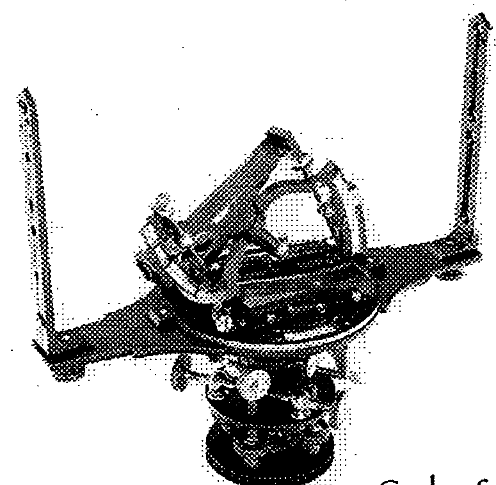
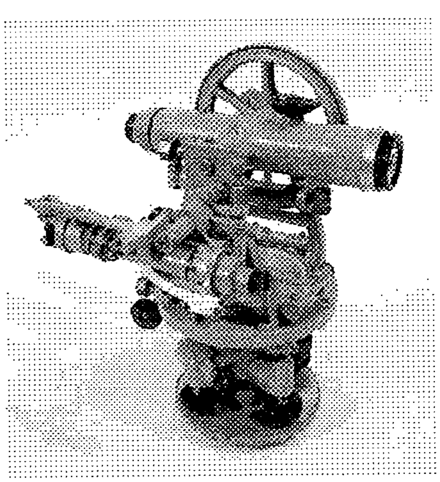
SURVEYING WITH SOLAR INSTRUMENTS

by

Tim Kent



Gurley Solar Compass



Gurley Solar Transit

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Tim recently retired as the Cadastral Survey section chief with the Bureau of Land Managements' Oregon/Washington State Office. He has been a land surveyor with the BLM and Forest Service since 1969 and has also worked in Alaska, Colorado and the Pacific Northwest. He is a graduate of Oregon Technical Institute and is a licensed land surveyor in several western states.

Tim is a member of LSAW, PLSO, and ACSM. He chairs the TrigStar program for PLSO, is the workshop and technical presentation chairman for the ACSM national conferences, and is the chairman of the 2006 LSAW/PLSO annual conference to be held in Vancouver, WA.

Tim has used both the solar compass and solar transit in his cadastral surveying work in the Pacific Northwest. He is passionate about his profession and wants to have others enjoy an opportunity to follow in the footsteps of the original surveyors.

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Historical Background

AN HISTORICAL SKETCH

Since our organization in 1845, W. & L. E. Gurley has designed and constructed every type of instrument that has been required in the subdivision of the vast area of the United States public domain. Many of the same instruments have been supplied to engineers engaged in general surveying practice in North and South America, and the Orient.

The rectangular surveying system, which was originated in the United States, has been applied throughout the public domain. The controlling lines have been established on cardinal courses. The directions of all lines of the minor subdivisions have been defined in terms of angular measure referred to the true north and south at the point of record. The principal control has been the survey of standard parallels of latitude and guide meridians, usually spaced at intervals of twenty-four miles. The smaller subdivisions are the townships six miles square, and the sections one mile square.

The rectangular plan was first established over all of what was called the Northwest Territory, and the areas of the South which were ceded by the Colonial States to the Federal Government. The same plan, with gradual improvements in the technique of making the surveys, has been extended over the great additions to the public domain which were acquired through the Louisiana purchase, and the lands ceded to the United States by Spain, Mexico, the Republic of Texas, Great Britain, and Russia. All of this required the adaptation of the rectangular plan to the spheroidal form of globe. The imperative need has always been for accurate instrumental orientation for the running of the lines of the meridian and the parallels of latitude. Emphatically, the problem has been one of large scale surveying, with the refinements in geodesy suited to the figure of the earth. This has attained a high practical development in the use of the solar transit.

In the early land-surveying practice of the Colonial area, i.e. - the States of the Atlantic seaboard, the principal instrument was the needle compass; the lines were usually run on irregular courses, with descriptions by metes-and-bounds. It was usually intended to orient first by reference to the magnetic north, then turning off the magnetic declination, so that the record courses could be expressed in true bearings. The same plan of orientation was applied in the early public-land surveys, but the inaccuracies of needle courses was a serious handicap to the rectangular plan when applied on a large scale. Its use had to be discontinued in the upper regions of the Great Lakes, and in all other areas where magnetic ore deposits made the needle more than ordinarily unreliable.

EVOLUTION OF THE SOLAR UNIT

The Burt solar compass was introduced in Northern Michigan about 1836, and was found to be thoroughly well suited to the requirements. It was widely used for many years throughout the public domain, both in the forest areas and on the prairies. Its great importance was due to the accurate instrumental orientation, and that the east and west lines through the forest could be run as true lines.

The transit construction became necessary in the rough mountain areas of the western portions of the public domain. The first type was the Burt design of a solar unit, mounted upon the telescope of a Gurley transit. This was a long step forward in instrumental design, both for accuracy and general usefulness. This instrument was extensively used on the public land and mineral surveys of the west.

Beginning with 1920, W. & L. E. Gurley has been making a telescopic solar unit, mounted on the standard to afford the advantages of good optics suited to solar observations, and the special arcs for setting off the latitude and the sun's declination, so as to operate entirely apart from the main telescope and circles. This has made for greater accuracy in solar orientation, increased dependability, and has very much reduced the time that is required in making the solar observation. In fact, it might be stated that, after the transit set-up and levelling, and after having made the initial settings of the latitude and declination for the day's work, the solar orientation scarcely takes any time at all.

MODERN DEVELOPMENTS

In the planning of the improvements, the Gurley engineers, opticians, and instrument designers have constantly studied the more exact methods of construction, operation, and the making of the adjustments and tests, always bearing in mind the general usefulness of the solar transit, including the larger field of land surveying in all of its many branches. The modifications in design have been made to improve the accuracy and dependability, in this problem disregarding the heavy expense of making the changes in the patterns. Our latest solar transit is the most complete and best instrument that has ever been made available for land surveying, to give rapid and accurate instrumental orientation, at the same time adding all detail requirements for the modern methods in the making of stellar observations. As a complete operating unit it has no worthy competitor when employed as a land surveying instrument.

The contributors to the preparation of this bulletin have both had many years practical and successful field experience in the use of the solar transit, covering many thousands of miles of actual line running, performed personally under all conditions of terrain, forest cover, undergrowth, and season, including field use of other well-known solar units. Both have made many valuable suggestions in planning the improvements, now finding expression in the Gurley No. 112 - RT.

A large proportion of the work in land surveying calls for reasonable accuracy, at reasonable cost, with directions of lines referred to the true north at the place of the survey. These are jobs that may take only a few hours time, seldom over a few days, the larger areas being an exception. What is wanted is to get started without delay, yet reasonably accurate. An instrument is needed that can perform well without having to depend upon references in azimuth, and without having to run a back-sight line if there are trees, tall undergrowth, or other obstructions. This also calls for passing short turns and offsets, where long back-sights may be impracticable, or consume much time of the field party, if the accuracy is to be maintained. These are the time and cost saving features of the solar transit, without undue sacrifice of accuracy.

In the general daily practice, the orientation to the solar meridian may be secured in a few minutes time, doing so without reference to any previously ascertained azimuth line, keeping within a normal tolerance of 1'30", and usually closer much of the time. Where still better accuracy is desired, the direction of the line may be verified by the direct altitude observation on the sun for azimuth. The latter can be followed in the late afternoon, if desired, by a Polaris and other stellar observations, usually completing the observing program before illumination is required.

SIMPLICITY OF OPERATION

Another question that is often asked, - What special background is required, or special training on the part of the engineer, for the proper operation of the solar transit? The background is found in the elements of applied field astronomy. It is extremely helpful when first becoming acquainted with the solar transit to go through the manipulation with someone who is familiar with the instrument, as the questions may be more easily answered by demonstration. The practical phases of the subjects are few however, and may be explained in simple terms.

The theory and practice of making the altitude observation upon the sun for azimuth is probably of first importance, because that involves an understanding of the computations for the sun's declination, and requires the value of the latitude of the station. The latter two elements supply the important data for the operation of the solar unit. The azimuth observation by the altitude method gives a convenient check to verify the instrumental orientation.

The latitude observation upon the sun at meridian passage for time and latitude is extremely useful. Also, the observation on Polaris at sunset for azimuth and latitude, hour angle method. The solar unit greatly simplifies the making of these observations, because a reference mark in azimuth may be secured so quickly. The combinations of these methods makes for the greatest possible usefulness of the solar transit.

On exploration surveys, where there may be considerable uncertainty in both latitude and longitude, these observations, together with radio time signals, will enable a quick and reliable determination of the position. Where the latitude value is quite uncertain, the noon solar observation may be reversed as to the usual procedure, i.e. - having made an approximate solar orientation in the a.m., make the noon observation by setting off the calculated noon declination (corrected for refraction) then bring in the sun in the solar telescope by the latitude tangent motion. This gives an "instrumental latitude" for the solar unit, which may be employed at once in the steps leading to the determination of the more exact values in latitude and azimuth.

