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UNDERSTANDING AND CONSTRUCTING SUNDIALS WITH A HYPOTHETICAL CYLINDRICAL SKY VAULT OF SUNPATHS

Abstract

Sundials were used for thousands of years and some are still used nowadays. Yet there is a need for an explicit full field graphical illustration of how sunlight direction at all possible combinations of day, time, and latitude are related to the gnomon and its shadow cast on the marking surface of the sundial. Starting with conceiving the sunpath traversing an imaginary cylindrical sky vault, this paper attempts to offer this explicit graphical illustration as presented on a horizontal sundial for Hong Kong.

Nomenclature

AST	Apparent Solar Time, or true solar time.
d	the declination angle of the sun with respect to the centre of the earth, d=+23.44 deg at Summer Solstice and d=-23.44 deg at Winter Solstice. Different declination angles correspond to the different days of the year [Table 1].
GMT	Greenwich Mean Time
L	geographical latitude of a place at Northern hemisphere
t	hour angle, t=0 deg for solar noon (i.e. AST, apparent solar time = l2:00 noon). For one hour, the hour angle elapsed is l5 deg., t is positive for AST p.m. and negative for AST a.m.
UT	Universal Time

Introduction

There are numerous ways of presenting the relationship of apparent solar time, day of year, solar azimuth angle, solar altitude angle for a defined latitude, as observed from a fixed point contained within a horizontal plane at that latitude.

The commonly used methods of presentation are based on the annual sun path appearing on an imaginary hemispherical sky-vault [Olgyay 1957a, Rohr 1965, Waugh 1973a, Fig 1]. In reality, the sun never traverses part of a perfect sphere relative to the earth. With the hemispherical sun-path sky-vault presentation, it is extremely inconvenient, if not impossible, to make the full field illustration, because projections involving spherical vault surface involve a very large number of curves for full field projection.

This perhaps has hindered authors so far from producing the explicit full field illustrations. Although there were many possible graphical approaches mentioned in a recent publication **(Waugh 1973b)**, it quoted a graphical method published in Paris in 1790 by Dom Francois Bedos de Celles for laying out a horizontal sundial. In this method, only the AST hour lines for the selected latitude were shown. The day curves were not shown. This method, and the other graphical approaches did not give full field illustrations.

In an attempt to make the full field graphical illustration for sundials, it is considered that projections involving an imaginary cylindrical sky vault for the sunpath would result in the least possible number of projected lines and curves, thus providing explicit and clear illustrations.

In this imaginary cylindrical sky vault approach **(Cheung 1997)**, the sun path is conceived as part of an imaginary cylindrical surface, with the line of AST noon and the cylinder axis lying in the meridian plane which contains the observer, or the sundial. Also the axis of the imaginary cylindrical surface is inclined at an angle equal to the latitude of the location of the observer, or the sundial, [Fig 2] to a horizontal plane containing the observer, or the sundial. With this approach, it will be demonstrated that clear and explicit graphical relationships linking the various sundial parameters, the sundial gnomon, and the sundial surface can be shown in a full field manner.

The basic assumption

The sun travels with respect to an observer 0 (or the tip of the gnomon of a horizontal sundial) on the surface of the earth (i.e. topocentric observation) from d=+23.44 deg to -23.44 deg from Summer Solstice to Winter Solstice and vice versa, year by year [Olgyay 1957b, Fig 2]. Because the distance between the sun and the earth is more than 2000 times the radius of the earth, for general purposes including sundial design, it is assumed that there is practically no difference between topocentric observation and geocentric observation (i.e. observing the sun fictionally at the centre of the earth) in relating the variables of concern of the sundials. Thus the observer point 0, and hence the shadow of the gnomon falling on the sundial surface, are interchangeable freely between a location on the surface of the earth, and fictionally the centre of the earth, provided that the parallelity of the sundial components are kept at both locations. That is, if a sundial were placed fictionally at the centre of the earth in this way, it would have the same reading as placed on the earth surface. This is most prominently illustrated in universal sundials.

The contracted imaginary cylindrical sky vault

Daily the sun can be considered to move about the cylinder axis passing through 0 [Fig 2] on a circular path at a speed of l hour AST equal to l5 deg from East to West, relative to the stationary observer 0, or any point along the gnomon of the sundial provided that the gnomon is parallel to the axis of the earth. In one year, the sun could appear to traverse an imaginary cylindrical surface MQNQM, having an axis passing through 0, this axis being parallel to the earth axis.

Each line on the imaginary cylindrical surface represents a particular moment of AST. All AST lines are inclined at an angle L to the reference horizontal plane passing through 0 which is at latitude L. Different days of the year on the same AST line [Fig 2] correspond to the various solar declination angles [Table 1] with respect to the stationary observer 0, or the location of the sundial.

