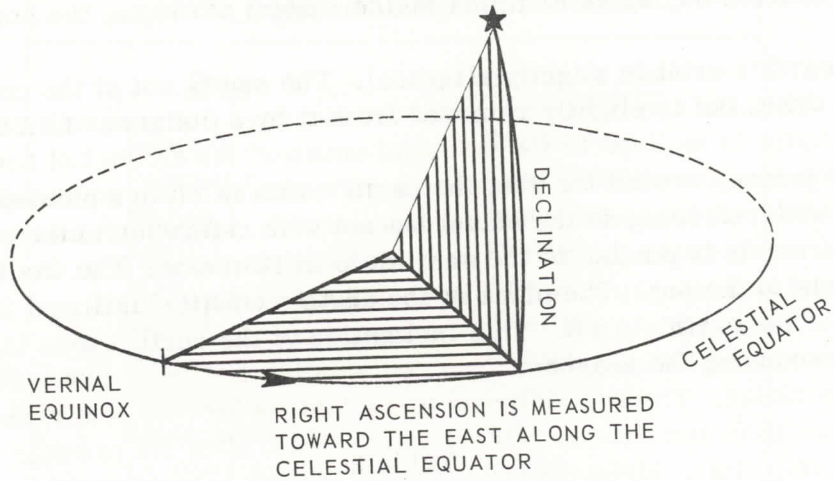


Figure 2. Determining Right Ascension and Declination.

A star's right ascension is usually stated in hours. One hour of right ascension represents an angle of 15° from the vernal equinox toward the east. A star with a right ascension of 12 hours would be located opposite or 180° from the vernal equinox.

SIDEREAL TIME

The right ascension of any star on the observer's meridian determines the observer's sidereal or star time. For example, a star with a right ascension of 2 hours and 15 minutes is on the observer's meridian. Therefore, the sidereal time at that instant is 2 hours and 15 minutes. The sidereal day is the amount of time between two successive crossings of the vernal equinox across the observer's meridian. Therefore, the sidereal day is approximately 23 hours and 56 minutes in length, equal to the total time for the earth to rotate once on its axis.

SOLAR TIME

In astronomy, the point directly overhead is known as the zenith point. The zenith point makes an angle of 90° with the horizon. Moreover, every location on the surface of the earth has what is known as its celestial meridian. Each meridian is an invisible line passing through and connecting the north celestial pole, located near the star Polaris, the zenith point, and continuing below the southern horizon. These imaginary lines continue to the south celestial pole where they turn north again to return to their point of origin, the north celestial pole.

Since the earth's revolution around the sun does not occur at a uniform rate, and the ecliptic is inclined to the celestial equator, the amount of time that it takes for the sun to cross the observer's meridian twice in succession varies. Because of this, an imaginary and fictitious sun is used which takes the same amount of time to cross the meridian twice in succession. The day then contains 24 hours, and this time is referred to as MEAN SOLAR TIME.

It is noon when the sun, or more precisely the fictitious sun, crosses the observer's meridian. Time is referred to as A.M. before the sun crosses the observer's meridian and time is referred to as P.M. after its passage across the observer's meridian. Midnight occurs when the sun is opposite the observer's meridian on the opposite side of the earth.

UNIVERSAL TIME

Universal time is the local mean solar time at the prime meridian at Greenwich. Universal time is the basis of all ordinary timekeeping. When a NASA satellite is launched, all of the events leading to and including the launch are cited in universal time. Therefore, all of the tracking stations throughout the world will read the same time. Because of this, NASA scientists do not have to keep converting from Cape Kennedy's time to their own local mean time.

CONSTRUCTION OF TIME CONVERTOR

Materials Needed:

a) 2 cardboard sheets (8"×10")
b) 1 brass paper fastener
c) rubber cement
d) ruler
e) 1 single edged razor blade

Directions:

1. Cut out the Time Convertor circle in Figure 3.

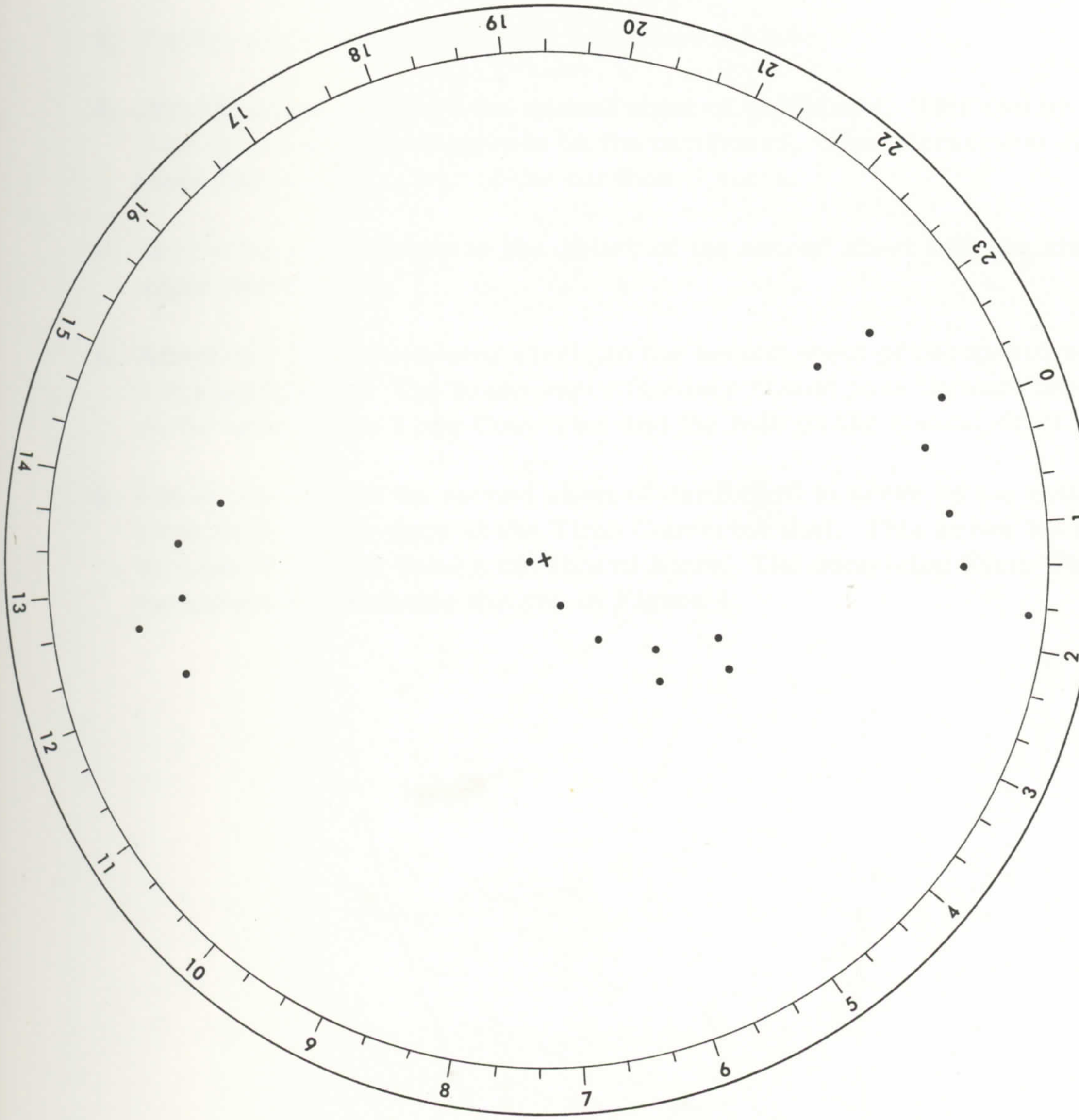


Figure 3. The Time Convertor Circle with Sidereal Time Indicated on the Outer Dial. The three constellations from left to right are Ursa Major, Ursa Minor, and Cassiopeia.

2. Place rubber cement on back of circle that you have cut out and allow it to dry.

3. On a sheet of cardboard cover with rubber cement an area large enough to fit the circle and allow to dry.

4. Affix the circle to the cardboard sheet.

5. Cut the circle out with a single edged razor blade.

6. Determine the center of the second sheet of cardboard. This can be done by drawing two diagonals on the cardboard. The intersection of these lines is the center of the cardboard sheet.

7. Make a very small hole in the center of the second sheet with the single edged razor blade.

8. Attach the Time Convertor circle to the second sheet of cardboard with a brass fastener. The brass paper fastener should pass through the "X" on the front of the Time Convertor and the hole on the second sheet.

9. Choose one end of the second sheet of cardboard to serve as the bottom. Draw an arrow to point at the Time Convertor dial. This arrow should be centered on the bottom cardboard sheet. The completed Time Convertor should resemble the one in Figure 4.