Solar System

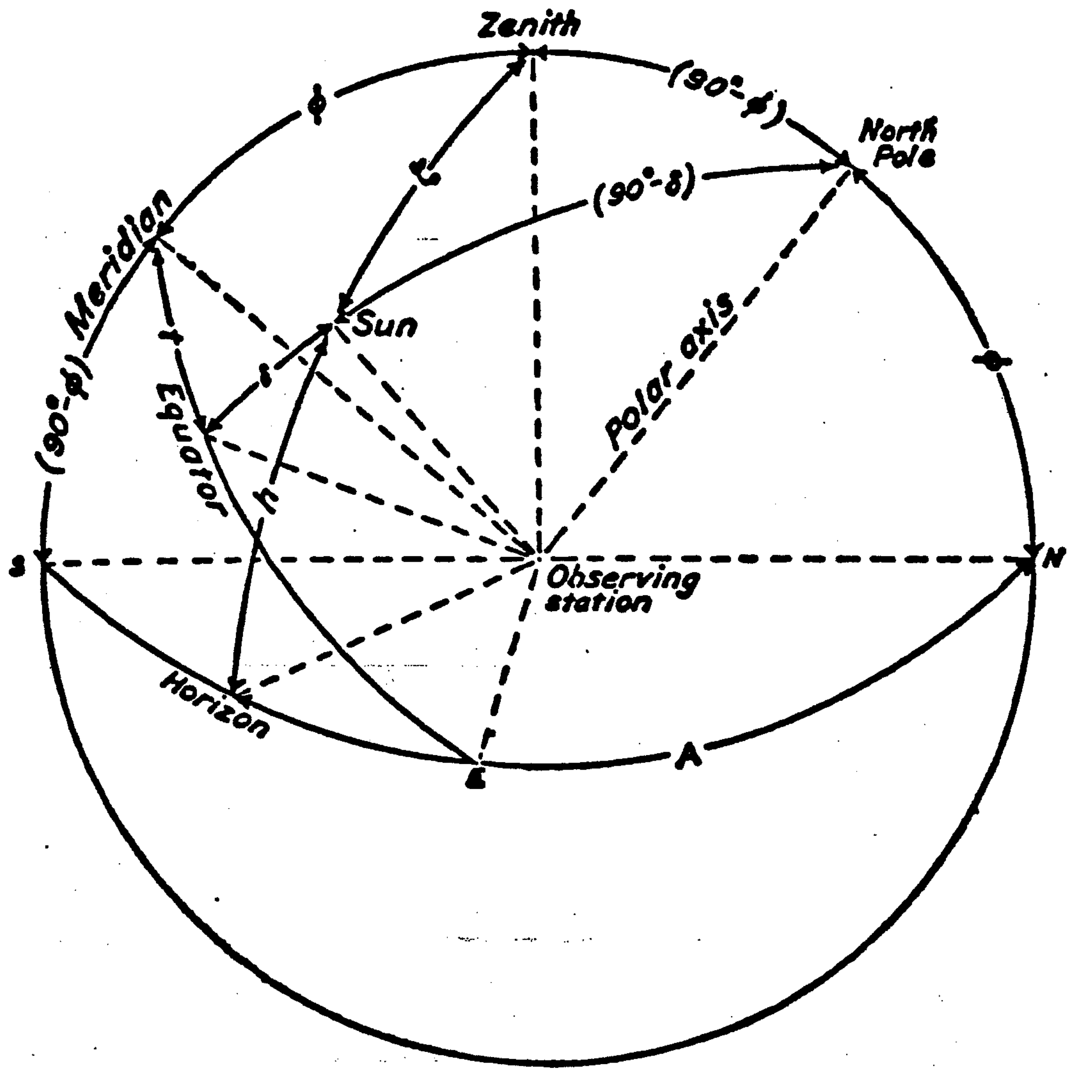
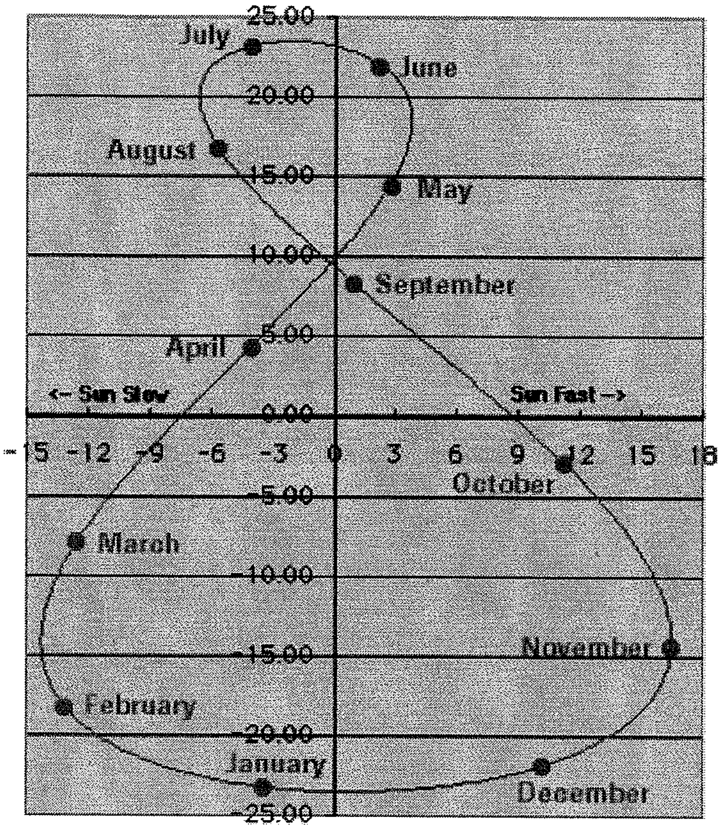


Fig. 4.

The "pole-zenith-sun" triangle as viewed from outside of the celestial sphere.

THE ANALEMMA

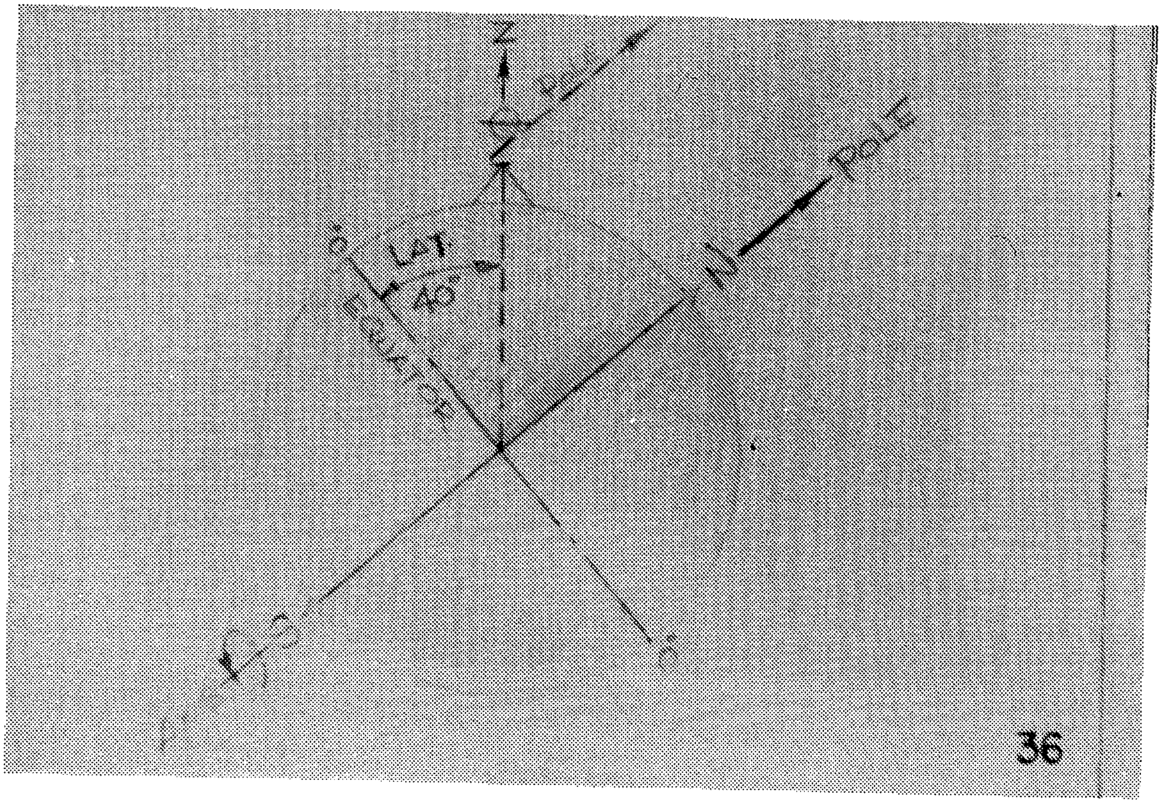


ANALEMMA CURVE

The y–axis on the chart represents the declination of the sun in the sky for one year, going from −23.45° in the winter to +23.45° in the summer. The x–axis represents the difference in time from what your watch reads to the actual position of the sun in the sky.

Have you ever looked at a rise and set time chart of the sun and noticed that in the summer the earliest sunrise and latest sunset do not occur on the longest day of the year? Or that in the winter the latest sunrise and earliest sunset do not occur on the shortest day of the year? This phenomenon is directly related to the ANALEMMA. The longest day of the year is around June 21st, the latest sunset occurs a few days after that. The opposite effect occurs in the winter, the shortest day of the year is around December 21st, the latest sunrise does not occur until several days after that.

The speed of the true sun on the ecliptic now reflects its elliptical orbit around the sun, moving faster in January and slower in July.



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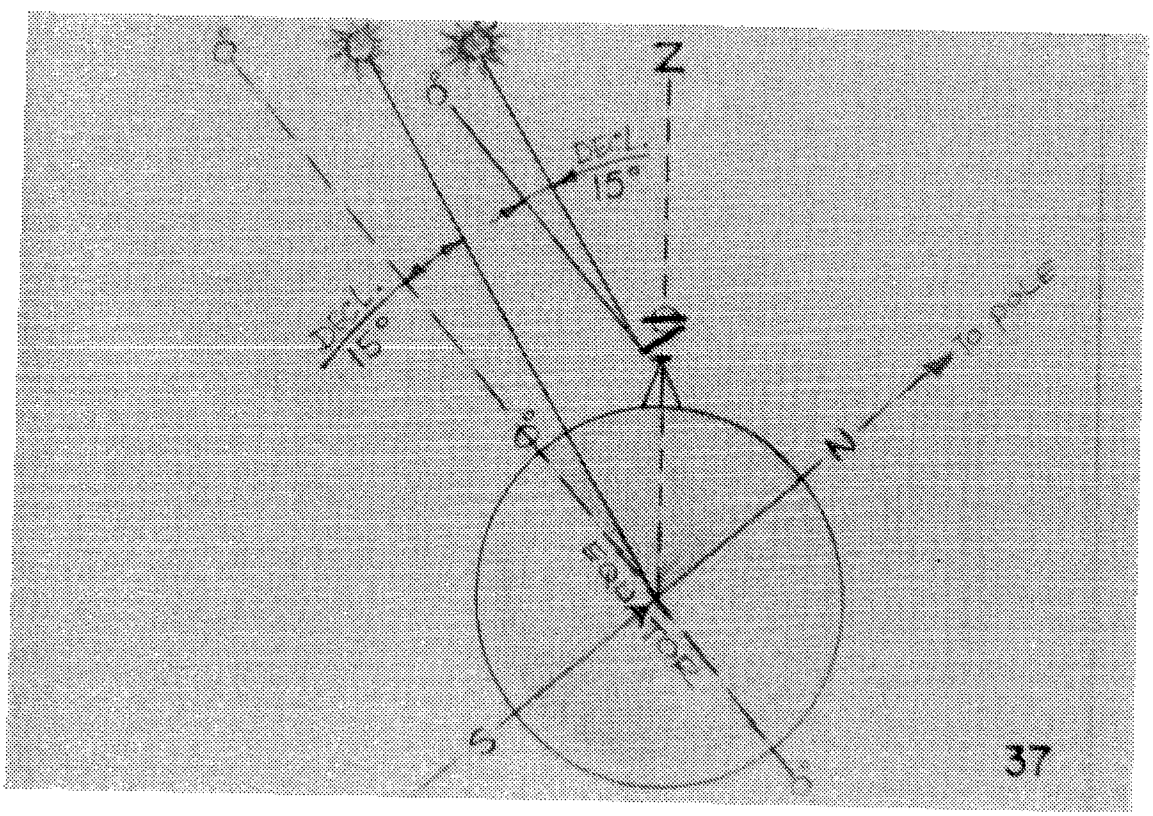

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Solar Compass

THE SOLAR COMPASS.

