





The Pearl astronomical dial is a rare timekeeping device of old world craftsmanship. The astronomical dial is handmade and hand-assembled by the esteemed German Artisans of Ungerer where for more than 200 years the greatest astronomical clocks have been made for the world's most famous cathedrals.

Pearl has the distinct honor and pleasure to be the first in introducing this lavish dial to North America. The astronomical dial is unique in that it combines the practical functions of the old sundial with the intricacies of the ancient mariner's astrolabe. (An astrolabe was an instrument to measure the altitude and degree of the sun's position.)

The astronomical dial has many useful and interesting functions that are more for conversation today, but in days gone by they were necessary to determine day to day activities. For example, the astronomical dial tells the:

1. Date and was used as a calendar.
2. Tells the astronomical time or standard time that is relative to your location. To put simply, standard time is the actual time it is according to the sun. The astronomical dial is a mechanical sundial that works 24 hours a day.
3. Tells the sidereal time. The sidereal time is the true time it takes for the earth to make one rotation on its axis, which is 23 hours, 56 minutes, and 4.09 seconds. To put this into perspective it is the difference between sidereal time and standard time that accumulates each year and causes us to have an extra day every 4 years. This is commonly called Leap Year. This was done to keep the calendar in proper sequence with the seasons.

4. Tells the time of the sunset and sunrise as well as the civil and astronomical twilight. By observing this function you can see the days growing longer or shorter, depending upon the season.

Civil twilight is the period after the sun has set in the evening but before the stars become visible or the period in the morning after the stars have disappeared, but before the sun rises above the horizon.

Astronomical twilight is the period in the evening when the stars begin to appear and in the morning when they begin to disappear.

5. Tells the degree of angle and the altitude of the sun at any moment of the day. This was valuable information to the mariner. With these two known points the mariner could determine his location on the ocean.

6. The astrological dial also indicates the position and phases of the moon. This information proved to be invaluable to the farmer because the new moon or Autumn signaled the beginning of harvest. During the full moon in Autumn you would find many farmers working late in the fields by the light of the moon. Also, knowing in advance the time of a full moon to old world travelers was helpful, in that they could plan to travel during that time because the moon provided the much needed light for their journey at night.

7. Position of the sun and moon in relation with the twelve signs of the zodiac. The zodiac is a name given to an imaginary circle in the heavens above the earth. The sun and moon and some of the other planets are seen at different times of the year in different parts of the heavens within this circle. The ancient peoples first used the zodiac to tell what time of year it was.

8. Eclipse of the sun and the moon.

9. The ascendant or the rising zodiac symbol tells the changing of the seasons by indicating the vernal equinox (first day of Spring), the autumnal equinox (the first day of Fall), Summer solstice (the first day of Summer which is the longest day of the year), and the Winter solstice (the first day of Winter which is the shortest day of the year.)

On the astronomical dial the movements of the planets are represented as seen from the earth; our planet being considered as a fixed central point around which the whole universe revolves.

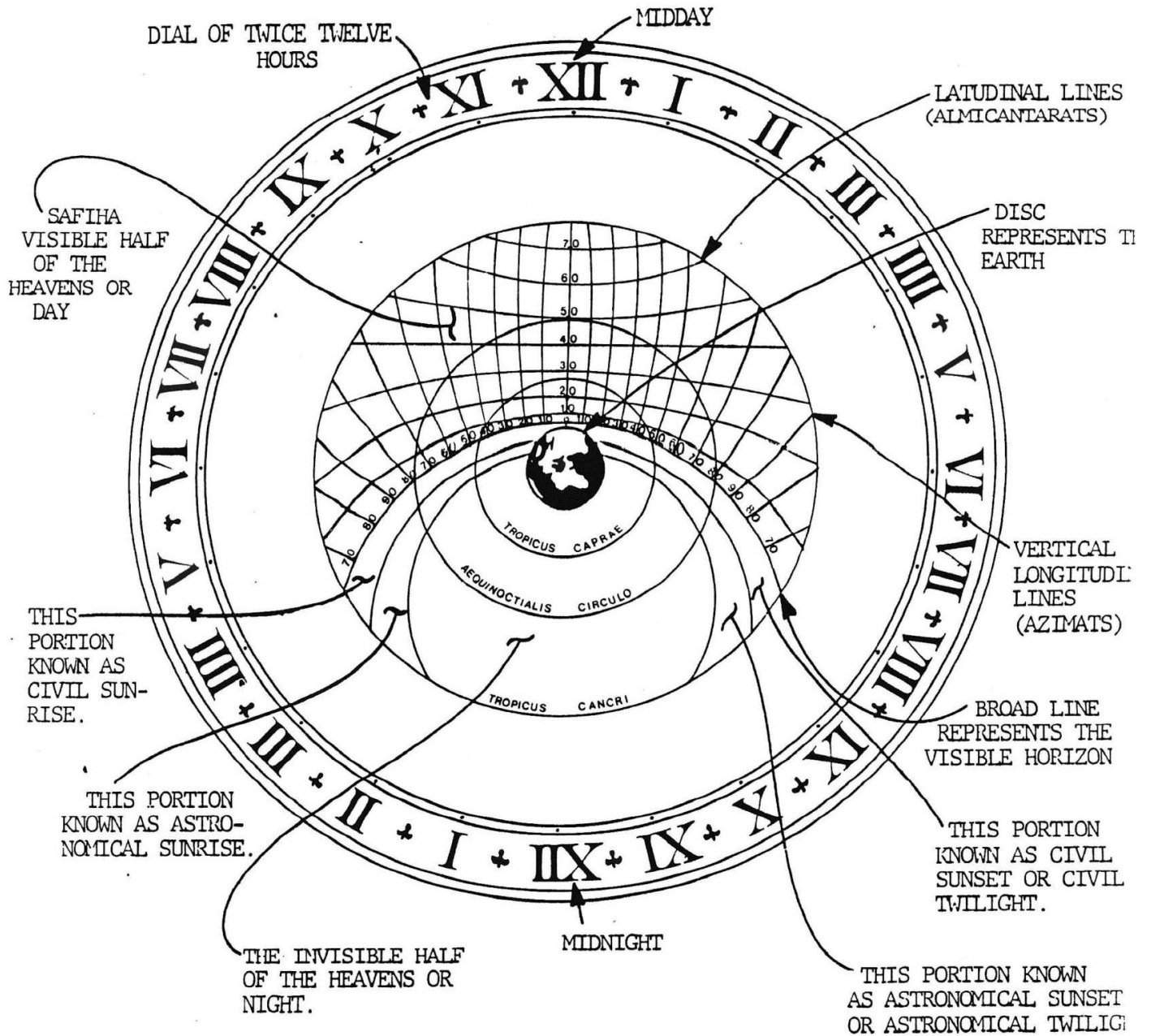
The stationary background on the astronomical dial called the safiha represents the heavens as curved latitudinal lines (almicantarats) and vertical longitudinal lines (azimats) of 10 degrees by 10 degrees each plotted for a given latitude. The brown portion of the safiha represents the visible half of the heavens, the darker colored portions the invisible half. The broad dividing line between the brown and gray portions represents the visible horizon (See Diagram 1).

The astronomical dial will not affect the operation of the regular clock if it is not set, but if you are interested in setting the astronomical dial the instructions following will explain set up and reading of the dial.

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(DIAGRAM 1)

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Before you set the astronomical dial it is suggested that you read through the instructions thoroughly to familiarize yourself with the parts and terms used. (See Diagram 2)

STEP ONE:

Set the regular clock to your official time. Note, the Kieninger movement is equipped with an automatic night shutoff feature. This feature stops the chimes from striking past the hour of 10:00 p.m. until 7:15 a.m. At 7:15 a.m. the chimes resume normal quarter hour chiming and hourly striking. Place your clock on "night off" to determine your a.m. and p.m. cycle before setting to your official time.

STEP TWO:

Setting the solar hand. The solar hand is used to indicate the astronomical hour, the approximate date.

It also shows the position of the sun in the zodiacal sign depicted on the "spider" or starry firmament.