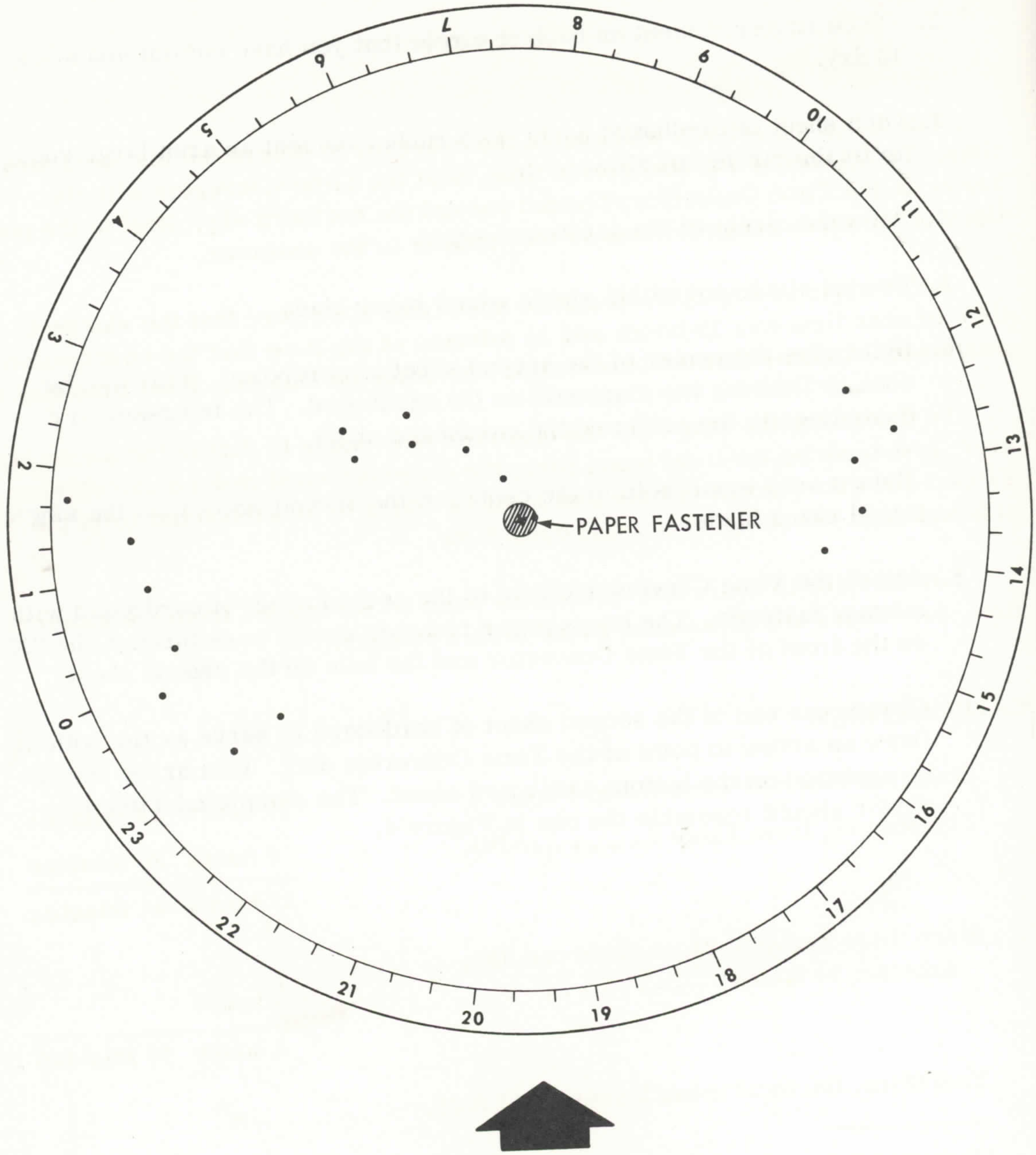


Figure 4. The Completed Time Convertor.

ACTIVITY

The following activity will enable the observer to determine his local mean time. To determine the observer's time, hold the Time Convertor with the arrow on the Time Convertor directed toward the northern sky. Dial in the positions of the three constellations as they appear to the observer.

Refer again to Figure 4. It can be seen from the figure that the sidereal time or star time was 19 hours and 24 minutes at the time that the observation was made. Assume that the observation was made on May 16. What time was it?

To determine the star time the observer only needs to dial in the stars; however, to determine the local mean time, the observer must make a calculation. Table 3 lists the amount of time that must be added to or subtracted from the sidereal time to convert it to local mean time.

For May 16, 15 hours and 40 minutes must be subtracted from the sidereal time, or 8 hours and 20 minutes added to this number.

CALCULATIONS:

Observed Sidereal Time (from Figure 4)	19 hours	24 minutes
For May 16, from Table 1 . . . . . . ADD	8 hours	20 minutes
	27 hours	44 minutes
Since there are only 24 hours in one day, subtract 24 hours	-24 hours	
	3 hours	44 minutes

Therefore, the local mean time is 3:44 A.M.

Observed Sidereal Time (from Figure 4)	19 hours	24 minutes
For May 16, from Table 1 SUBTRACT. . . .	-15 hours	40 minutes
	3 hours	44 minutes

Therefore, the local mean time by this method is also 3:44 A.M.

Table 3

CONVERSION TABLE

Sidereal Time to Local Mean Solar Time

Date	Subtract	or	Add
January 6	700		1700
January 11	720		1640
January 16	740		1620
January 21	800		1600
January 26	820		1540
January 31	840		1520
February 5	900		1500
February 10	920		1440
February 15	940		1420
February 20	1000		1400
February 25	1020		1340
March 1	1040		1320
March 6	1100		1300
March 11	1120		1240
March 16	1140		1220
March 21	1200		1200
March 26	1220		1140
March 31	1240		1120
April 5	1300		1100
April 10	1320		1040
April 15	1340		1020
April 20	1400		1000
April 25	1420		940
April 30	1440		920
May 6	1500		900
May 11	1520		840
May 16	1540		820
May 21	1600		800
May 26	1620		740
May 31	1640		720
June 6	1700		700
June 11	1720		640
June 16	1740		620
June 21	1800		600
June 26	1820		540

Date	Subtract	or	Add
July 2	1840		520
July 7	1900		500
July 12	1920		440
July 17	1940		420
July 22	2000		400
July 27	2020		340
August 2	2040		320
August 7	2100		300
August 12	2120		240
August 17	2140		220
August 22	2200		200
August 27	2220		140
September 3	2240		120
September 8	2300		100
September 13	2320		040
September 18	2340		020
September 23	--		--
September 28	020		2340
October 3	040		2320
October 8	100		2300
October 13	120		2240
October 18	140		2220
October 23	200		2200
October 28	220		2140
November 2	240		2120
November 7	300		2100
November 12	320		2040
November 17	340		2020
November 22	400		2000
November 27	420		1940
December 1	440		1920
December 6	500		1900
December 11	520		1840
December 16	540		1820
December 21	600		1800
December 26	620		1740
December 31	640		1720

Use your Time Convertor to determine your local mean time at different times during the evening, and also use it on different dates. (Remember to compensate for summer daylight time by subtracting one hour from your answer).

Since local mean time depends on your exact location, your results may not agree with "radio" time. If you are located west of your standard meridian your determined time will be slower than "radio" time, while if you are situated east of your standard meridian, it will be faster. The difference depends on how far you are located east or west of your standard meridian. Located one degree of longitude west of your standard meridian will make your calculated results four minutes slow, while situated one degree east of your standard meridian will make your results four minutes faster than they should be according to the clock.

CONSTRUCTION OF TIME COMPUTER

Materials Needed:

a) 3 cardboard sheets (8" × 10")
b) rubber cement
c) 1 single edged razor blade
d) 1 acetate sheet (6" × 6") — Reprocessed X-ray film works well
e) 1 brass paper fastener
f) 1 wax pencil or felt tip pen

Directions:

1. Cut out the Time Computer circles in Figures 5, 6 and 7.

2. Place rubber cement on the back of each circle that you have cut out and allow to dry.

3. On a cardboard sheet cover with rubber cement an area large enough to fit the circle from Figure 5 and allow to dry.

4. Repeat step 3 for the circles in Figures 6 and 7 on the other two cardboard sheets.

5. Affix the circles to the cardboard sheets.

6. Cut the circles out with a single edged razor blade.

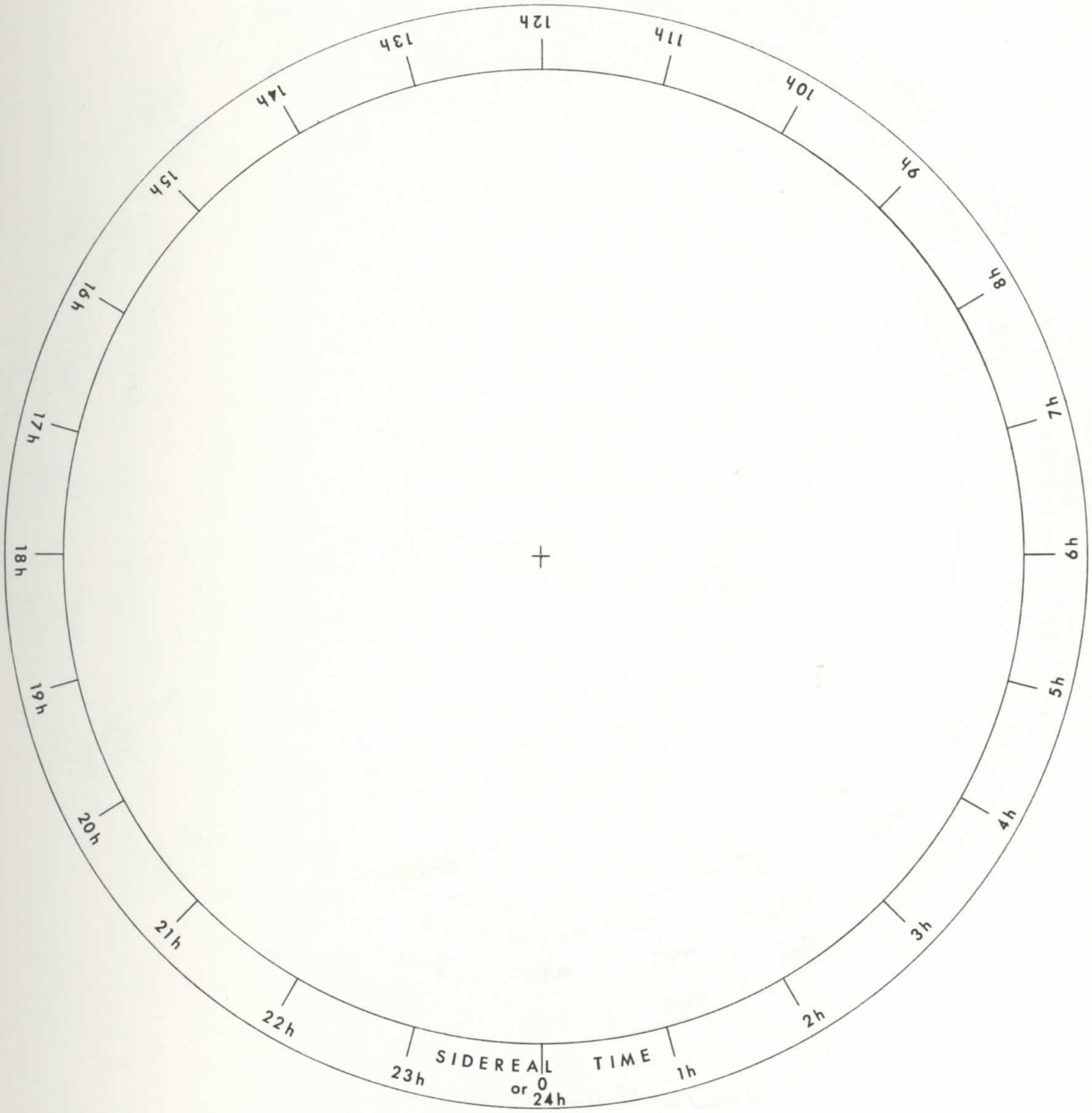


Figure 5. Sidereal Time Circle.