This instrument was invented by William A. Burt, of Michigan, and it has become the standard compass in U. S. Surveys. As it does not depend upon the magnetic needle in any way, lines run with it are true sun courses, and when used by a skilled surveyor are very accurate.

The government requires its standard and township lines to be run by its means, and in every class of work it will be found serviceable.

Its parts consist of latitude arc *a*, upon which is set off or ascertained the latitude of a station; the declination arc *b*, whereon the distance of the sun from the equator is set off; the hour arc *c*, which gives the hour angle of the sun, or the hours and minutes of the day; the horizontal arc or plates *d*, upon which may be turned off any desired angle; the needle arcs, one enclosed in the needle-box *n*, and the other resting upon the horizontal plate outside, by means of which the amount of departure of the magnetic needle from the true north may be determined; the needle-lifter, on the side of the box; the adjustable levels; the sights, as on the vernier compass; the polar axis *p*, or spindle of the declination arc; the declination arm *h*, attached to which are the solar lenses and blocks *g*, through and upon which the sun's image is produced, and guided between the equatorial and hour lines engraved on the block; the equatorial sights *u*, attachable to the blocks, and used in adjusting the instrument; clamp and tangent screws, *f*, *k*, *t*, and verniers *e*, *v*, and others attached to the principal arcs.

The image block attached to the declination arm receives the image of the sun (while lines are being surveyed) anywhere between the two principal horizontal equatorial lines; the perpendicular or hour lines being used in taking time or latitude when the image is kept between both sets of lines in the square formed at their intersection.

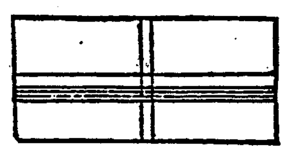

FIG. 32.

Below the equatorial are the refraction lines, 5′ apart, used when the sun is near the horizon, by causing its image to rest upon one or the other, as occasion requires.

A small dot in the center of the square facilitates an observation in determining the exact position of the image; the sun being nearer the earth in winter, causing its image to overrun or fill the lines, and in summer leaving a space between the limbs and lines, the dot assists in centering the image, particularly when the irradiated edges and lines do not coincide.

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LATITUDE BY THE SOLAR COMPASS.

After the solar compass has been correctly adjusted in all of its parts, its future usefulness depends upon finding the latitude as given by the instrument, at the place where it is used.

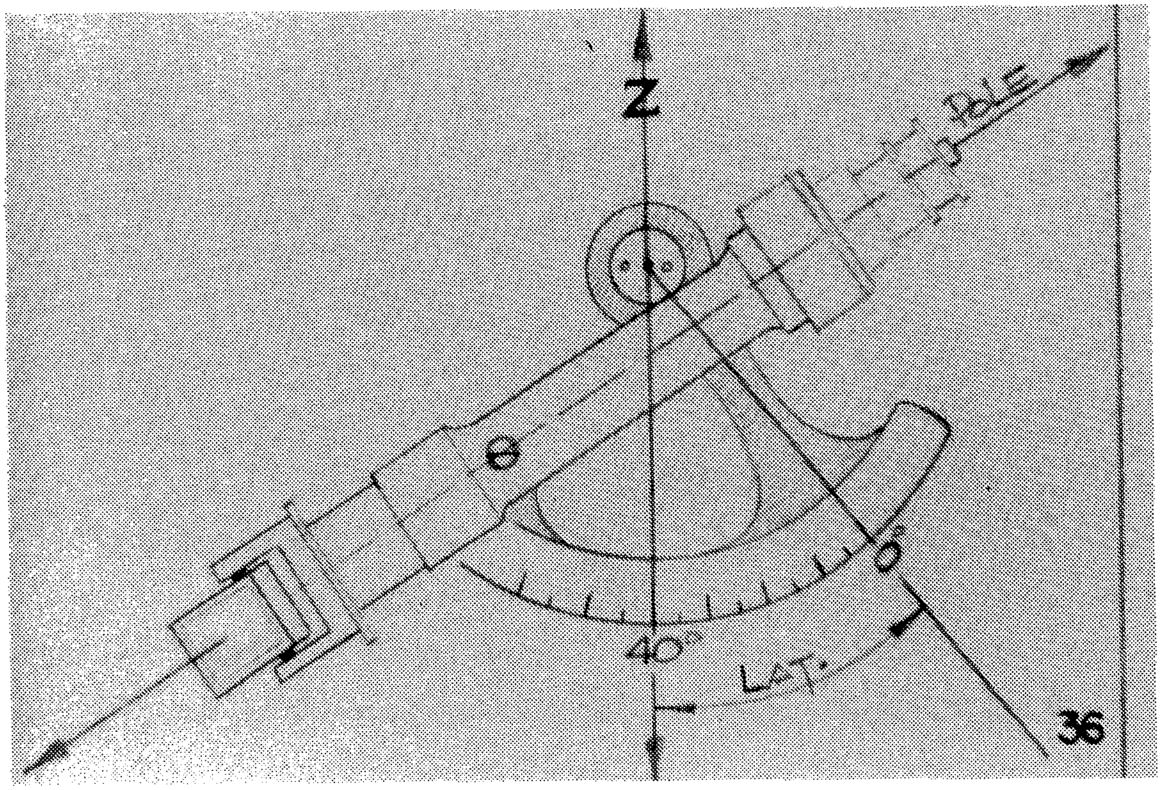
That it may not be repeated again, hereafter, it should be remarked, that in all observations with the solar compass, it must be placed on the tripod, and accurately levelled, with the latitude arc turned toward the equator; except, that when making an observation on the pole-star, it must be turned in that direction. This can be done approximately by the magnetic needle.

Thus prepared, set off the sun's declination for noon on the declination arc, allowing for its index error, if any, and the sun's meridional refraction, also, adjust the latitude arc approximately to the latitude of the place, and the revolving limb *v.* at its true zero point on the hour arc *i.*: in other words, for noon.

Commence the observation for latitude about fifteen minutes before the sun culminates, by turning the instrument horizontally on its lower axis, so that the sun's image will fall between the hour lines on the silver plate, and raise or lower the latitude arc, if necessary, to bring the sun's image between the equatorial lines. Then follow the motion of the sun, by turning the compass horizontally, at short intervals of time, and adjust the latitude arc, to keep the sun's image between the equatorial lines, until he culminates. The latitude of the station can then be read at the vernier of the latitude arc.

The same method may be pursued by night to determine the latitude by an observation on any celestial object within the zodiac, viewed through the equatorial sights. In making these observations, it will sometimes be necessary for an assistant to hold a lighted candle a little behind and above the head of the observer, in such a manner that the equatorial sights can be seen; but not so bright as to obscure the star.

Solar Transit



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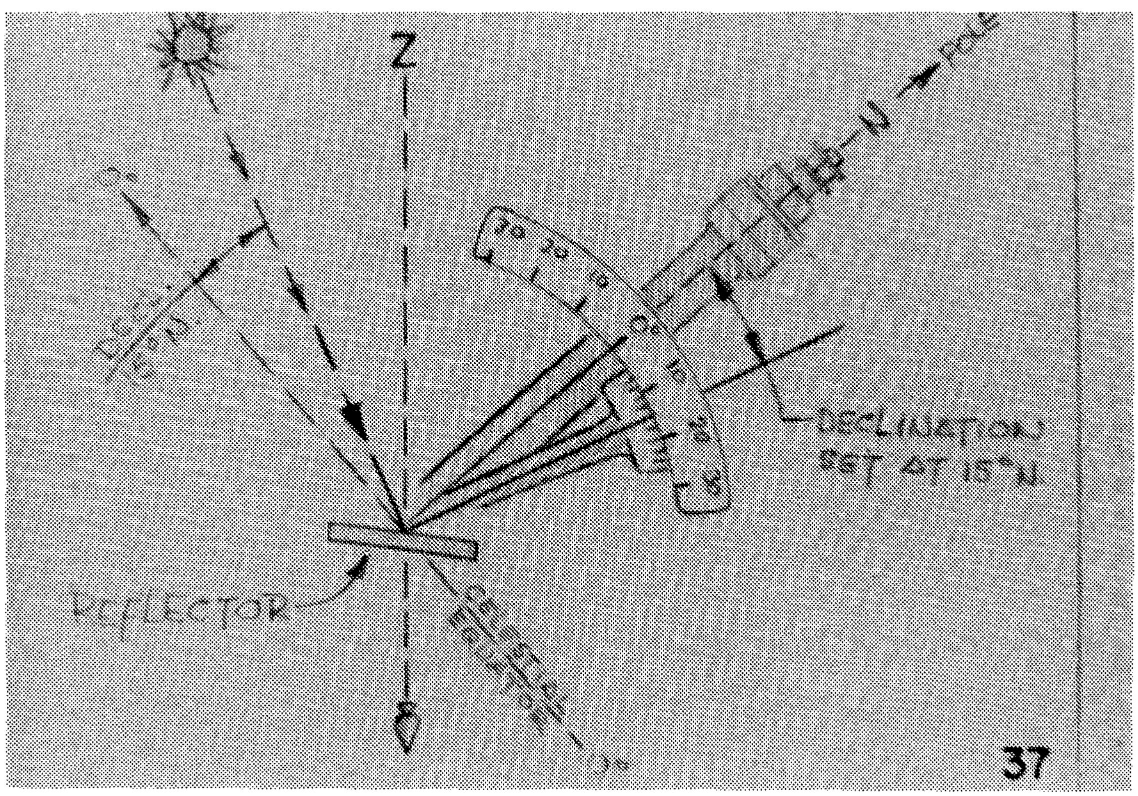