In actual fact, the sun never traverses a cylindrical path in the sky as described, nor does it ever truely traverse a path occupying part of a sphere in the sky. The transposition of the position of the sun relative to the earth onto either part of an imaginary spherical surface or an imaginary cylindrical surface are both acceptable for **relating the directional relationship** of the solar altitude angle and solar azimuth angle with the different times of the day, the different days of the year (i.e. the solar declination angle) and the latitude(s) in which the sundial is designed for.

In the conventional spherical sky-vault transposition the sun appears to traverse an arc for a particular apparent solar time [Fig 1], moving from one day to the next. However in this proposed cylindrical transposition, the sun appears to traverse a straight line such as line MQN [Fig 2], under the same conditions and assumptions of topocentric and geocentric observations.

The directional relationship of sunlight with the gnomon of the sundial is identical whether the sun is interpreted to traverse a hemispherical sky vault, or a cylindrical sky vault, because the same practically parallel sunlight exists for both interpretations. Based on the latter interpretation, a proposed method of constructing a horizontal sundial is discussed [Fig 3]. In this method, the sky vault containing the sunpath is imaginarily contracted into a small cylinder occupying a small area in a piece of paper.

The essential components of a sundial

The essential components of a sundial is the gnomon and the sundial surface. Sunlight shines on the gnomon, casting a shadow or a bright spot on the sundial surface for reading the day/time. There are a variety of gnomon and sundial surface. For a horizontal sundial illustrated [Fig. 3], the sundial surface is a horizontal surface containing the AST hour lines and day curves, and the gnomon is a vertical pointer stemming from the dial surface. The virtual line joining the tip of the pointer to the converging point of the AST hour lines makes an angle with the AST noon line, this angle being qual to the angle of the latitude at which the sundial is designed for.

A proposed method of constructing a horizontal sundial

Starting with the imaginary contracted cylindrical sky vault for the sun path, the construction [Fig 3] of the horizontal sundial is self-explanatory to a person having a background of basic technical drawing.

The construction [Fig 3] starts with the direction of sunlight defined for the day/time combinations. It also enables the days for any shadow point on the dial surface such as the point E to be obtained (i.e. March 14 and September 30, with d = -2.73 deg = angle QOb and line ab is parallel to line OQ, point a cutting 17:00 line) by direct reverse projection if its time (i.e. 17:00) is known. Furthermore, it enables the day(s) and the time for any shadow point on the dial surface such as the point S' to be obtained (i.e. 15:30 and Feb 18 / Oct 24) by reverse projection if both the day(s) and time of the shadow point are not known initially.

These are elaborated in the following steps of constructing and understanding a horizontal sundial [Fig 3] : [Click here for downloading Fig 3]

1. Set line RG'F'V, such that Point H coincides with Point O, line HG' is at 90 deg to line RG'F'V, line HF' coincides with the axis of the cylinder, and length HG' = (tan L) x length G'F'.

2. Project the shadow of the tip of the gnomon (i.e. Point H, Point O) due to direct sunlight initiated from the day / time point of the cylindrical surface onto the horizontal dial surface via projection lines directly drawn on the vertically projected dial surface and indirectly via the side projected dial surface as viewed from B.
3. For a point such as Point E on the dial surface with the time line known (i.e. 17:00 AST), reverse projection via the path EH (i.e. Point 0) abOQ will enable the day to be determined (i.e. angle d = -2.73 deg representing March 14 and September 30, Table 1), with point a hitting the 7 & 17 line on the cylinder, line ab being drawn parallel to line OQ, and angle QOb = d = -2.73 deg.
4. Since each shadow point of the tip of the gnomon cast on the dial surface represents a specific d / time (note that one d value presents 2 days expect at the solstices) combination for direct sunlight, any such shadow point can be projected reversely to obtain the day(s) and the time, although both of them are not known initially.

Suppose Point S' is such a shadow point, path S'SH (i.e. Point O) a'b'OQ will give the related day to be Feb 18 and Oct 24 (i.e. d = -11.6 deg = angle b'OQ) and time = 15:30 AST, with Point a' and Point a" hitting the 15:30 line on the cylindrical surface, line a'b' being drawn parallel to line OQ (i.e. line HQ), and angle QOb' = d = -11.6 deg (i.e. Feb 18 and Oct 24, Table 1). Path S'S S" Oa"a' via the View B projection complements this reverse projection process. Note that Point a' and Point a" are in fact one point.

In understanding the construction one needs to note that if the gnomon is a thin style FH coinciding with the axis of the cylinder (i.e. the style HF is parallel to the axis of the earth), the shadow of the style for a particular time (AST) falling on a flat plane is a straight line, independent of the horizontal/vertical declination/inclination/reclination the plane is making.