But in order for the solar hand to do all this you need to:

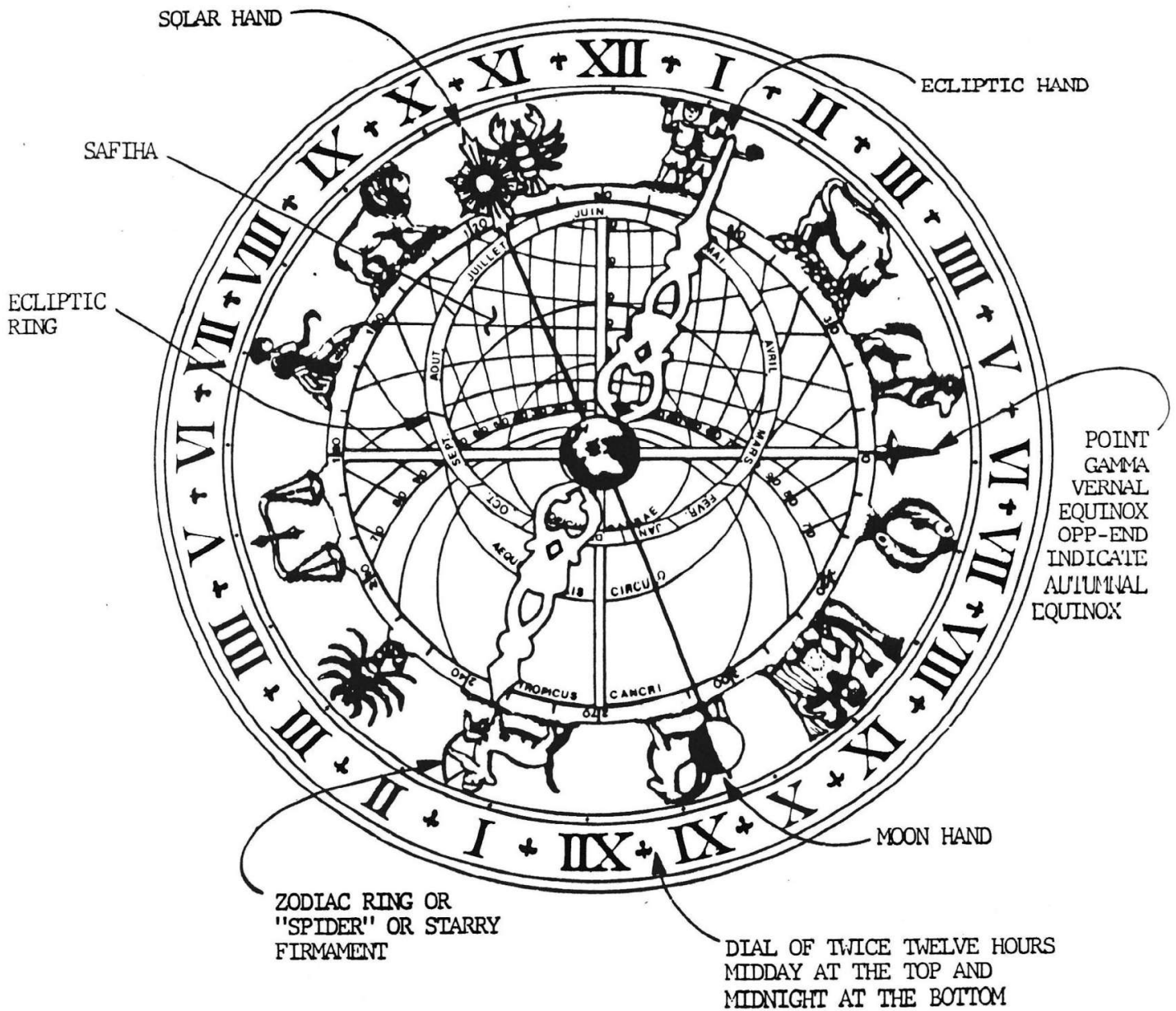
- a. Determine where to set the hand.
- b. Synchronize the solar hand with the regular clock.

To do this fill in the Worksheet #1 to find your exact astronomical time. And in setting your astronomical time you will have synchronized the two clocks.

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(DIAGRAM 2)

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WORKSHEET TO DETERMINE POSITION OF SOLAR HAND

Line 1. Find out your degree of longitude for your location.

Your longitude can be found on a globe, atlas, a good
road map, or call your local airport.

Enter Here:

Line 2. Multiply the degree of longitude by 4.

Enter Here: M

Line 3 Now divide the answer from Line 2 by 60 and Enter Here: Dec. H

NOTE: See decimal hour conversion chart and convert
answer from Line 3 into hours and minutes.

This will help simplify the procedure (Diagram 3)

Line 4. Enter converted decimal hours from Line 3 Here: Hrs. Mins

Line 5. Enter present central standard time here: Circle On
NOTE: That it is Central and not Eastern, Mountain A.M. / P.M.
or Pacific.

Line 6. Add six hours to Line 5 and Enter Answer Here: Circle On
A.M. / P.M.

Line 7. The time entered on Line 6 is Greenwich time. The
hours and minutes entered on Line 4 is how far behind
your astronomical time is from Greenwich, England.
Also, the answer on Line 4 will always be the same
regardless of what time of day or night it is.

Line 8. Now subtract Line 4 hours and minutes from the time
determined on Line 6 and Enter Here: A.M.
P.M.

Line 9. Continue with Step 2, Page 9.

DECIMAL HOUR CONVERSION CHART

(DIAGRAM 3)

<u>MIN.</u>	<u>DECIMAL HOUR</u>	<u>MIN.</u>	<u>DECIMAL HOUR</u>
1	.0166	31	.5166
2	.0333	32	.5333
3	.05	33	.55
4	.0666	34	.5666
5	.0933	35	.5833
6	.1	36	.6
7	.1166	37	.6166
8	.1333	38	.6333
9	.15	39	.65
10	.1666	40	.6666
11	.1833	41	.6833
12	.2	42	.7
13	.2166	43	.7166
14	.2333	44	.7333
15	.25	45	.75
16	.2666	46	.7666
17	.2833	47	.7833
18	.3	48	.8
19	.3166	49	.8166
20	.3333	50	.8333
21	.35	51	.85
22	.3666	52	.8666
23	.3833	53	.8833
24	.4	54	.9
25	.4166	55	.9166
26	.4333	56	.9333
27	.45	57	.95
28	.4666	58	.9666
29	.4833	59	.9833
30	.5	60	1.0

EXAMPLE: If you had a figure of 7.466667, 7 would be 7 hours and you would (for ease) convert .466667 into minutes look for .466667 on the chart and in this instance 7.46667 would be 7 hours and 28 minutes.

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STEP TWO (cont'd)

Once you have filled in the Worksheet and page 7, you are ready to set the solar hand.

The answer on Line 8 of the Worksheet is the position where the solar hand will be set.

Set the solar hand to the hour and approximate minute on the interior dial of twice twelve hours. See (Diagram 4). Make sure you move the hand to the proper hour in regards to a.m. and p.m.

STEP THREE

SETTING THE "SPIDER" OR STARRY FIRMAMENT

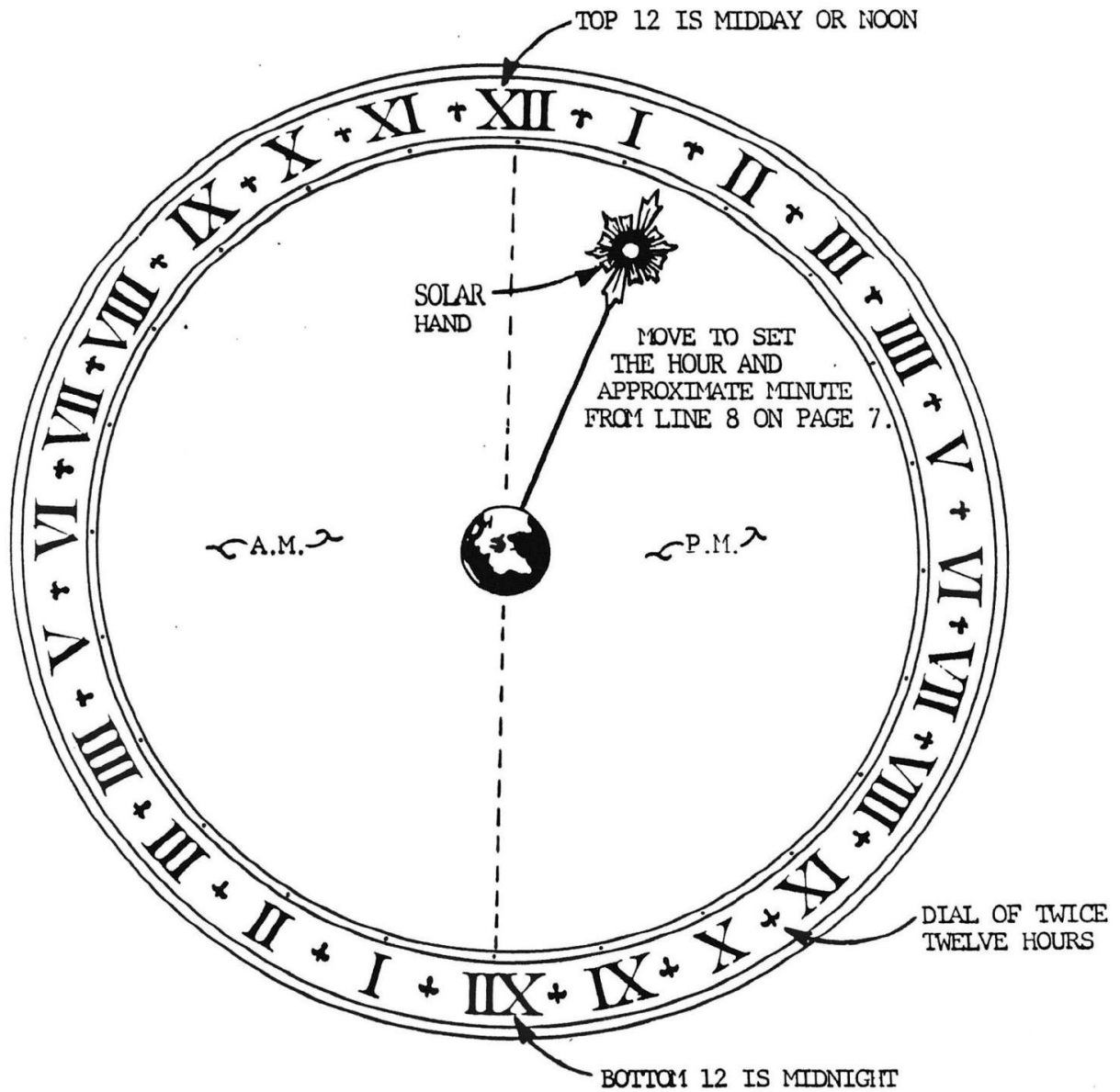
The "spider" is the ring with the 12 signs of the zodiac around it. The spider is used as the gauge by which all the other functions of the astronomical dial are read (See Diagram 5).