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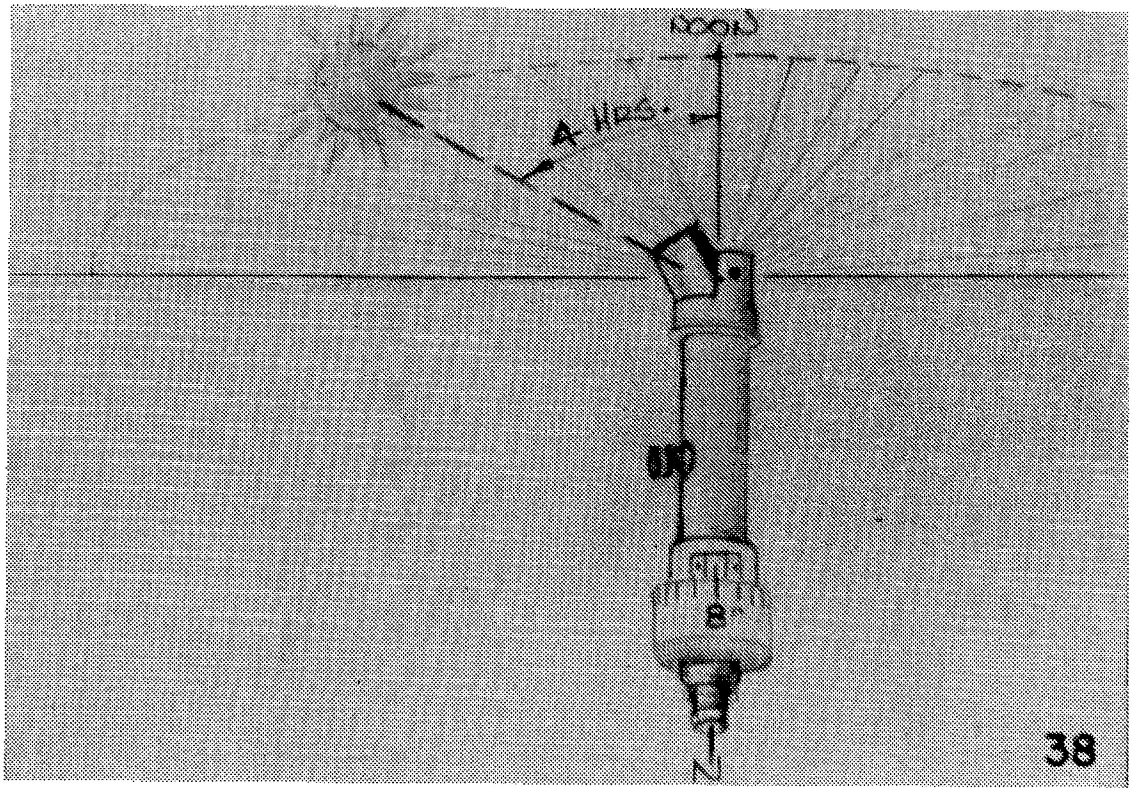
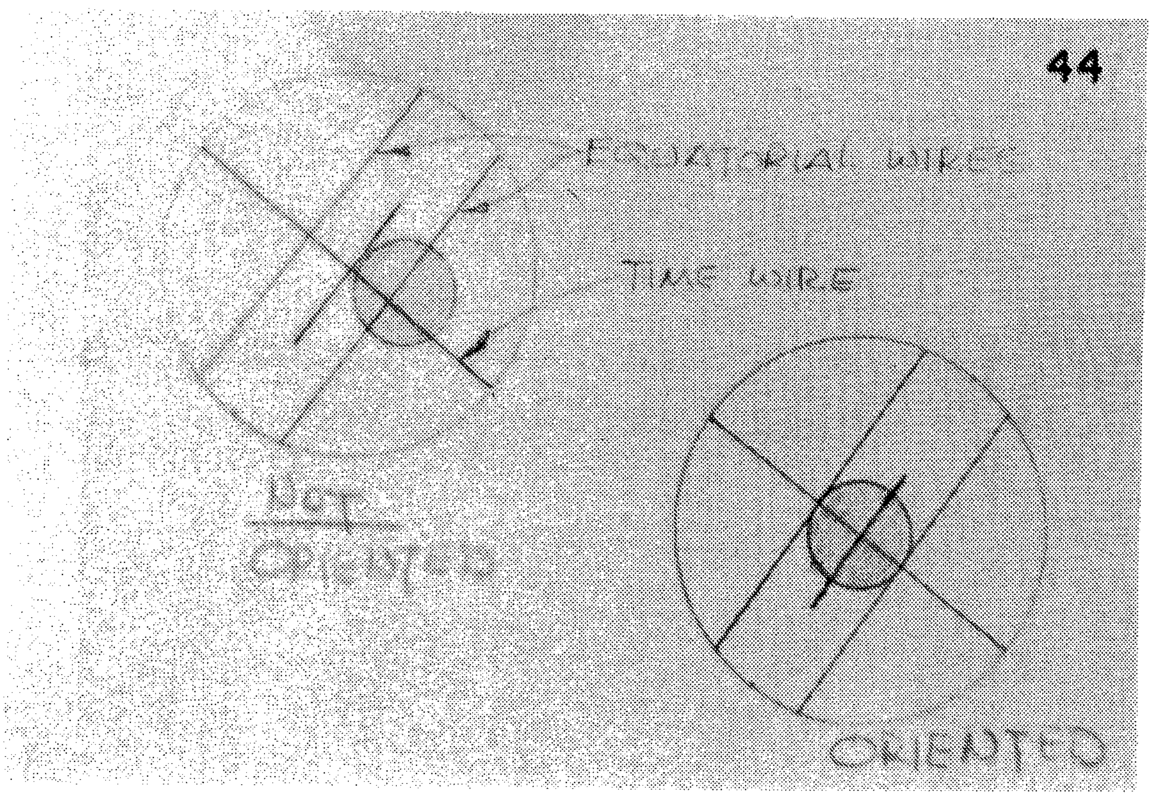
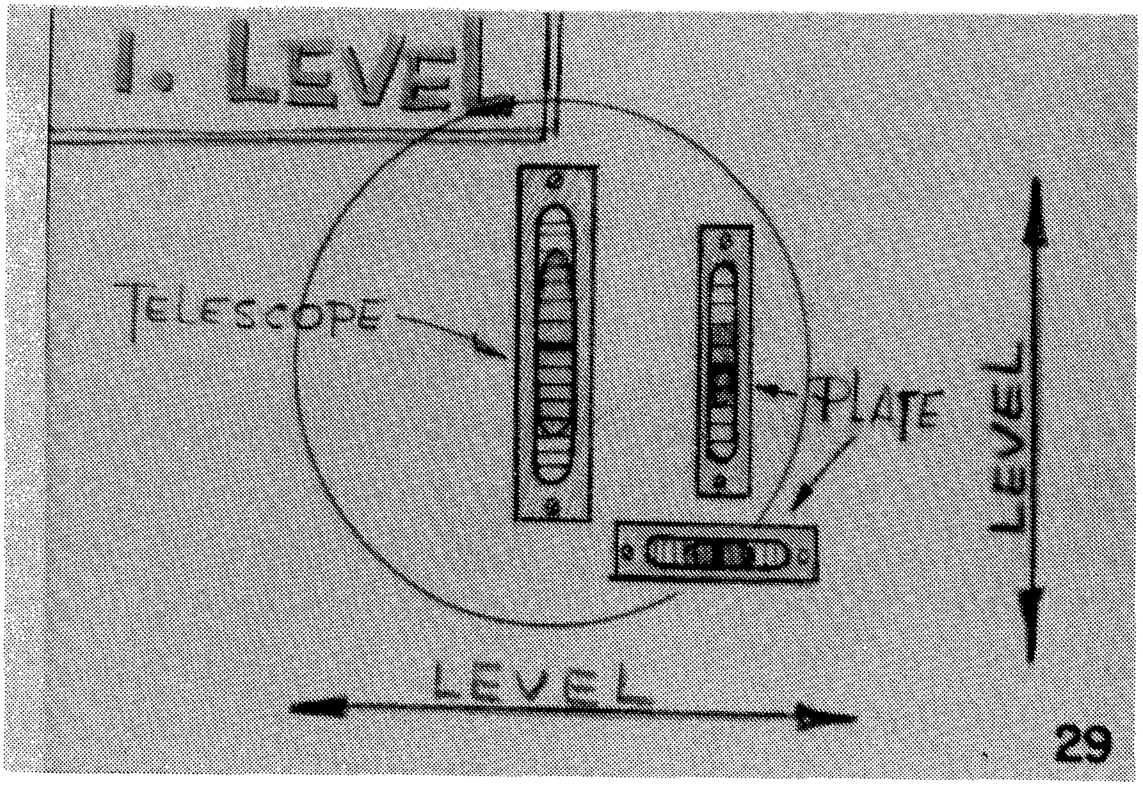