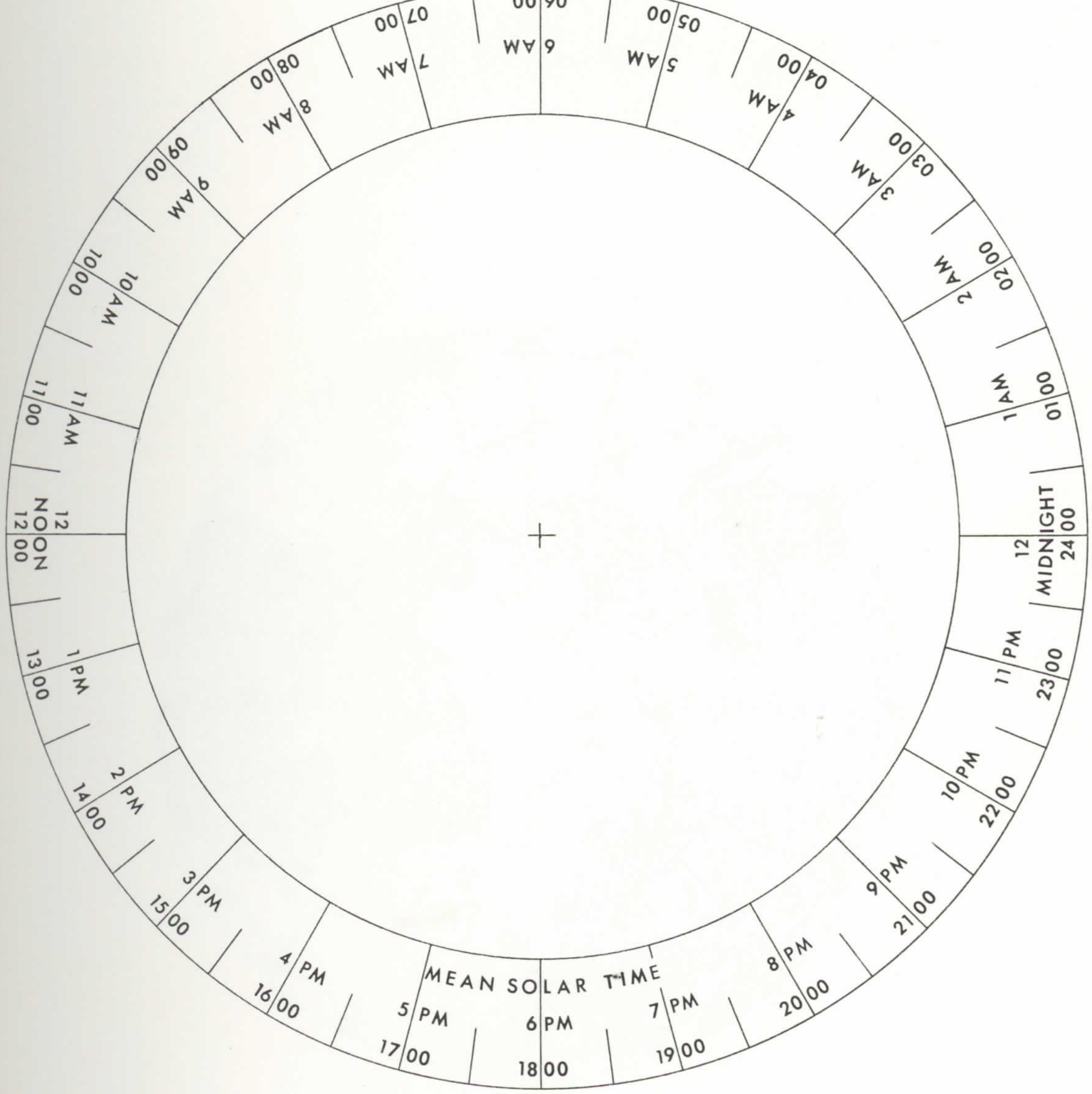


Figure 6. Mean Solar Time Circle.

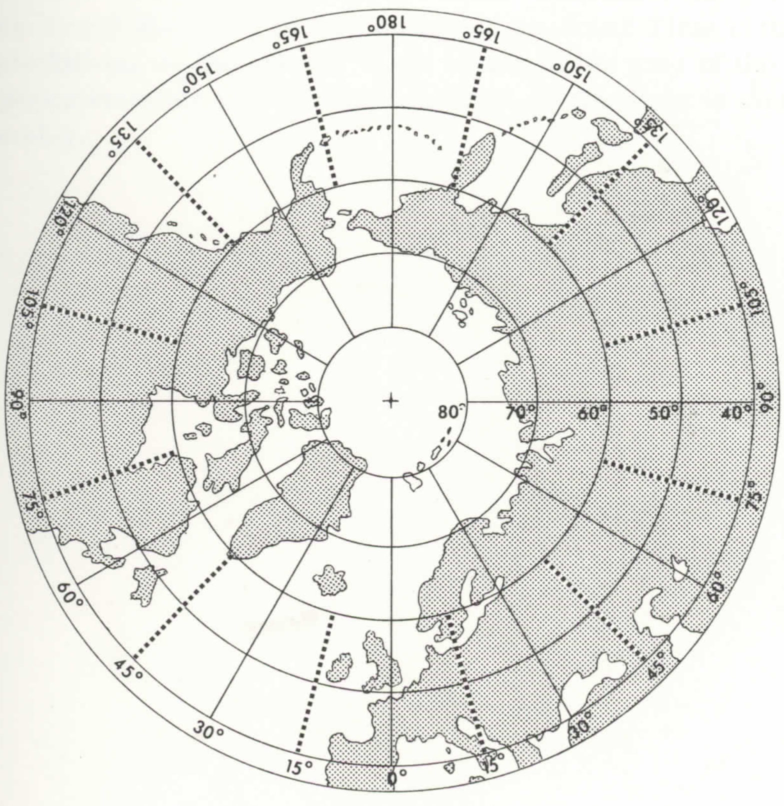


Figure 7. Circumpolar Map of the World.

7. Place an acetate sheet over the constellation chart in Figure 8. Plot the stars accurately onto the acetate sheet with a wax pencil or felt tip pen. Also, record the numbers on Figure 8 onto the acetate sheet. Place an "X" on the acetate sheet to locate its center.

8. After completing step 7, cut out the acetate sheet. It should also be circular in shape.

9. Punch a hole through the "X" on each of the circles.

10. Attach all of the circles together with a paper fastener. The bottom dial will be the Sidereal Time circle. The Mean Solar Time circle should be centered over the Sidereal Time circle. Likewise, the Circumpolar Map of the World should be placed on top of the Solar Time circle. Place the constellations on the acetate sheet on top of the map of the world. Push the paper fastener through the center of all the dials to complete the assembly.