You will notice that on the outside diameter of the spider it is divided into degrees. This represents one complete revolution of the sun and moon. To set the spider fill out the Worksheet #2 to determine its position. Note the degree marks on the spider will be used to set all the other hands by.

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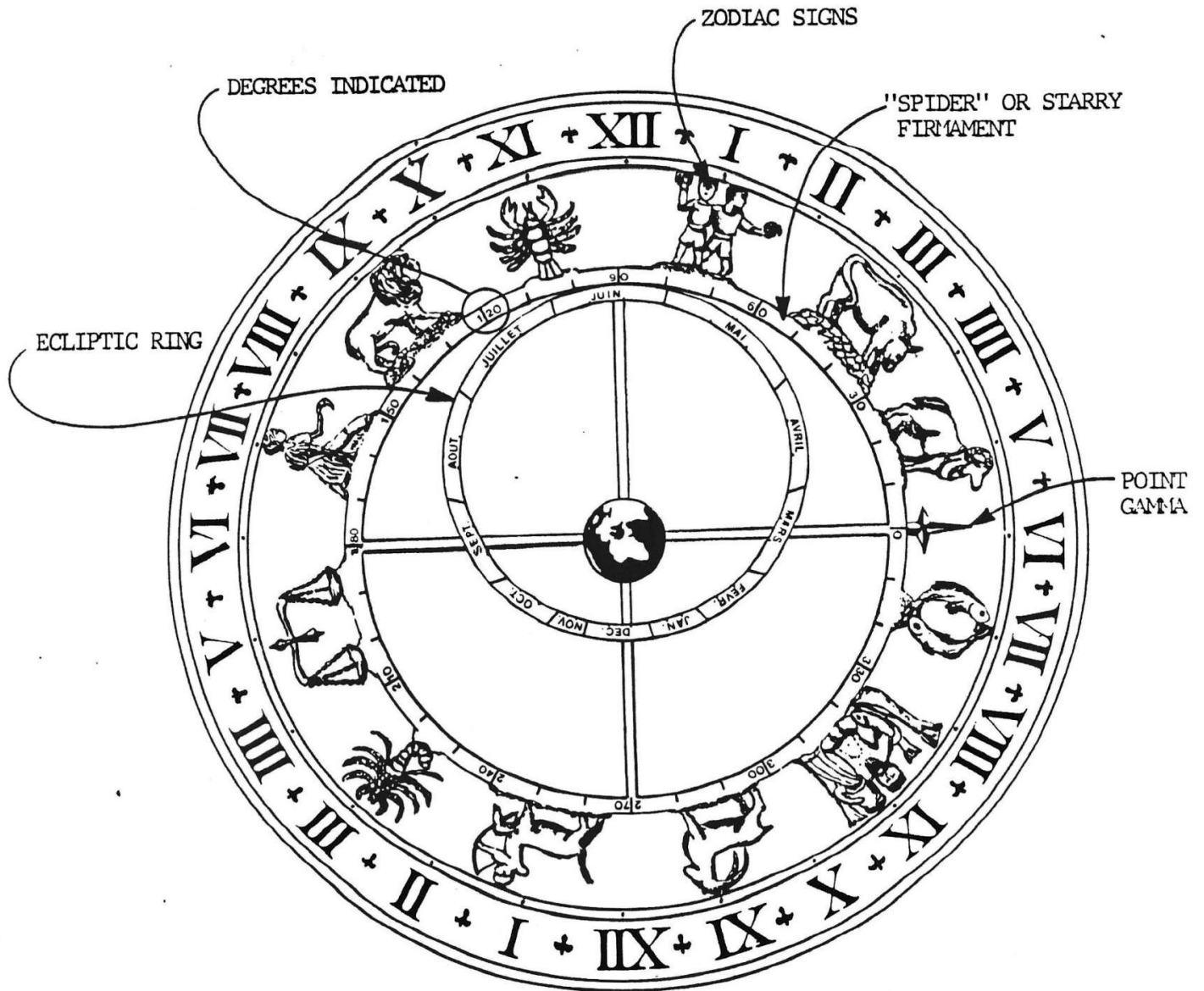
(DIAGRAM 4)

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(DIAGRAM 5)

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WORKSHEET #2

WORKSHEET TO DETERMINE POSITION OF SPIDER

Line 1. What is the date today?

Enter Here:

Line 2. Refer to the ephemerides table and locate

the nearest past date.

Enter Here:

EXAMPLE; If your date is 10/1/85 the nearest
past date would be 9/22/85.

Line 3. Enter the difference between Line 1 and Line 2

Days

Line 4. Multiply Line 3 by 0.985647 Enter Answer Here:

Line 5. On the ephemerides table next to the date from

Line 2 in Column 1, Enter that figure here:

Line 6. Add Lines 4 and 5. Enter Here:

Line 7. If Line 6 is larger than 360 subtract Line 6 from
360 and enter answer, or if Line 6 is smaller than
360 enter amount from Line 6 here:

Line 8 Continue with Step 3, Page 14

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Ephemeriden - Tare ---
für das Richten des astronomischen Zifferblattes

<u>DATUM</u>	<u>SONNE</u>	<u>MOND</u>	<u>AUFSTEIGENDER MOND</u> <u>KNOTEN (Länge Teil</u> <u>Zeig</u>
05.01.1987	284,0610	342,9033	16,2822
15.01.1987	293,91	114,66	15,75
25.01.1987	303,77	246,43	15,22
04.02.1987	313,63	18,19	14,69
14.02.1987	323,48	149,95	14,16
24.02.1987	333,34	281,72	13,63
06.03.1987	343,19	53,48	13,10
16.03.1987	353,05	185,25	12,57
26.03.1987	2,91	317,01	12,04
05.04.1987	12,76	88,77	11,51
15.04.1987	22,62	220,54	10,98
25.04.1987	32,48	352,30	10,45
05.05.1987	42,33	124,07	9,92
15.05.1987	52,19	255,83	9,39
25.05.1987	62,05	27,59	8,86
04.06.1987	71,90	159,36	8,33
14.06.1987	81,76	291,12	7,80
24.06.1987	91,62	62,89	7,28
04.07.1987	101,47	194,65	6,75
14.07.1987	111,33	326,41	6,22
24.07.1987	121,19	98,18	5,69
03.08.1987	131,04	229,94	5,16
13.08.1987	140,90	1,71	4,63
23.08.1987	150,75	133,47	4,10
02.09.1987	160,61	265,23	3,57
12.09.1987	170,47	37,00	3,04
22.09.1987	180,32	168,76	2,51
02.10.1987	190,18	300,53	1,98
12.10.1987	200,04	72,29	1,45
22.10.1987	209,89	204,05	0,92
01.11.1987	219,75	335,82	0,39
11.11.1987	229,61	107,58	359,86
21.11.1987	239,46	239,35	359,33
01.12.1987	249,32	11,11	358,80
11.12.1987	259,18	142,87	358,27
21.12.1987	269,03	274,64	357,74
31.12.1987	278,89	46,40	357,21
10.01.1988	288,75	178,17	356,68

Variation

journalière + 0,985647

+ 13,176396

- 0,052954

(Tages-
Koeffizient)

Ephemeriden - Tafel 1988
für das Richten des astronomischen Zifferblattes

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<u>DATUM</u>	<u>SONNE</u>	<u>MOND</u>	<u>AUFSTEIGENDER MON</u> <u>KNOTEN (Länge Teil</u> <u>Zeig.</u>
10.01.1988	288,7504	178,1700	356,6892
20.01.1988	298,60	309,93	356,15
30.01.1988	308,46	81,69	355,63
09.02.1988	318,31	213,46	355,10
19.02.1988	328,17	345,22	354,57
29.02.1988	338,03	116,98	354,04
10.03.1988	347,88	248,75	353,51
20.03.1988	357,74	20,51	352,98
30.03.1988	7,60	152,28	352,45
09.04.1988	17,45	284,04	351,92
19.04.1988	27,31	55,80	351,39
29.04.1988	37,17	187,57	350,86
09.05.1988	47,02	319,33	350,33
19.05.1988	56,88	91,10	349,80
29.05.1988	66,74	222,86	349,27
08.06.1988	76,59	354,62	348,74
18.06.1988	86,45	126,39	348,21
28.06.1988	96,31	258,15	347,68
08.07.1988	106,16	29,92	347,15
18.07.1988	116,02	161,68	346,62
28.07.1988	125,87	293,44	346,09
07.08.1988	135,73	65,21	345,56
17.08.1988	145,59	196,97	345,03
27.08.1988	155,44	328,74	344,50
06.09.1988	165,30	100,50	343,98
16.09.1988	175,16	232,26	343,45
26.09.1988	185,01	4,03	342,92
06.10.1988	194,87	135,79	342,39
16.10.1988	204,73	267,56	341,86
26.10.1988	214,58	39,32	341,33
05.11.1988	224,44	171,08	340,80
15.11.1988	234,30	302,85	340,27
25.11.1988	244,15	74,61	339,74
04.12.1988	254,01	206,38	339,21
14.12.1988	263,87	338,14	338,68
24.12.1988	273,72	109,90	338,15
03.01.1989	283,58	241,67	337,62

Variation
journalière + 0,985647 + 13,176396 - 0,052954
(Tages-
Koeffizient)

STEP THREE (cont'd)

Once you have the number of degrees from Line 7 on your Worksheet you are ready to set the "spider".