NOON
4 HRS.
8
N

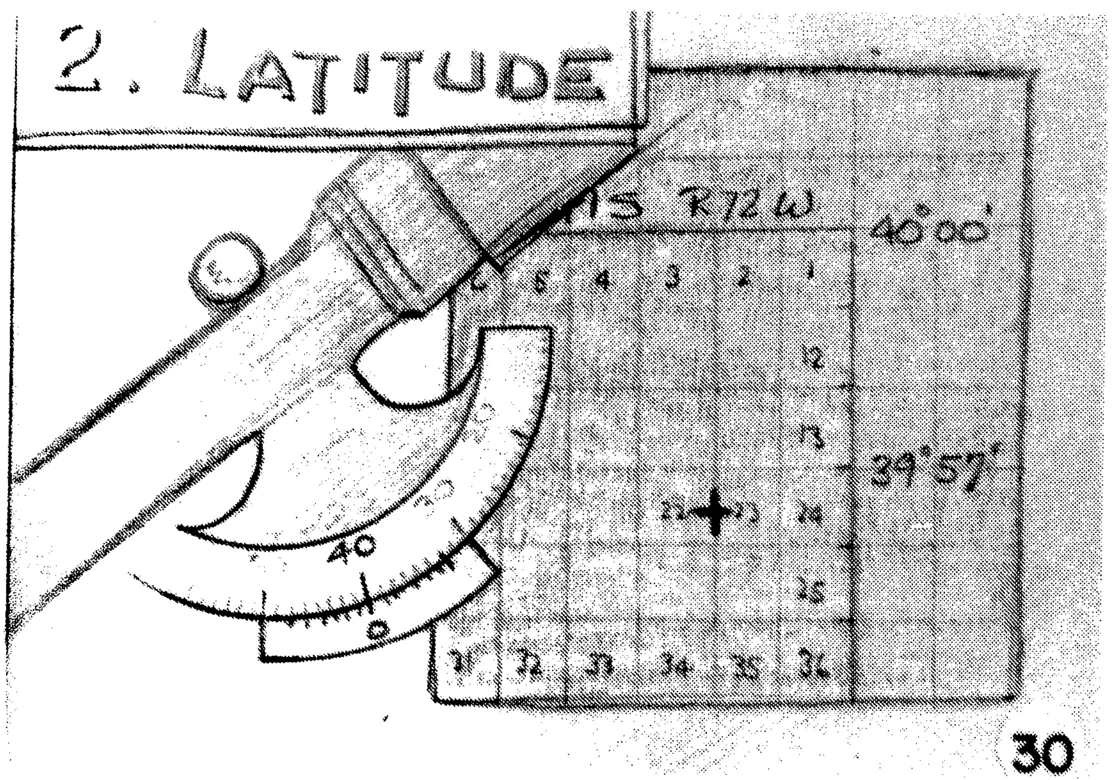
38

44

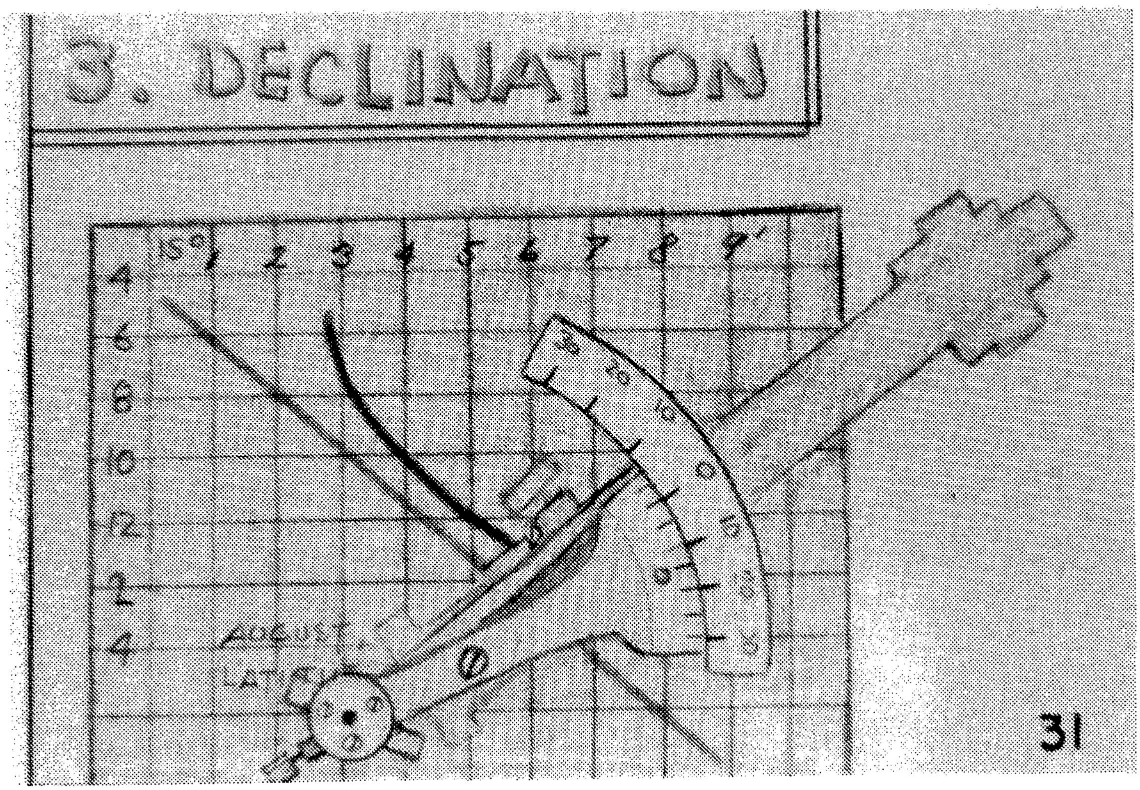

EQUATORIAL WIRE
TIME WIRE
NOT
ORIENTED
ORIENTED



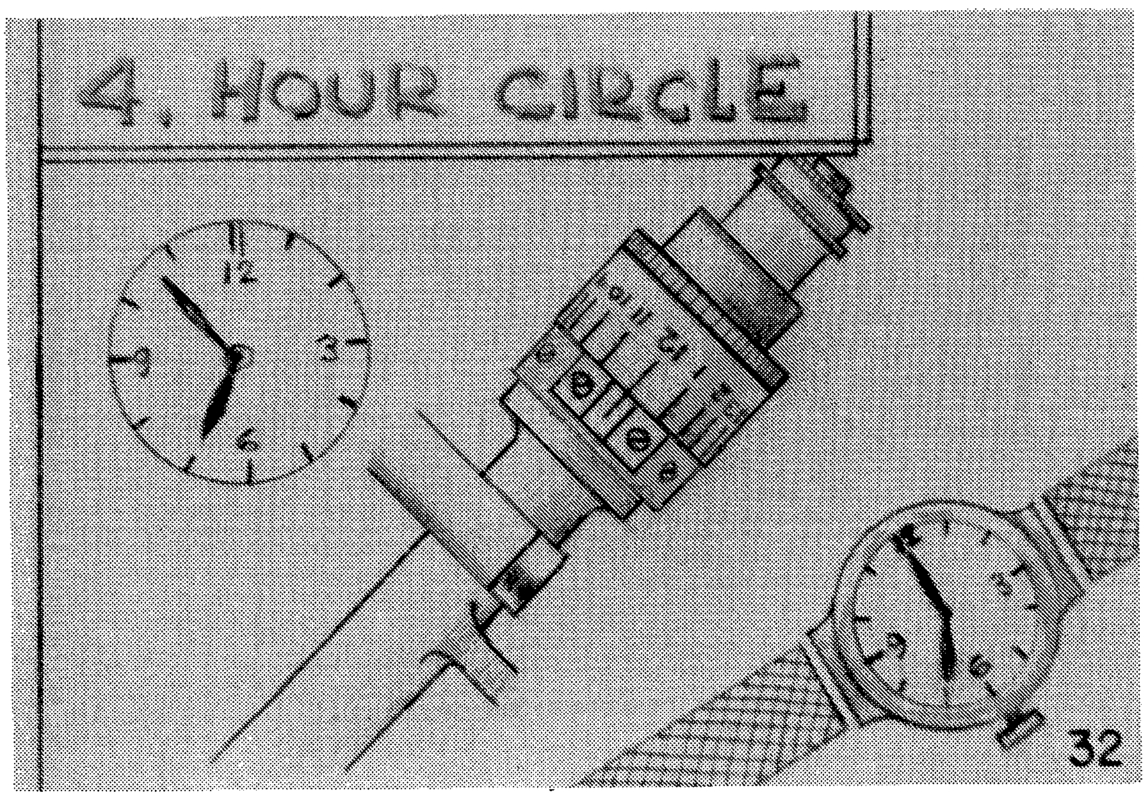
No. 1 Level the Instrument



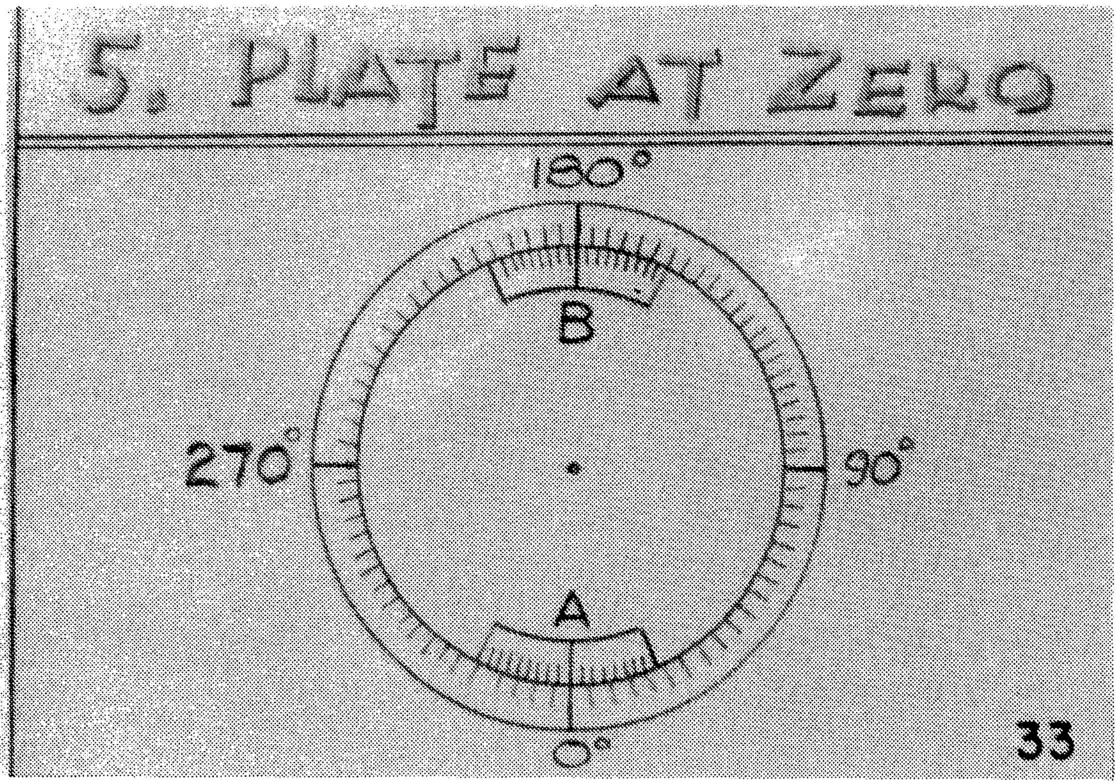
No. 2. Set the Latitude



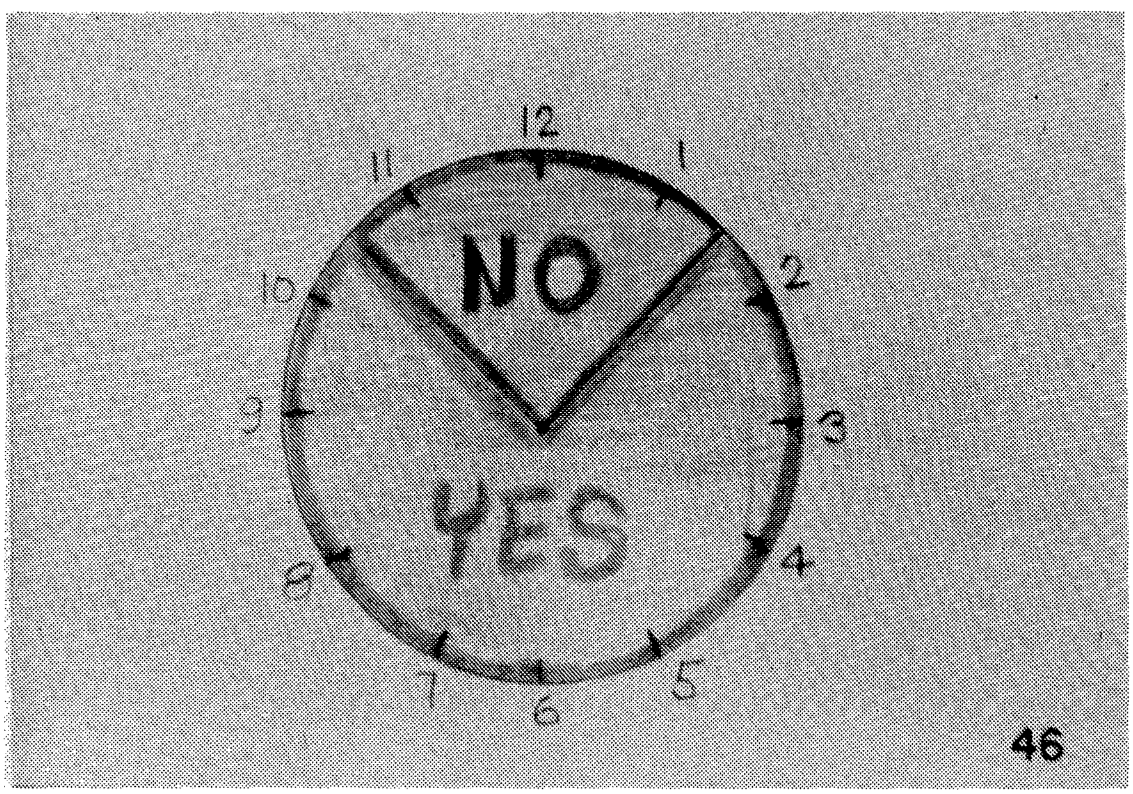
No. 3. Set the Declination



No. 4 Set the Hour Angle



No. 5 Zero the main plate



Running Line

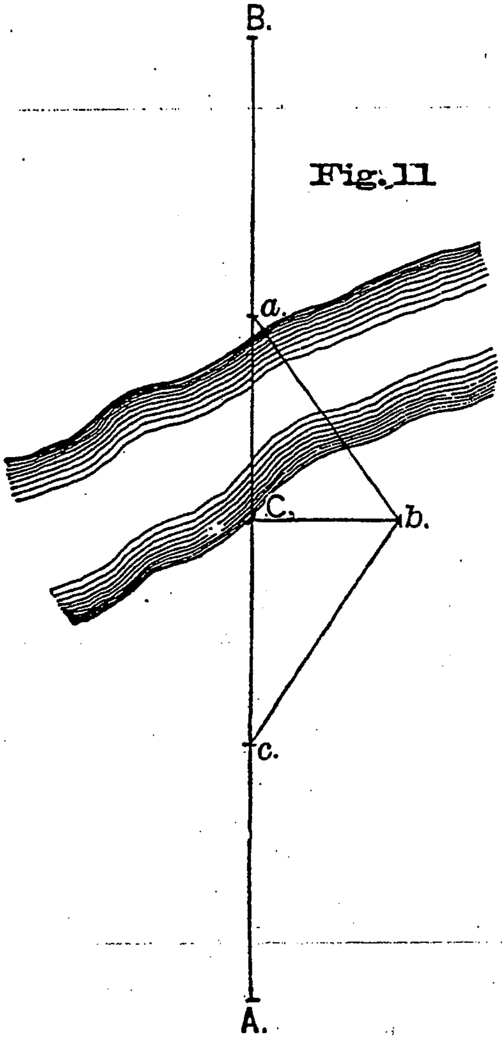


Fig. 11

TO FIND THE DISTANCE ACROSS A STREAM.

1*st.* *Without any calculation.*

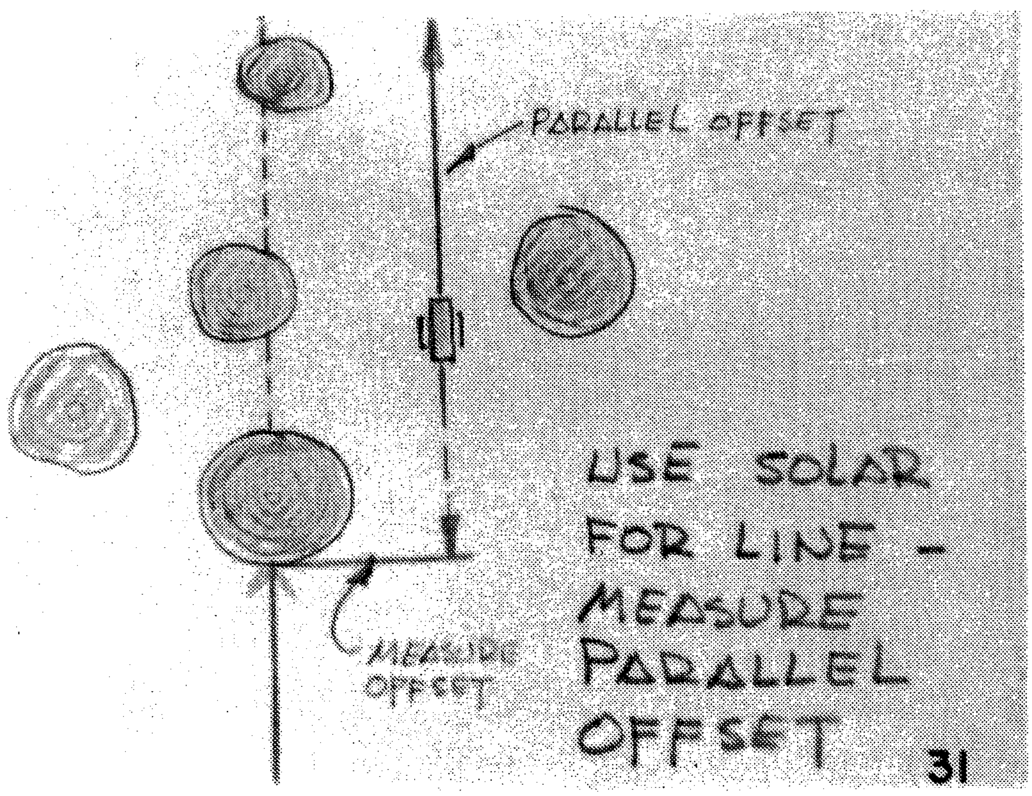
In running the line A B you reach a stream at C.

Set a flag on opposite bank at *a*. Then make an offset from C to *b* of any convenient distance —*e.g.*, four or six rods. Take the angle *a b* C. Then turn your compass till *c b* C equals *a b c*. Send a flag back on the line A B to *c*. Measure the distance *c* C, which will equal C *a*.

REMARK.—The above rule is convenient when the bank at C is cleared land and level; but if the land is bluffy or bushy the following is a better way:

Rule 2—Subtract *a b* C from 90°, which will leave *b a* C.

Then nat sine of *b a* C: nat sine of *a b* C:: *b* C: *a* C.



Example.

$b\,a\,C = 14° 40'$; $90° - (14° 40') = 75° 20'$; $C\,b = 150$ links; nat sine 14° 40′ is 253195; nat sine 75° 20′ is .967415.

.253195 : .967415 :: 150 : 573

Check by traverse-table, thus:

	Lat.	Dep.
14½°	5.81	1.50
14¾°	5.80	1.53

making by traverse-table for 14° 40′

Lat.	Dep.
5.806	1.52.

Then

Dep.	My Dep.	Lat.	My Lat.
1.52 :	1.50 ::	5.806 :	5.73

NOTE.—*If, on account of local attraction, the bearing from b to C differs from the bearing from C to b, move your vernier till they agree before taking the angle a b C.*

Third Method.

From C set a flag at D and measure an offset to *a*.

From some point in C *a* measure the offset *b c*.

Then

a b : *a* C :: *b c* : C D.

To get the point *c* let an assistant at *a* put your flagman in the line *a* D, while you put him in the line *b c* with your compass.

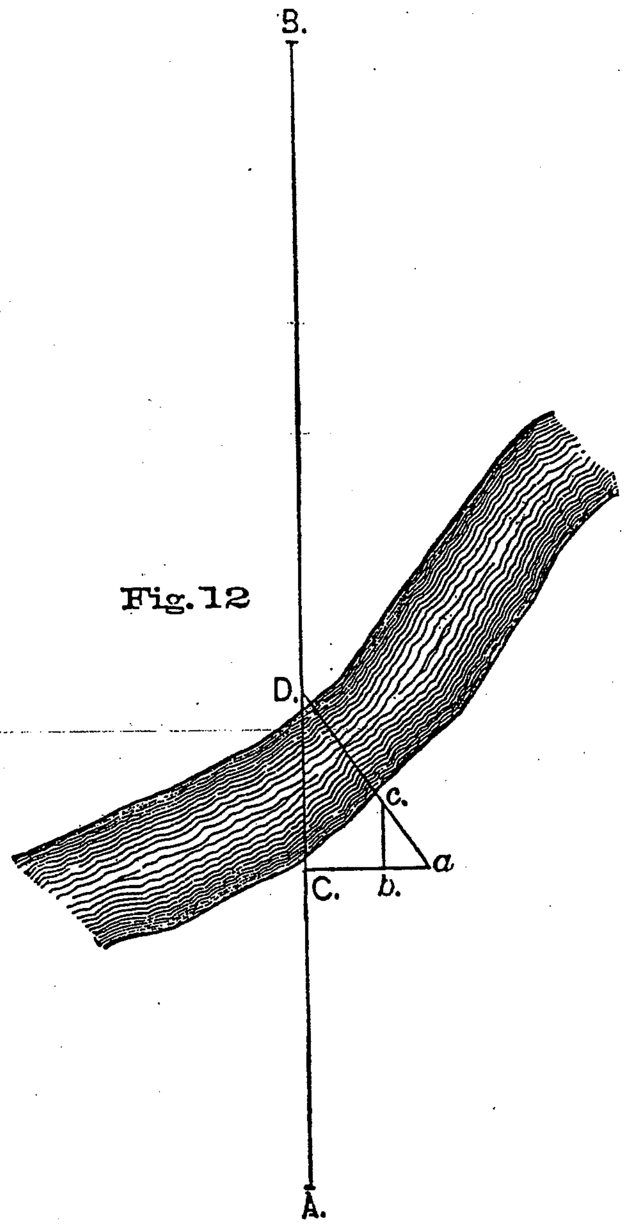


Fig. 12

7-3

Example.