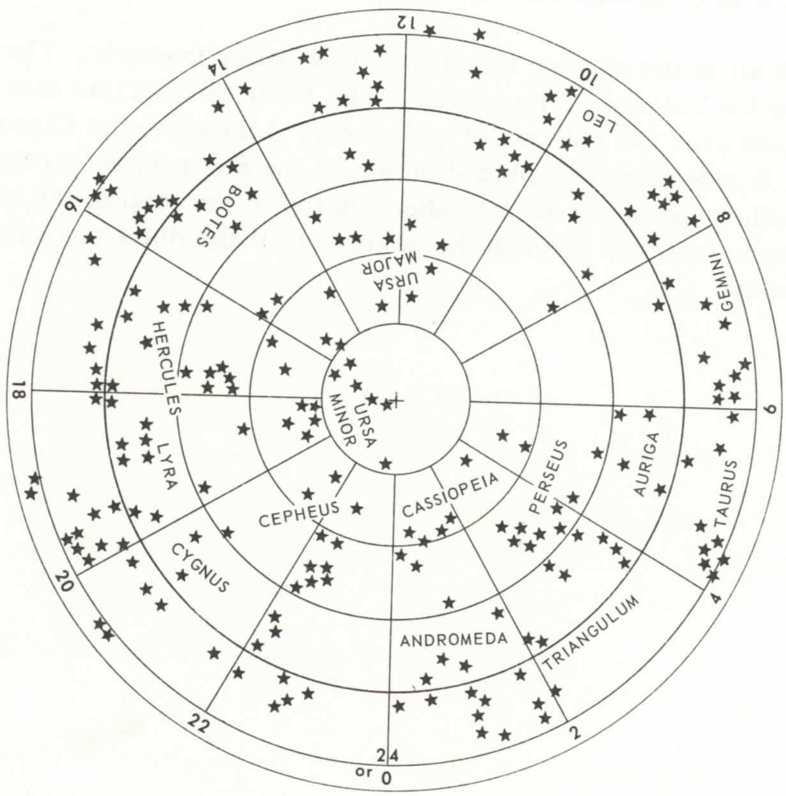


Figure 8. Circumpolar View of the Constellations. The numbers on the outside of the circle represent sidereal time.

ACTIVITIES

Locate the 0° meridian line or prime meridian on the Time Computer's map of the world. The numbers on the right of this line (when the 0° meridian is directed toward the observer) are toward the east, while those on the left are directed to the west.

Use the following examples to become acquainted with the use of your Time Computer.

Set the 105° west meridian line of the map opposite the 9 P.M. time line of the mean solar time dial.

1. What time is it at: 150° east of the prime meridian?
   Answer: 2:00 P.M.

2. What time is it at: 120° east of the prime meridian?
   Answer: 12:00 noon.

3. What time is it at: 165° west of the prime meridian?
   Answer: __________

4. What time is it at: 75° west of the prime meridian?
   Answer: __________

Set the 105° west meridian line of the map opposite the 11h time line of the sidereal time dial.

1. What is the sidereal time at: 90° east of the prime meridian?
   Answer: 0 or 24 hours.

2. What is the sidereal time at: 165° west of the prime meridian?
   Answer: 5 hours.

3. What is the sidereal time at: 60° west of the prime meridian?
   Answer: __________

Once the sidereal time dial has been properly positioned the star dial on the top of the "wheel" can be turned to properly position the stars as they will be located over the earth's surface. For a sidereal time of 11 hours at the 180° meridian it can be determined at that instant the constellation HERCULES will be over the central United States, CEPHEUS and CYGNUS over the Atlantic Ocean, etc.

ACTIVITY

AN ASTRONOMICAL METHOD FOR DETERMINING YOUR SOUTHERN MERIDIAN

Drive a three-foot stake into the ground in a location where it will be ex posed to sunlight. Make sure the stake is driven straight into the ground. It will be seen that a shadow is produced by the stake and it is directed toward the north.

Begin making your observations approximately one hour before noon. Plac a pebble or some other marker at the precise end of the shadow. Measure the length of the shadow with a ruler. Do this procedure until you determine another shadow with an equal length. When two shadows are produced with equa lengths, bisect the angle between them and your southern meridian can be deter- mined. SEE FIGURE 9 FOR INSTRUCTIONS ON BISECTING THE ANGLE. The bisector of the angle will point precisely to the south toward your southern meridian.

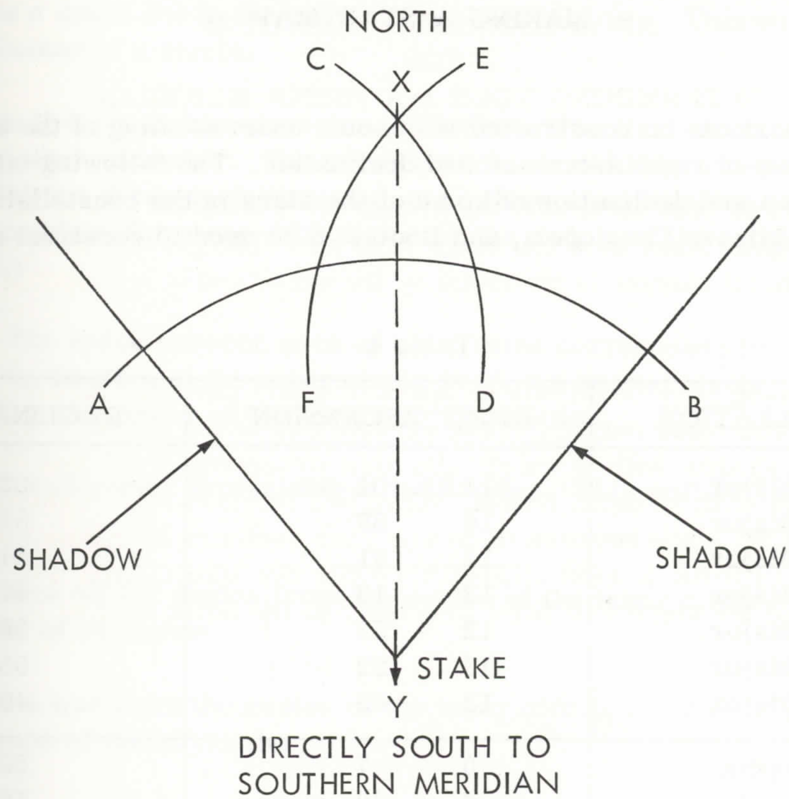


Figure 9. The Bisection of the Shadow's Angle

INSTRUCTIONS

1. With string tied to the stake, draw ARC AB.
2. Very accurately mark the points A and B on the SHADOW.
3. From A.......Draw ARC CD.
4. From B....... Draw ARC EF.
5. Note the intersection of these arcs at X.
6. A line running from X through the stake and continued toward Y will point to your southern meridian.