The way this is done is to hold solar hand in place and rotate the "spider" to the approximate degree of Line 7. The indicating point will be the stem of the solar hand. (See Diagram 6).

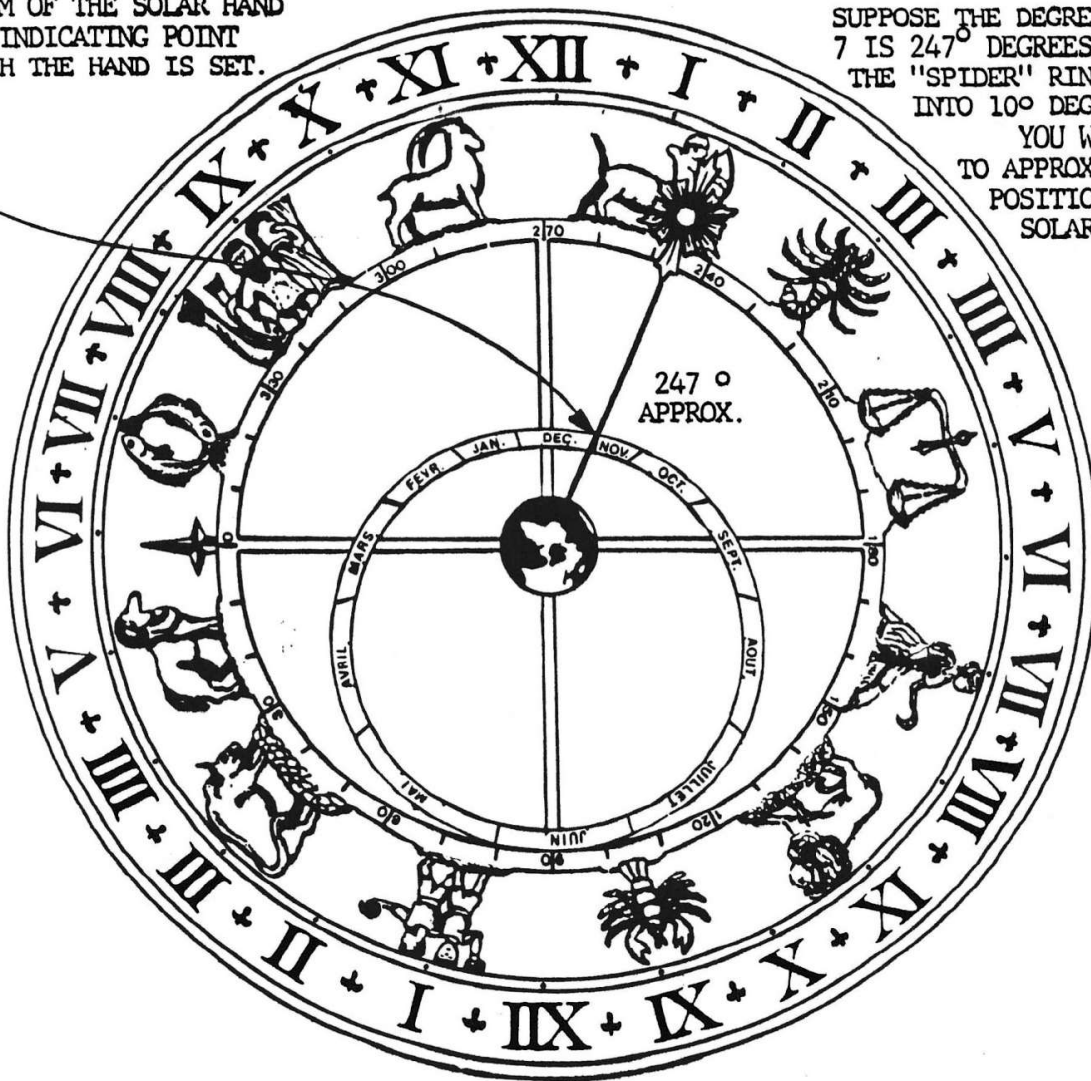
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(DIAGRAM 6)

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THE STEM OF THE SOLAR HAND
IS THE INDICATING POINT
BY WHICH THE HAND IS SET.

SUPPOSE THE DEGREE OF Line
7 IS 247° DEGREES. BECAUSE
THE "SPIDER" RING IS DIVIDED
INTO 10° DEGREE INCREMENTS
YOU WILL HAVE
TO APPROXIMATE THE
POSITION OF THE
SOLAR HAND.



STEP FOUR

SETTING THE LUNAR HAND OR MOON HAND

Once the solar hand and spider are synchronized with the regular clock you are ready to proceed with the setting of the other functions of the astronomical dial. The lunar hand (See Diagram 7) shows the travel of the moon on its course across the sky and its relation to the zodiac.

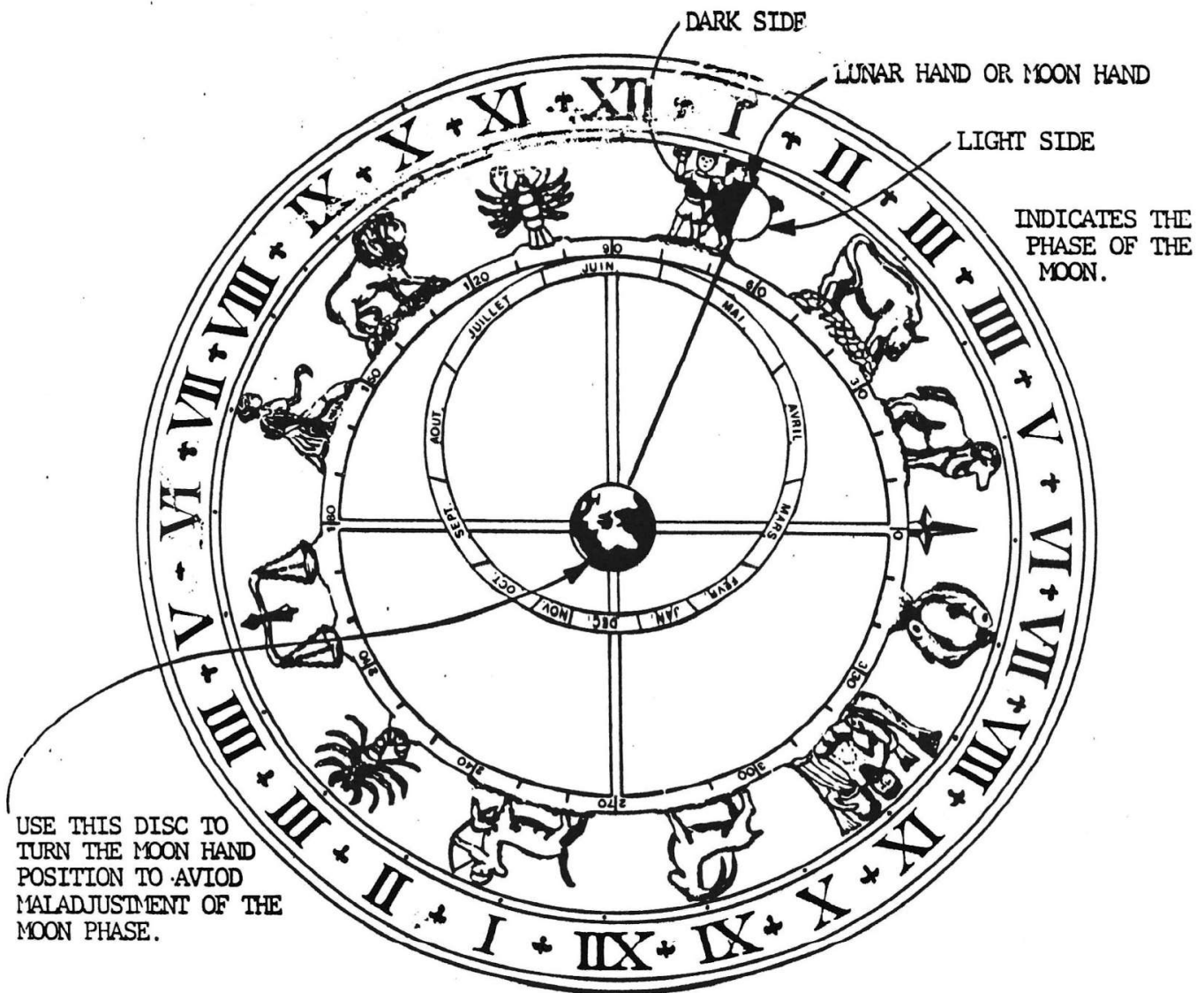
The body of the moon which is half light and half dark revolves on a spindle, its light "sun" side provides an accurate depiction of the various phases of the moon. The lunar clock or hand performs one revolution every 24 hours, 48 minutes and 45 seconds. With respect to the solar hand, the lunar hand loses one revolution every 29 days. It completes a full revolution on its own axis in the same period.