Let $a\,b$=30 links ; $b\,c$=70 links ; a C=150 links.
Then 30 : 150 :: 70 : 350.

Fourth Method.

From C set a flag at *c*.

Then offset from C to *a*.

Run *a b* parallel with C *c*.

The distance from *a* to *b* will equal the distance from C to *c*.

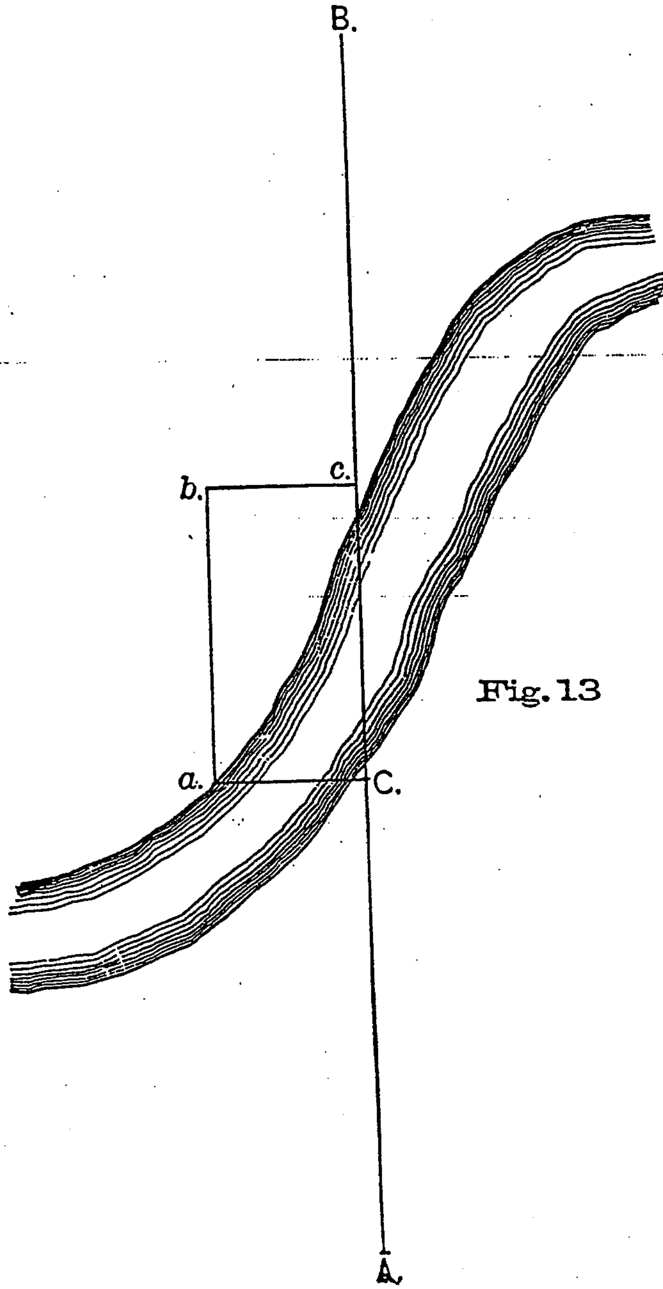


Fig. 13

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Appendix A

2005 Sun and Polaris Ephemerii

for Land Surveyors *(c) 2000-2005 jerry l. wahl*

These pages/files contain Sun and Polaris Ephemerii for the year 2005 suitable for use by land surveyors. These versions were generated by Jerry Wahl and verified by spot checks with the Astronomic Almanac and other sources. No warrantee is expressed or implied as to their accuracy or suitability for any specific purpose. These documents are offered as freeware.

You are free to use and copy these documents for any personal or business use but not to charge or redistribute for any fee or use them in a commercial product.

Web format: Showing data by the month.

FTP Windows help file format.

If you find any errors, please contact the author at jwahl@qubicle.com

2004 and earlier Ephemeris pages

Explanation of *(some)* Column Data Abbreviations

Date

Month abbreviated
Day of the Month Number
Day of the Week Name abbreviated

Sun

All values are for 0h GMT aka UT1.

Declination: in degrees minutes and seconds Note: negative values are south declination.

GHA: Greenwich Hour Angle in degrees minutes and seconds.

Eq o Time: EOT: Equation of Time in minutes and seconds.

Semi-DI: SD: Semi Diameter of the Sun in minutes and seconds.

Polaris

All values are for 0h GMT aka UT1.

Declination: in degrees minutes and seconds. Some users may use polar distance which is the angular complement of declination p - 90degrees minus declination.

GHA: Greenwich Hour Angle in degrees minutes and seconds.

Upper: TUC: Time of upper culmination or upper meridian passage. This is redundant in the sense that it is derived from and used in the same way as the GHA already tabulated. It is provided for the benefit of a few users who are

March 2006 Sun and Polaris Ephemeris

January | February | **March** | April | May | June | July | August | September | October | November | December

2006	S U N ------	For 0 hrs Universal Time	------>|		<---- Polaris	------- 0 hrs	UT ----
Date	Declination	--- GHA ---	Eq o Time	Semi-Di	Declination ---	GHA ---	-- TUC ---
	d m s	d m s	m s	m s	d m s	d m s	d m s
Mar 1 WE	- 7 43 21.5	176 53 06.2	-12 27.58	16 08.5	89 17 49.5	119 17 33.6	16 00 12.0
Mar 2 TH	- 7 20 32.0	176 56 00.2	-12 15.99	16 08.3	89 17 49.3	120 17 07.1	15 56 14.4
Mar 3 FR	- 6 57 36.2	176 59 01.7	-12 03.88	16 08.1	89 17 49.1	121 16 37.7	15 52 17.0
Mar 4 SA	- 6 34 34.6	177 02 10.6	-11 51.29	16 07.8	89 17 48.9	122 16 05.8	15 48 19.8
Mar 5 SU	- 6 11 27.5	177 05 26.7	-11 38.22	16 07.6	89 17 48.7	123 15 32.1	15 44 22.7
Mar 6 MO	- 5 48 15.5	177 08 49.5	-11 24.70	16 07.4	89 17 48.5	124 14 57.5	15 40 25.7
Mar 7 TU	- 5 24 58.8	177 12 18.9	-11 10.74	16 07.1	89 17 48.4	125 14 23.0	15 36 28.6
Mar 8 WE	- 5 01 37.9	177 15 54.6	-10 56.36	16 06.9	89 17 48.2	126 13 49.4	15 32 31.5
Mar 9 TH	- 4 38 13.2	177 19 36.2	-10 41.58	16 06.6	89 17 48.0	127 13 16.9	15 28 34.3
Mar 10 FR	- 4 14 45.1	177 23 23.5	-10 26.43	16 06.4	89 17 47.9	128 12 45.7	15 24 37.1
Mar 11 SA	- 3 51 13.8	177 27 16.1	-10 10.93	16 06.1	89 17 47.7	129 12 15.6	15 20 39.7
Mar 12 SU	- 3 27 39.9	177 31 13.6	-09 55.09	16 05.9	89 17 47.6	130 11 46.4	15 16 42.3
Mar 13 MO	- 3 04 03.6	177 35 15.8	-09 38.94	16 05.6	89 17 47.4	131 11 17.6	15 12 44.9
Mar 14 TU	- 2 40 25.4	177 39 22.3	-09 22.51	16 05.3	89 17 47.1	132 10 48.5	15 08 47.5
Mar 15 WE	- 2 16 45.4	177 43 32.8	-09 05.82	16 05.1	89 17 46.9	133 10 18.6	15 04 50.1
Mar 16 TH	- 1 53 04.2	177 47 46.8	-08 48.88	16 04.8	89 17 46.7	134 09 47.4	15 00 52.8
Mar 17 FR	- 1 29 22.0	177 52 04.1	-08 31.72	16 04.6	89 17 46.4	135 09 14.4	14 56 55.7
Mar 18 SA	- 1 05 39.1	177 56 24.3	-08 14.38	16 04.3	89 17 46.1	136 08 39.5	14 52 58.7
Mar 19 SU	- 0 41 56.0	178 00 47.1	-07 56.86	16 04.0	89 17 45.8	137 08 02.6	14 49 01.8
Mar 20 MO	- 0 18 12.9	178 05 12.1	-07 39.19	16 03.7	89 17 45.6	138 07 24.2	14 45 05.0
Mar 21 TU	+ 0 05 29.8	178 09 39.0	-07 21.40	16 03.5	89 17 45.3	139 06 44.7	14 41 08.3
Mar 22 WE	+ 0 29 11.7	178 14 07.4	-07 03.51	16 03.2	89 17 45.1	140 06 04.9	14 37 11.6
Mar 23 TH	+ 0 52 52.6	178 18 37.0	-06 45.54	16 02.9	89 17 44.9	141 05 25.6	14 33 14.8
Mar 24 FR	+ 1 16 32.1	178 23 07.4	-06 27.50	16 02.6	89 17 44.7	142 04 47.6	14 29 18.0
Mar 25 SA	+ 1 40 09.7	178 27 38.5	-06 09.43	16 02.3	89 17 44.5	143 04 11.4	14 25 21.1
Mar 26 SU	+ 2 03 45.1	178 32 09.9	-05 51.34	16 02.1	89 17 44.3	144 03 36.8	14 21 24.0
Mar 27 MO	+ 2 27 18.0	178 36 41.4	-05 33.24	16 01.8	89 17 44.1	145 03 03.2	14 17 26.9
Mar 28 TU	+ 2 50 47.8	178 41 12.6	-05 15.16	16 01.5	89 17 43.8	146 02 29.4	14 13 29.8
Mar 29 WE	+ 3 14 14.4	178 45 43.3	-04 57.11	16 01.2	89 17 43.5	147 01 53.7	14 09 32.9
Mar 30 TH	+ 3 37 37.2	178 50 13.4	-04 39.11	16 01.0	89 17 43.2	148 01 15.4	14 05 36.1
Mar 31 FR	+ 4 00 55.8	178 54 42.5	-04 21.16	16 00.7	89 17 42.8	149 00 34.0	14 01 39.5