ACTIVITY

MAKING A STAR MAP

A star chart can be constructed with some understanding of the celestial coordinate system of right ascension and declination. The following table lists the right ascension and declination of some of the stars in the constellations Ursa Major, Ursa Minor, Cassiopeia, and Bootes to be used to construct a star map.

Table 4

CONSTELLATION	RIGHT ASCENSION		DECLINATION
Ursa Major	11 hr.	01 min.	62
Ursa Major	10	59	57
Ursa Major	11	51	54
Ursa Major	12	13	57
Ursa Major	12	52	56
Ursa Major	13	22	55
Ursa Major	13	45	49
Cassiopeia	0	7	59
Cassiopeia	0	38	56
Cassiopeia	0	54	60
Cassiopeia	1	23	60
Cassiopeia	1	57	63
Ursa Minor	1	53	89
Ursa Minor	17	46	86
Ursa Minor	16	50	82
Ursa Minor	15	45	78
Ursa Minor	16	19	76
Ursa Minor	15	20	72
Ursa Minor	14	51	74
Bootes	15	11	34
Bootes	14	40	28
Bootes	14	11	20
Bootes	14	28	39
Bootes	14	58	41
Bootes	14	36	14
Bootes	13	50	19
Bootes	14	27	31

Directions:

1. Make a small dot in the center of a sheet of paper. This will represent the center of a circle.

2. From this point draw a series of circles. The first circle should have a one-inch diameter. The second circle should have a two-inch diameter, the third a three-inch diameter, etc. Draw a series of six circles. (Remember, for a one-inch diameter the radius of the circle will be 1/2 inch.)

   The space between each of the circles corresponds to 15° declination. The declination of the outer circle is 0°; the second circle, 15°, and the point in the center of the circle 90° declination.

3. Draw a diameter through all of the circles. This will be your reference line.

4. Measure off 15° angles from the center of the inner circle. There will be a total of 24 angles.

5. Draw a line from the center of the inner circle, intersecting all six circles for each of the 15° angles.

6. Arbitrarily select a starting point. The numbers of this line are 0 and 24. Number each of the remaining 23 lines consecutively — proceeding in a clockwise direction. The distance between two consecutive lines is equivalent to one hour of right ascension.

Plot star locations from Table 4 according to right ascension and declination on the constructed circle drawings. If a star has a right ascension of one hour and a declination of 15°, make a small dot where these two lines intersect. This is the procedure to be used in plotting the location of stars.

The constructed star map is called a polar star map. This is what the stars look like when viewed from the earth toward the north star in the center of the map.

OBSERVING THE SKY WITH GROUPS

Astronomy cannot be totally taught in the classroom. Like all fields of science it requires observation. Properly conducted, a star party can do more to enhance the student's understanding of the basic concepts of astronomy than can be accomplished in several weeks of concentrated study. In one evening of observation, the students can see that stars do differ in apparent brightness, learn to recognize several constellations or planets if visible, and can readily see how the stars move across the heavens in his locality. Then, too, by watching the moon during the course of an evening the student can actually see its real motion among the stars.

The only materials necessary for a successful evening of "star gazing" are some star charts of various types. It would also be advisable to have binoculars or a telescope for observing and a camera for photographing.

One important thing to remember in any star party is to keep the students busy. The following are some activities which can be done by the students during an observation session.