To determine the position of the lunar hand complete Worksheet #3.

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(DIAGRAM 7)

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WORKSHEET #3

WORKSHEET TO DETERMINE POSITION OF LUNAR HAND

Line 1. Enter Line 1 from Worksheet 2 here:

Line 2. Enter answer from Line 2 on Worksheet 2 here:

Line 3. Enter Line 3 from Worksheet 2 here:

Days

Line 4. Multiply Line 3 by 13.176396 enter answer here:

Line 5. On the ephemerides table next to the date from

Line 2, Column 2, enter that figure here:

Line 6. Add Line 4 and 5 and enter answer here:

Line 7. If Line 6 is larger than 360 subtract Line 6 from
360 and enter answer, or if Line 6 is smaller than
360 enter amount from Line 6 here:

Line 8. Continue with Step 4, Page 19

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STEP FOUR (cont'd)

When setting the lunar hand, hold the solar hand and "spider" in place and move lunar hand directly over the solar hand. Then rotate the ball representing the moon to where the dark side is facing out and the light side is facing the solar hand. This is done to make sure the moon is in the proper phase when moving it to the correct position.

Once this is done, still holding the solar hand and "spider" in place, move the lunar hand to the corresponding degree mark on the "spider" as Line 7 (from Worksheet #3) indicates. Once again the stem of the moon hand is the indicating point.

IMPORTANT NOTE:

By holding the stem to move the moon will have a tendency not to let the moon rotate on the stem. This would put the moon out of phase. To avoid this always use the center disc (which represents the earth) to move the moon hand or lunar hand to the proper position.

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STEP FIVE

THE ECLIPTIC HAND (Diagram 8)

Represents the region of the sky the sun and moon must be in for an eclipse to occur. The ecliptic hand represents the nodal path, i.e., the point of intersection of the ecliptic orbit with the lunar orbit. The longest point of the ecliptic hand shows the rising node and the shortest point represents the falling node in the zodiac.

The ecliptic hand tells us two things:

1. When we are to have a lunar eclipse
2. When we are to have a solar eclipse

The ecliptic hand will overtake the "spider" by a full revolution every 6793 days and twelve hours or every $18\frac{2}{3}$ years.

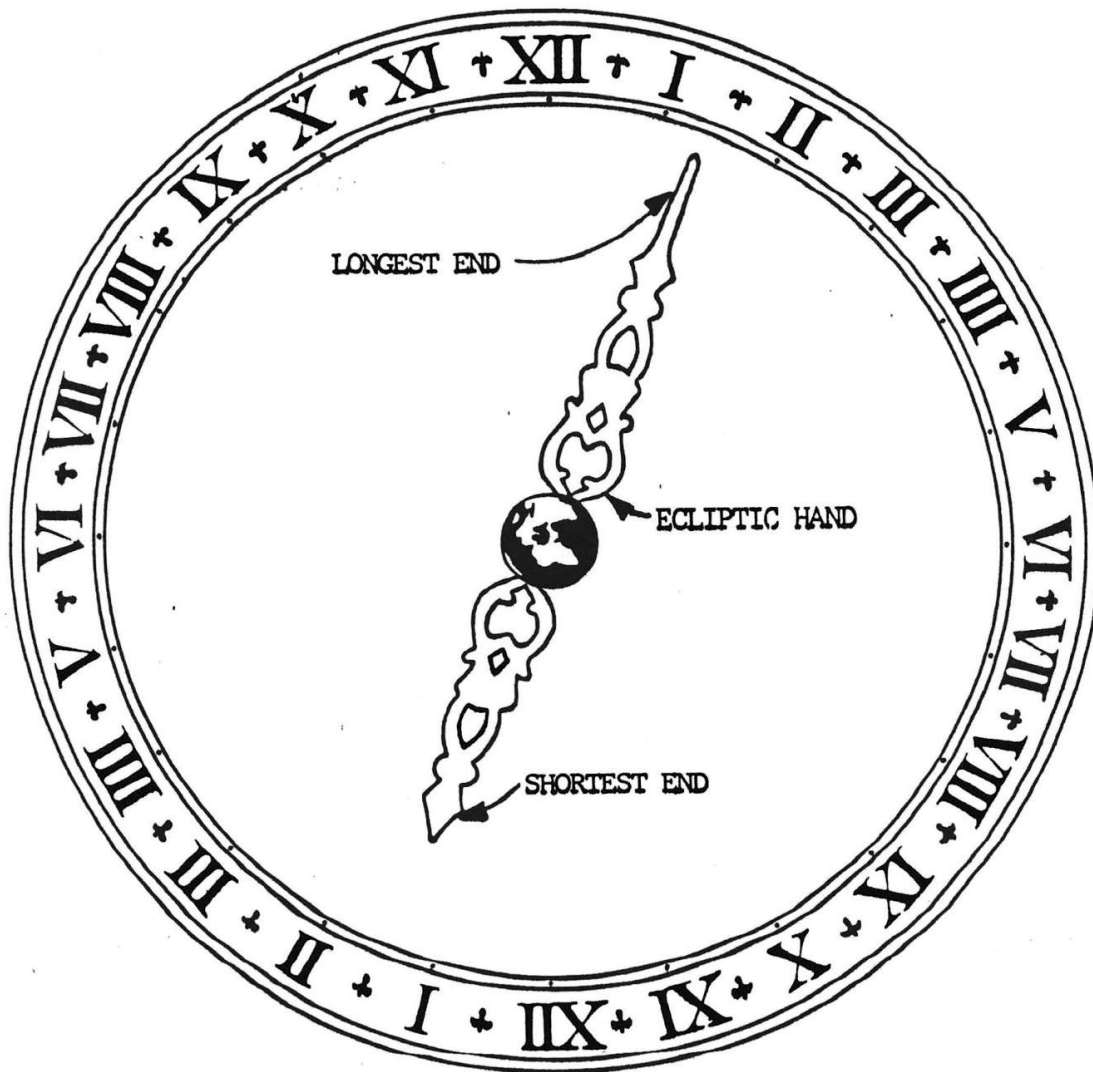
To determine position of the ecliptic hand fill in Worksheet

#4.

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(DIAGRAM 8)

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WORKSHEET #4

WORKSHEET TO DETERMINE POSITION OF ECLIPTIC HAND

Line 1. Enter Line 1 from Worksheet 2 here:

Line 2. Enter answer from Line 2 on Worksheet 2 here:

Line 3. Enter Line 3 from Worksheet 2 here: days

Line 4. Multiply Line 3 by .052954 enter here:

Line 5. On the ephemerides table next to the date
from Line 2, Column 3 enter that figure here:

Line 6. Subtract Line 4 from Line 5 and enter here:

Line 7. Continue with Step 5, Page 23

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STEP FIVE (Cont'd)

Once you have filled in Worksheet #4 and have the number of degrees that the ecliptic hand will be set to you are ready to begin. As you did when you made any other adjustments on the astronomical dial, hold the "spider", solar hand, and lunar hand in place. Now move the ecliptic hand to the determined degree as found on Line 6 of Worksheet #4 using the longest part of the hand. to indicate its position (See Diagram 9), once this is done the functions of the clock have been set. You are ready now to learn how to read or interpret the astronomical dial.