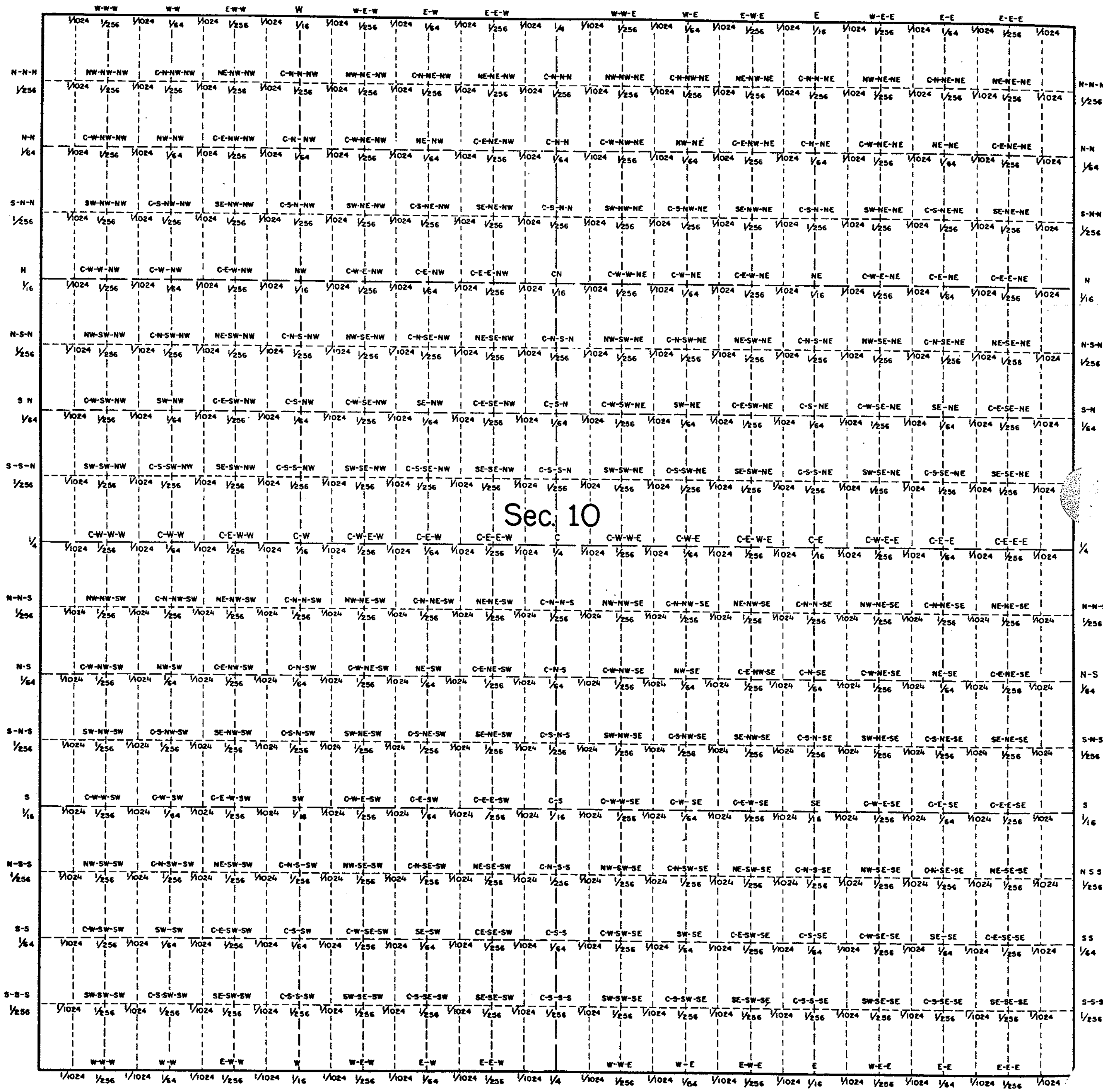
Solar Noon Calendar for Doaks Road - Salem at 44:55:58N : 123:06:36W

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
1	12:15:38	12:25:59	12:25:00	12:16:34	12:09:35	12:10:01	12:15:59	12:18:42	12:12:38	12:02:21	11:56:06
2	12:16:06	12:26:07	12:24:49	12:16:16	12:09:27	12:10:10	12:16:11	12:18:39	12:12:19	12:02:02	11:56:04
3	12:16:34	12:26:14	12:24:37	12:15:58	12:09:20	12:10:20	12:16:23	12:18:35	12:12:00	12:01:43	11:56:03
4	12:17:02	12:26:21	12:24:24	12:15:40	12:09:14	12:10:30	12:16:34	12:18:30	12:11:41	12:01:24	11:56:03
5	12:17:29	12:26:27	12:24:11	12:15:23	12:09:08	12:10:40	12:16:45	12:18:25	12:11:21	12:01:06	11:56:04
6	12:17:56	12:26:32	12:23:45	12:15:06	12:09:03	12:10:50	12:16:55	12:18:19	12:11:01	12:00:48	11:56:06
7	12:18:23	12:26:36	12:23:43	12:14:49	12:08:59	12:11:01	12:17:05	12:18:12	12:10:41	12:00:30	11:56:08
8	12:18:49	12:26:40	12:23:29	12:14:32	12:08:55	12:11:12	12:17:15	12:18:05	12:10:21	12:00:13	11:56:11
9	12:19:15	12:26:42	12:23:14	12:14:15	12:08:51	12:11:23	12:17:24	12:17:57	12:10:00	11:59:56	11:56:15
10	12:19:40	12:26:44	12:22:59	12:13:58	12:08:48	12:11:35	12:17:33	12:17:49	12:09:39	11:59:40	11:56:20
11	12:20:04	12:26:45	12:22:44	12:13:42	12:08:46	12:11:47	12:17:42	12:17:40	12:09:18	11:59:24	11:56:26
12	12:20:28	12:26:46	12:22:28	12:13:26	12:08:44	12:11:59	12:17:50	12:17:31	12:08:57	11:59:08	11:56:33
13	12:20:51	12:26:45	12:22:12	12:13:10	12:08:42	12:12:11	12:17:58	12:17:21	12:08:36	11:58:53	11:56:40
14	12:21:14	12:26:44	12:21:56	12:12:55	12:08:42	12:12:23	12:18:05	12:17:10	12:08:15	11:58:39	11:56:49
15	12:21:36	12:26:42	12:21:39	12:12:40	12:08:42	12:12:36	12:18:12	12:16:59	12:07:54	11:58:25	11:56:58
16	12:21:58	12:26:39	12:21:22	12:12:25	12:08:42	12:12:49	12:18:18	12:16:47	12:07:33	11:58:12	11:57:08
17	12:22:18	12:26:36	12:21:05	12:12:11	12:08:43	12:13:02	12:18:24	12:16:35	12:07:12	11:57:59	11:57:19
18	12:22:38	12:26:32	12:20:48	12:11:57	12:08:45	12:13:15	12:18:29	12:16:23	12:06:51	11:57:47	11:57:30
19	12:22:58	12:26:27	12:20:30	12:11:43	12:08:47	12:13:28	12:18:34	12:16:10	12:06:30	11:57:35	11:57:43
20	12:23:16	12:26:21	12:20:12	12:11:30	12:08:49	12:13:41	12:18:38	12:15:56	12:06:08	11:57:24	11:57:56
21	12:23:34	12:26:15	12:19:54	12:11:26	12:08:52	12:13:54	12:18:41	12:15:42	12:05:46	11:57:14	11:58:10
22	12:23:51	12:26:08	12:19:36	12:11:05	12:08:56	12:14:07	12:18:44	12:15:27	12:05:25	11:57:04	11:58:25
23	12:24:07	12:26:01	12:19:18	12:10:53	12:09:02	12:14:20	12:18:46	12:15:12	12:05:04	11:56:55	11:58:41
24	12:24:23	12:25:53	12:19:00	12:10:41	12:09:05	12:14:33	12:18:48	12:14:56	12:04:43	11:56:46	11:58:58
25	12:24:38	12:25:44	12:18:42	12:10:30	12:09:10	12:14:46	12:18:50	12:14:40	12:04:22	11:56:39	11:59:15
26	12:24:52	12:25:35	12:18:24	12:10:20	12:09:16	12:14:59	12:18:51	12:14:24	12:04:01	11:56:32	11:59:33
27	12:25:05	12:25:25	12:18:06	12:10:10	12:09:23	12:15:11	12:18:51	12:14:07	12:03:40	11:56:25	11:59:52
28	12:25:17	12:25:14	12:17:47	12:10:00	12:09:30	12:15:23	12:18:50	12:13:50	12:03:20	11:56:20	12:00:12
29	12:25:29	12:25:08	12:17:28	12:09:51	12:09:37	12:15:35	12:18:49	12:13:33	12:03:00	11:56:15	12:00:32
30	12:25:40		12:17:10	12:09:43	12:09:45	12:15:47	12:18:47	12:13:15	12:02:40	11:56:11	12:00:53
31	12:25:50		12:16:52		12:09:53		12:18:45	12:12:57		11:56:08	

NOTES:
The times in the table are based on averages and may be in error by 10-15 seconds in January and December.
If your area has daylight saving time in the summer, we recommend that you highlight or draw a box round the relevant time, and write "Add one hour for daylight saving time" at the foot of the relevant months.

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

IDENTIFICATION OF CORNERS ON SUBDIVISION OF SECTION LINES



If 1/1024 corners are established they will be marked 1/1024 only

See figs. 65 & 66 MANUAL OF SURVEYING INSTRUCTIONS, 1973, for marks on the monuments