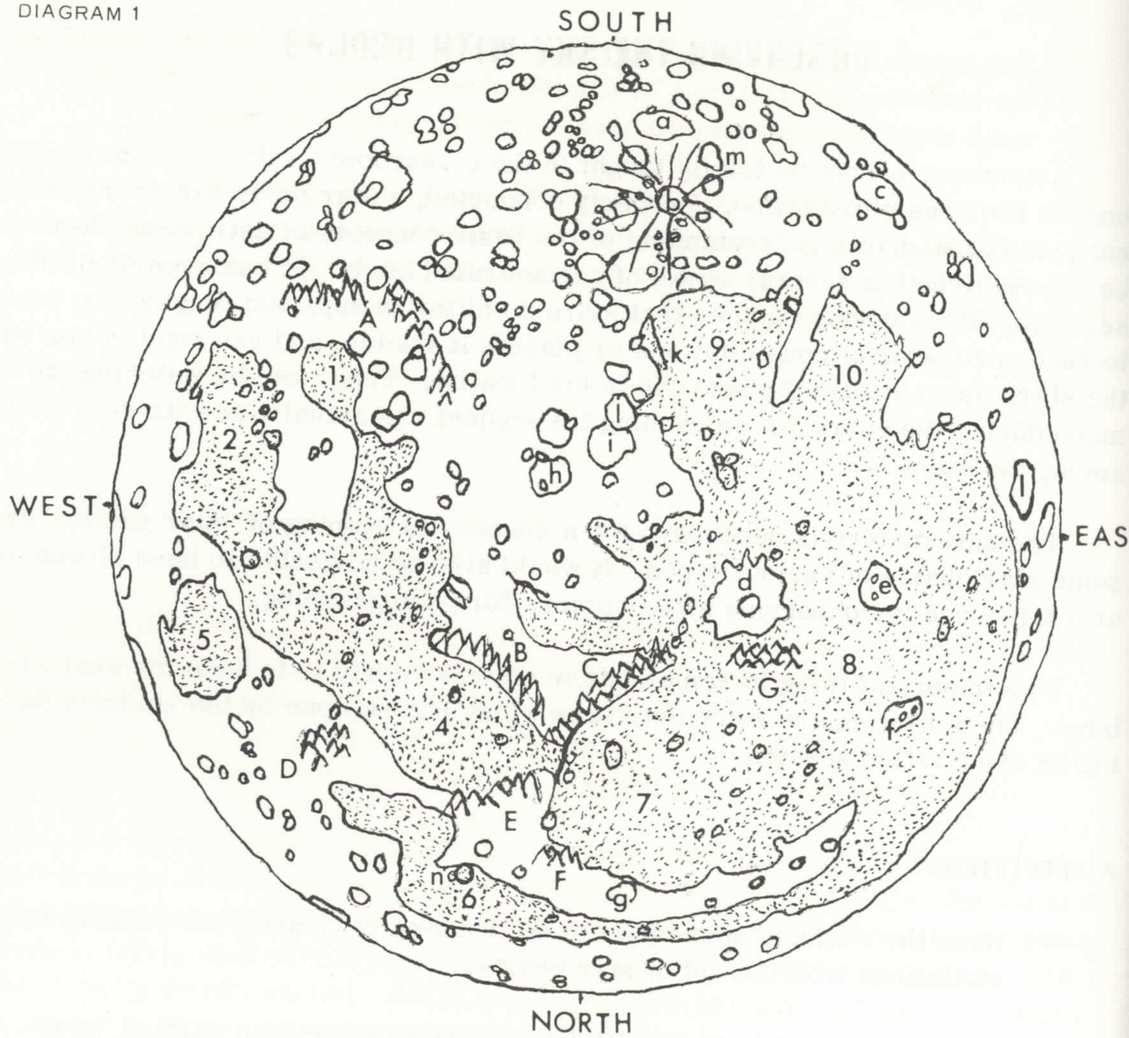
ACTIVITIES

1. Have the students spend part of the evening in locating the various constellations with the aid of star charts.

2. In the event there are insufficient telescopes for each student, have them take turns viewing through any available telescope. They can observe the moon, planets, double stars, or just search the heavens for interesting objects. Many hours have been spent by astronomers in searching the heavens with the telescope. Messier, a comet hunter, spent many evenings searching the sky. During the course of his observations he encountered many unusual objects, and later compiled this list of objects noting their position in the sky, and had it published so no other observer would mistake them for comets.

   For those students who want to learn the names of the major craters, mountains and seas on the surface of the moon, an inverted map of the moon (the way that it appears through a telescope) is included (see Diagram 1).

DIAGRAM 1



INVERTED TELESCOPE VIEW OF MOON

MARIA

1 **MARE NECTARIS**
SEA OF NECTAR
2 **MARE FECUNDITATIS**
SEA OF FERTILITY
3 **MARE TRANQUILLITATIS**
SEA OF TRANQUILITY
4 **MARE SERENITATIS**
SEA OF SERENITY
5 **MARE CRISIUM**
SEA OF CRISES
6 **MARE FRIGORIS**
SEA OF COLD
7 **MARE IMBRIUM**
SEA OF RAINS
8 **OCEANUS PROCELLARUM**
OCEAN OF STORMS
9 **MARE NUBIUM**
SEA OF CLOUDS
10 **MARE HUMORUM**
SEA OF MOISTURE

MOUNTAINS

A **ALTAI MOUNTAINS**
B **HAMUS MOUNTAINS**
C **APENNINES MOUNTAINS**
D **TAURUS MOUNTAINS**
E **CAUCASUS MOUNTAINS**
F **ALPS MOUNTAINS**
G **CARPATHIAN MOUNTAINS**

CRATERS

a **CLAVIUS**
b **TYCHO**
c **SCHICKARD**
d **COPERNICUS**
e **KEPLER**
f **ARISTARCHUS**
g **PLATO**
h **HIPPARCHUS**
i **PTOLEMY**
j **ALPHONSUS**
k **STRAIGHT WALL**
l **GRIMALDI**
m **LONGOMONTANUS**
n **ARISTOTELES**
o **HYGINUS RILLE**

CRATERS

a CLAVIUS
b TYCHO
c SCHICKARD
d COPERNICUS
e KEPLER
f ARISTARCHUS
g PLATO
h HIPPARCHUS
i PTOLEMY
j ALPHONSUS
k STRAIGHT WALL
l GRIMALDI
m LONGOMONTANUS
n ARISTOTELES
o HYGINUS RILLE

3. The number of stars in the various regions of the sky can be counted by the students, and can then be compared within the group. A simple method of counting can be accomplished by using a tin can.

4. Those with cameras (mounted on a tripod) can spend some of the evening in photographing. Aiming their cameras at Polaris, and leaving the shutter open a few minutes, will allow the students to photograph star trails around the pole star.

5. Another activity can involve the students in the use of the astrolabe which they prepared. The observer's latitude can be determined by measuring the angle of Polaris above the horizon.

6. Solar, or local mean time, can be determined by the students with the use of the time convertor which they prepared.

7. By using any object with a narrow slit, approximately 1/8 inch wide, the students can determine if it takes the same amount of time for an object at different altitudes in the sky to move the same distance. For example, it will be found that it will take a star of 60° declination twice as long as it will for a star of 0° declination to cross the slit.

Before the star party is conducted, be sure that the students know what they are to do before the outing. The site for the star party should be a location that is easily available to everyone. However, it is best to get as far out in the country as possible. In addition, there must be a purpose for the outing, and it should be related to what the students are studying in class. Forms can be given to each student to insure that they are making the proper observations and are getting an understanding from their work. Two samples are included which can be used by the students (see Observation Form numbers 1 and 2).

The students will also enjoy studying the sun during the day. <u>THE SUN SHOULD NEVER BE VIEWED DIRECTLY</u> whether one uses a telescope or a pair of binoculars. The image of the sun must be projected on a piece of white cardboard. Once the sun's image has been projected, the students can count the number of sunspots and by sketching the sun, note their location. Then by doing this activity on subsequent days the students can determine:

1. The location of the sunspots on the sun and see if their latitude varies.

2. That the sun does not rotate uniformly on its axis. It soon becomes apparent from the study of the sunspots that the sun's equator rotates faster than the regions to the north or south of it.