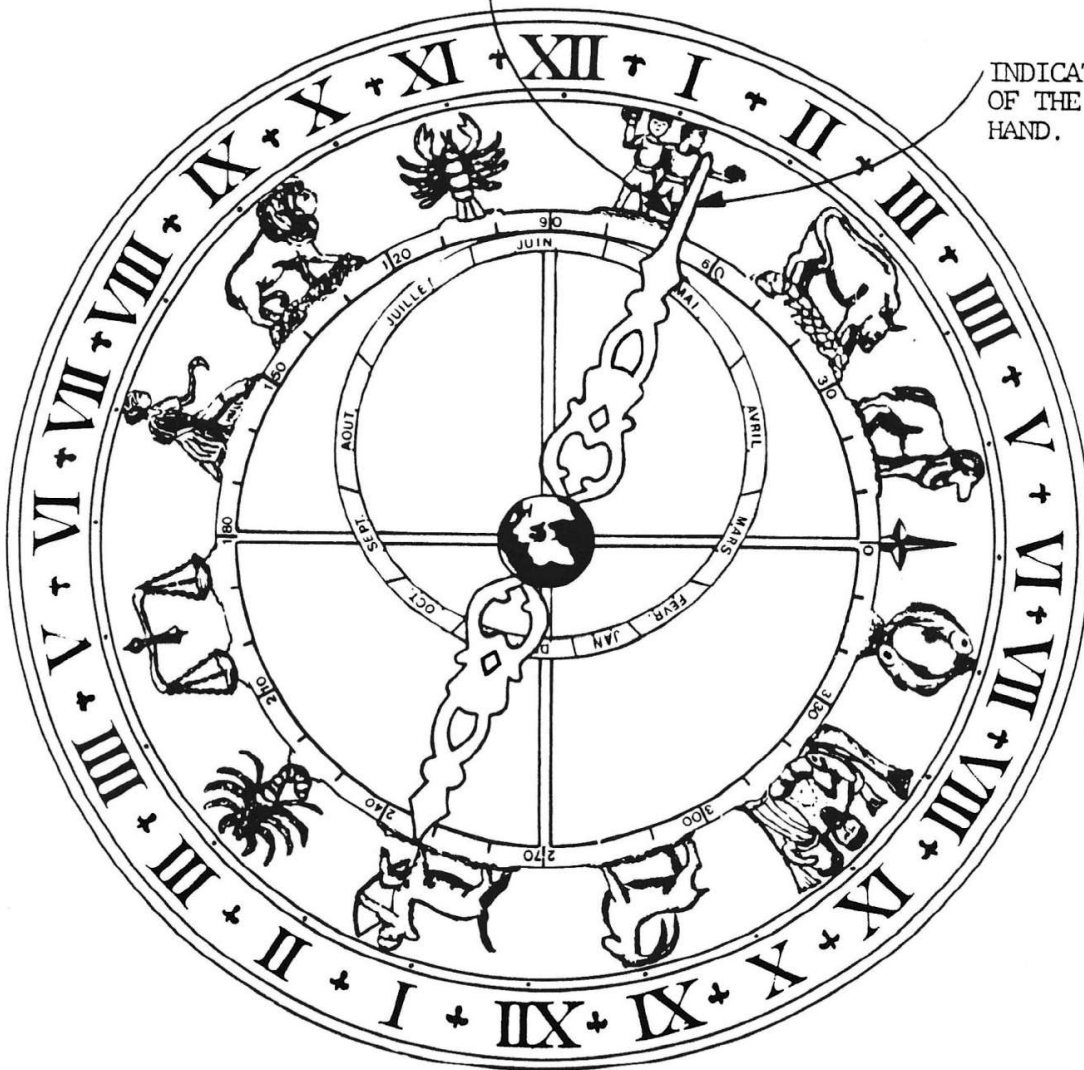
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(DIAGRAM 9)

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SUPPOSE THE ANSWER ON WORKSHEET #4
LINE 6 IS 67° DEGREES MOVE THE LONGEST
PART OF THE ECLIPTIC HAND TO THE
CORRESPONDING DEGREE ON THE "SPIDER" RING
AS SHOWN.

INDICATING POINT
OF THE ECLIPTIC
HAND.



WITH THE OTHER HANDS SET AND THE "SPIDER" SET
MOVE THE ECLIPTIC HAND TO THE PROPER POSITION.
NOTE: BE SURE TO HOLD THE OTHER HANDS IN PLACE
WHILE MOVING THE ECLIPTIC HAND.

INTERPRETATION OF THE ASTRONOMICAL DIAL OR THE READING OF ITS FUNCTIONS

1. READING THE DATE

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Reading the date is done by looking where the stem of the solar hand crosses the ecliptic ring. The date will be approximate due to the fact that the ecliptic ring is not divided into exact days but is divided into 12 months. (See Diagram 10).

2. THE ASTRONOMICAL TIME

The astronomical time is indicated by the point of the solar hand. The solar hand makes 1 revolution every 24 hours. The time is told by using the interior dial of twice twelve hours. (See Diagram 10).

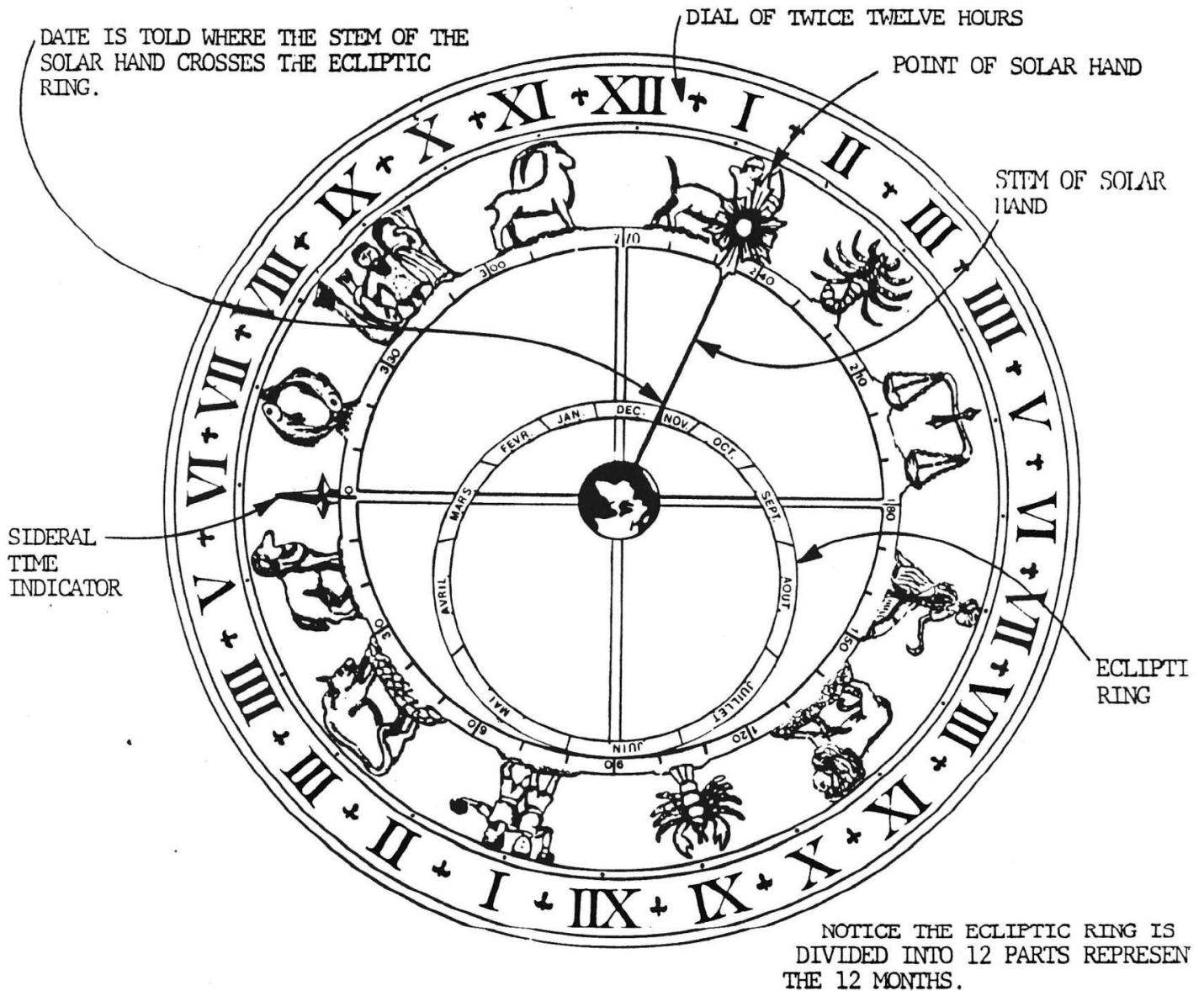
Astronomical time is calculated for a given longitude in reference to the international date line through Greenwich, England. Astronomical time is the exact time in relation to the sun.

3. THE SIDEREAL TIME

Sidereal time is based on the rotation of the earth with respect to the stars and the sidereal day is 23 hours, 56 minutes, and 4.09 seconds of mean solar time in length. If the correct calculations are made it can be seen to 365 revolutions of the earth. With respect to the sun it does not return the earth to the same place in its orbit with respect to the stars. It is this discrepancy that creates the need for the complex system of leap years, whereby we periodically add a day to our calendar to prevent the seasons from shifting the months in which they occur. The indicator for the sidereal time is the pointer, located on the astrological ring between the ram, aries and the fish pices, and it is read against the interior dial of twice twelve hours.

(DIAGRAM 10)

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4. READING SUNRISES, SUNSETS AND CIVIL AND ASTRONOMICAL TWILIGHTS

The meantime of these daily events can be read from the solar hand as the intersection of the stem of the solar hand and the outside edge of the ecliptic ring passes over the lines dividing the shaded regions of the safiha. (See Diagram 11).

At the sunrise for instance, the intersection will pass from the black region of the safiha into the dark gray shaded area marking the beginning of astronomical twilight. As it passes from the dark gray into the light gray, civil twilights begins. As it passes from the light gray into the brown colored portion of the safiha, the sun will be visible on the horizon.

5. AZIMUTH AND THE ALTITUDE OF THE SUN OR RELATIVE POSITION OF THE DAYTIME SUN

The relative position of the daytime sun is read from the intersection of the solar hand stem and the ecliptic ring as it passes over the brown colored portion of the safiha. The reference lines are the direction due South.

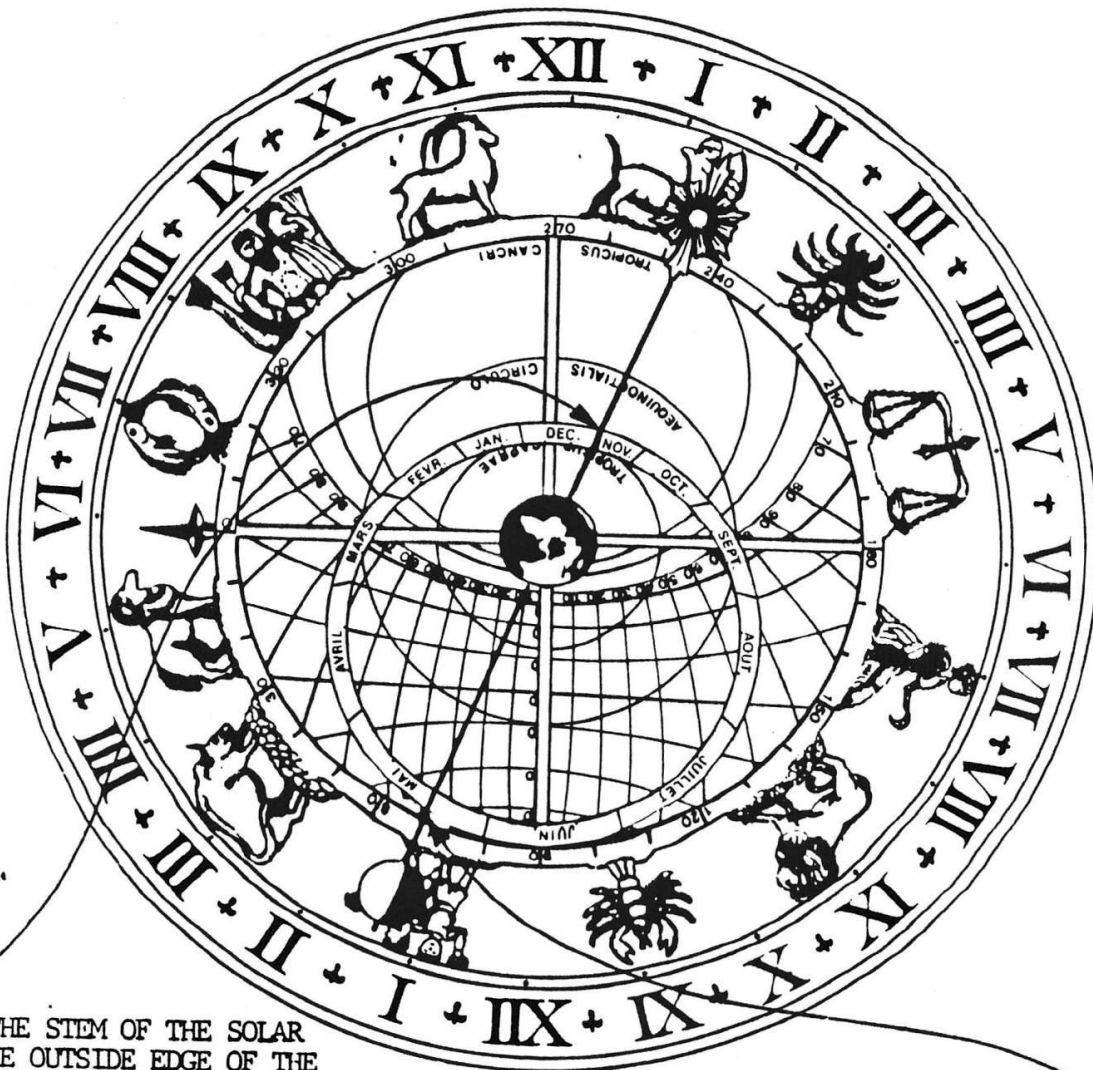
The vertical line on the background dial marked zero degrees and the horizon, the curved lines separating the dark portion of the dial and the brown colored portion also designated zero degrees. (See Diagram 11).

6. READING THE AVERAGE LONGITUDE AND PHASES OF THE MOON

The longitude of the moon can also be approximated by determining the point where the stem of the moon hand intersects with the outer edge of the ecliptic ring. (See Diagram 11).

The phase of the moon can be determined directly from the moon hand, when properly adjusted, by merely observing what portion of the moon's sphere shows as light. When the moon hand shows totally dark a new moon is indicated and when all the light side shows, it means a

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WHERE THE STEM OF THE SOLAR HAND THE OUTSIDE EDGE OF THE ECLIPTIC RING INTERSECT. THIS INTERSECTION AS IT MAKES ITS REVOLUTION INDICATES THE SUNRISE, SUNSET, AND CIVIL AND ASTRONOMICAL TWILIGHTS, AS WELL AS THE AZIMUTH AND ALTITUDE OF THE SUN. ALSO, THE SOLAR HAND INDICATES THE TIME OF THESE EVENTS WHEN THEY OCCUR.

WHERE THE STEM OF THE MOON HAND AND THE OUTER EDGE OF THE ECLIPTIC RING INTERSECT THIS INTERSECTION INDICATES THE LONGITUDE AND THE POSITION OF THE MOON ON ITS TRAVEL AROUND THE EARTH.

full moon. (See Diagram 12).

7. POSITION OF THE SUN AND MOON IN RELATION WITH THE TWELVE SIGNS OF THE ZODIAC

The position of the sun and moon in astrological terms are said to be the house of the sun and moon which is the particular constellation behind them at any given time. This means, for example, that when the solar hand is over the full and the astrological ring, the sun will be in the house of tarus. Similarly, when the moon is over the gemini twins, the moon is considered to be in the house of gemini.

8. ECLIPSES OF THE SUN AND THE MOON

Eclipses occur when the sun, the moon and the earth are in direct alignment. The ecliptic hand of the astronomical dial shows the region of the sky that the sun and moon must be in for alignment to occur. Therefore, when the sun and the moon hands simultaneously pass over the same end of the ecliptic hand, a solar eclipse will occur. (Diagram 13).

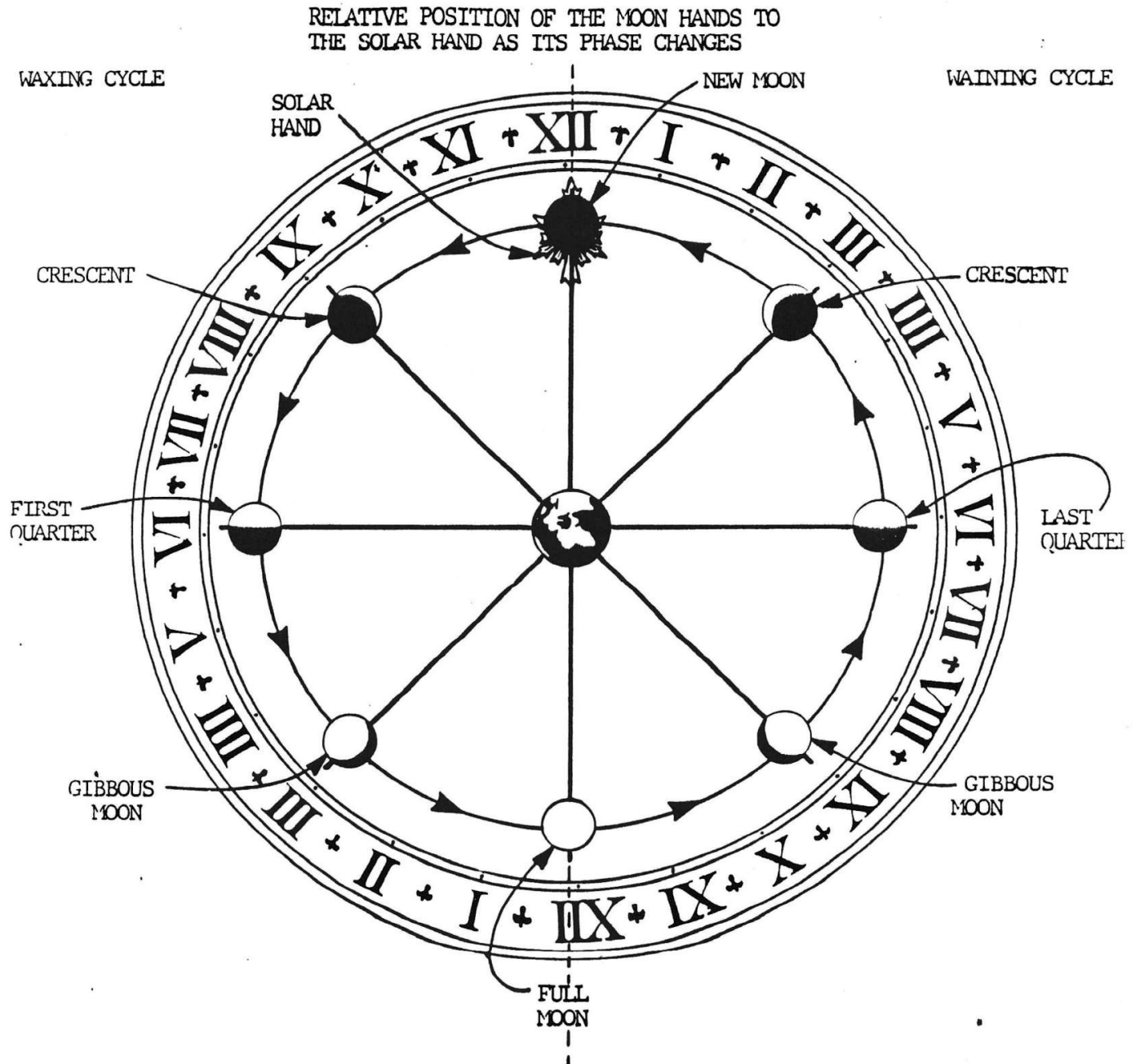
When the sun and moon hand simultaneously pass over opposite ends of the ecliptic hand a lunar eclipse will occur. (Diagram 14).

9.. READING THE ASCENDENT OR THE RISING ZODIAC SIGN

This particular function of the astronomical dial is read by the solar hand and the signs of the zodiac around the "spider". When the solar hand is beginning to cross over a particular sign, for instance, if the solar hand is beginning to cross over the sign Pices, it would be said that Pices is in the ascendent or Pices is rising and Aries is desending, Aries being the sign next to Pices.

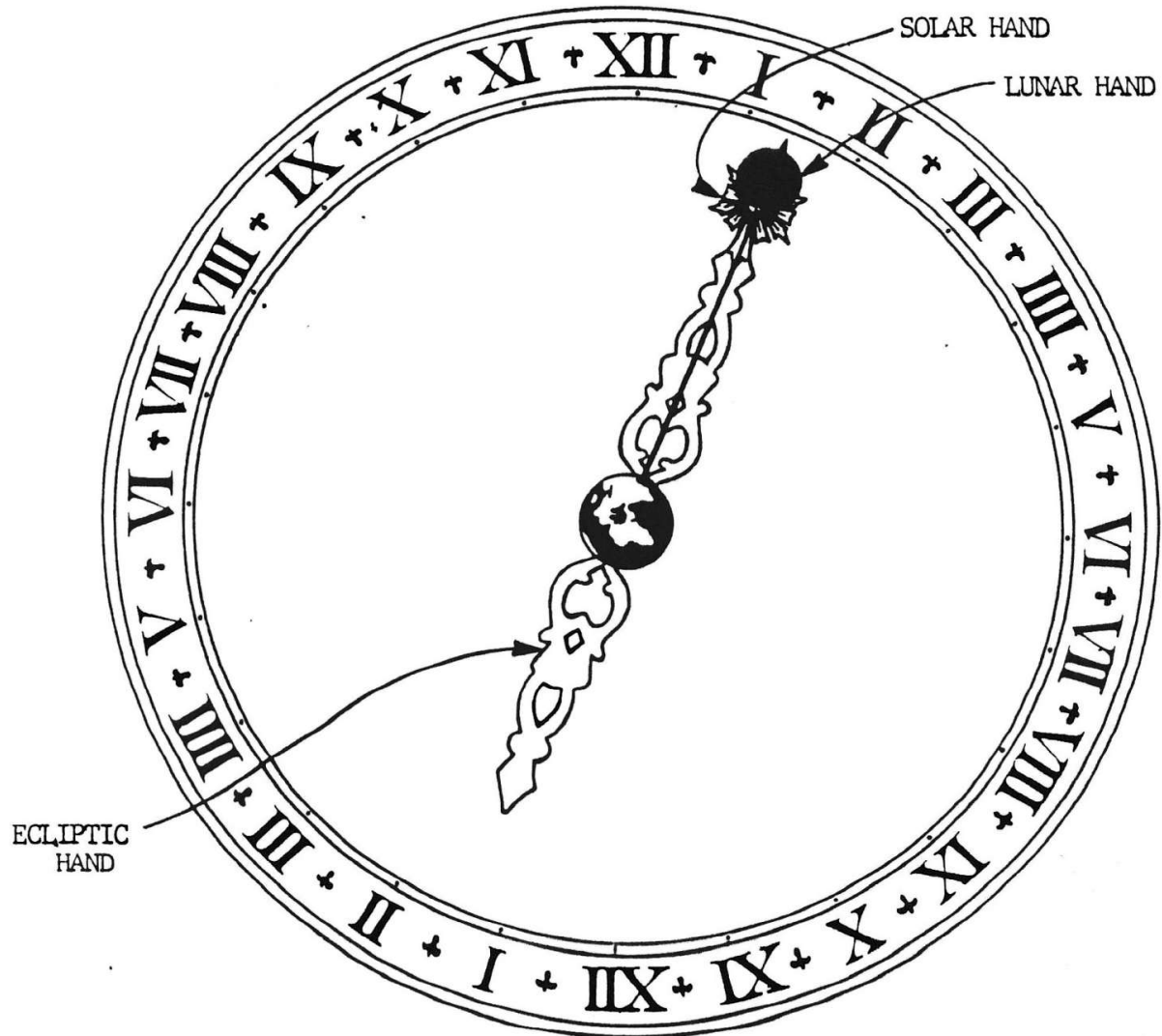
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(DIAGRAM 12)



(DIAGRAM 13)

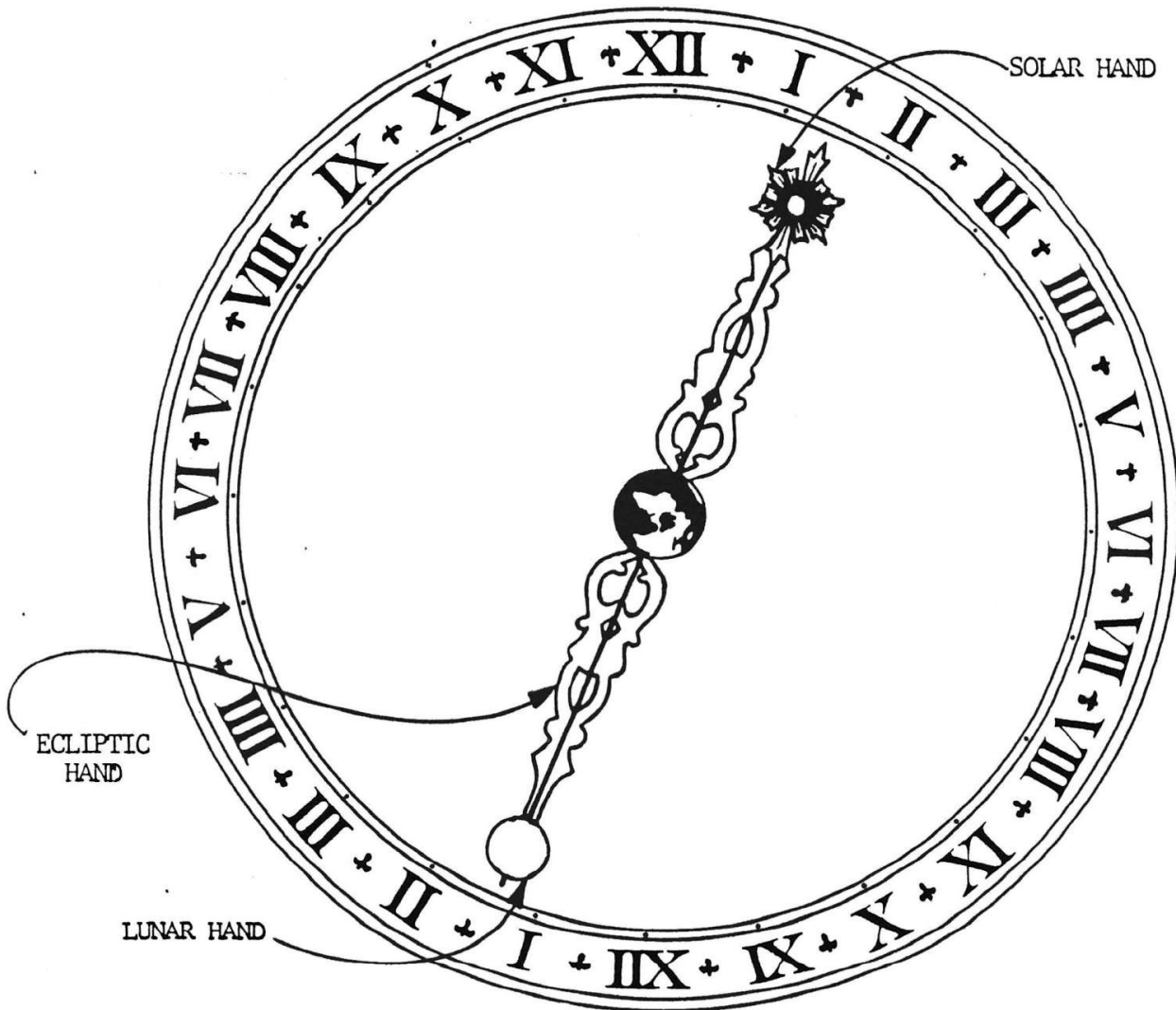
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EXAMPLE OF A SOLAR ECLIPSE.

(DIAGRAM 14)

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EXAMPLE OF A LUNAR ECLIPSE.

10. CHANGE OF SEASONS

The "spider" is divided into 4 equal parts known as quadrants. Between these quadrants are dividers. Each quadrant divider represents a change of season starting with the point gamma (vernal equinox) located between Aries the ram and Pices the fish. This divider represents Spring. An equinox occurs when there is twelve hours of daylight and twelve hours of moonlight in 1 day, which occurs twice a year. The divider at the 90 degree mark represents the first day of summer. This is known as the summer solstice. A summer solstice is the longest day of the year. The divider at 180 degree is known as the autumnal equinox which marks the first day of Autumn usually between September 22 and 23. The divider at the 270 degree mark is the winter solstice and marks the first day of winter. A winter solstice is the shortest day of the year. (See Diagram 15). the way the seasons are indicated is when the solar hand passes directly over the quadrant dividers.

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(DIAGRAM 15)

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