Times around sun rise and sun set can likewise be projected. However, due to the slanting path of sun movement at latitudes other than the equator, atmospheric refraction of sun light, and the definition of the times of sun rise and sun set regarding siting of the solar disc, there exists a difference of several minutes between the graphically estimated and actual times of sun rise and sun set. **(Strahler 1975, Nautical 1990)** It is advisable to consult the local meteorological stations for exact sun rise and sun set periods.

Conclusion

It has demonstrated that an alternative way of constructing and understanding a horizontal sundial gives convenience and clarity over traditional methods, in that the direction of sunlight at different day and time combinations are clearly shown for projecting the shadow of the gnomon as cast by sunlight on the dial surface, and vice versa. [Click here for downloading a horizontal sundial surface for making your own horizontal sundial for Hong Kong].

The illustration is for a horizontal sundial in Northern Hemisphere. However the principles for constructing one in Southern Hemisphere remain the same.

This proposed method can also be applied to other types of sundials which are subjects of separate presentation.

The illustration has used a concept of the contracted imaginary cylindrical sky vault. In fact the traditional way of presenting the solar path as part of a sphere can be retained, but only sunlight direction is conceived as emanating from an contracted imaginary cylindrical surface as described earlier.

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TABLE 1 - Mean value of the solar declination (for l99l, noon UT (GMT), adapted from The Nautical Almanac l99l, HMSO, UK, p.10-253)

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
1	-23 01	-17 10	-07 40	+04 27	+15 01	+22 02	+23 08	+18 04	+08 22	-03 06	-14 22	-21 46
2	-22 56	-16 53	-07 17	+04 50	+15 19	+22 10	+23 03	+17 49	+08 00	-03 29	-14 41	-21 55
3	-22 51	-16 35	-06 54	+05 14	+15 37	+22 17	+22 59	+17 34	+07 38	-03 53	-15 00	-22 04
4	-22 45	-16 17	-06 31	+05 36	+15 54	+22 24	+22 54	+17 18	+07 16	-04 16	-15 18	-22 13
5	-22 38	-15 59	-06 08	+05 59	+16 11	+22 31	+22 49	+17 02	+06 54	-04 39	-15 37	-22 20
6	-22 31	-15 41	-05 45	+06 22	+16 28	+22 38	+22 43	+16 46	+06 32	-05 02	-15 55	-22 28
7	-22 24	-15 23	-05 22	+06 45	+16 45	+22 44	+22 37	+16 29	+06 09	-05 25	-16 13	-22 35
8	-22 16	-15 04	-04 59	+07 07	+17 02	+22 50	+22 30	+16 12	+05 47	-05 48	-16 30	-22 42
9	-22 08	-14 45	-04 35	+07 30	+17 18	+22 55	+22 23	+15 55	+05 24	-06 11	-16 48	-22 48
10	-21 59	-14 25	-04 12	+07 52	+17 34	+23 00	+22 16	+15 38	+05 01	-06 34	-17 05	-22 54
11	-21 50	-14 06	-03 48	+08 14	+17 49	+23 04	+22 08	+15 20	+04 39	-06 56	-17 22	-22 59
12	-21 41	-13 46	-03 25	+08 36	+18 05	+23 08	+22 00	+15 02	+04 16	-07 19	-17 38	-23 04
13	-21 31	-13 26	-03 01	+08 58	+18 20	+23 12	+21 52	+14 44	+03 53	-07 41	-17 54	-23 08
14	-21 21	-13 06	-02 37	+09 20	+18 35	+23 15	+21 43	+14 26	+03 30	-08 04	-18 10	-23 12
15	-21 10	-12 45	-02 14	+09 41	+18 49	+23 18	+21 34	+14 07	+03 07	-08 26	-18 26	-23 15
16	-20 59	-12 25	-01 50	+10 03	+19 03	+23 21	+21 24	+13 48	+02 44	-08 48	-18 41	-23 18
17	-20 47	-12 04	-01 26	+10 24	+19 17	+23 23	+21 14	+13 29	+02 21	-09 10	-18 56	-23 21
18	-20 35	-11 43	-01 02	+10 45	+19 30	+23 24	+21 04	+13 10	+01 57	-09 32	-19 10	-23 23
19	-20 23	-11 21	-00 39	+11 06	+19 43	+23 25	+20 53	+12 51	+01 34	-09 54	-19 25	-23 25
20	-20 10	-11 00	-00 15	+11 27	+19 56	+23 26	+20 42	+12 31	+01 11	-10 16	-19 38	-23 26
21	-19 57	-10 38	+00 09	+11 47	+20 08	+23 26.4	+20 31	+12 11	+00 47	-10 37	-19 52	-23 26.3
22	-19 44	-10 17	+00 33	+12 07	+20 21	+23 26	+20 19	+11 51	+00 24	-10 58	-20 05	-23 26.4
23	-19 30	-09 55	+00 56	+12 28	+20 32	+23 26	+20 07	+11 31	+00 01	-11 20	-20 18	-23 26.1
24	-19 16	-09 33	+01 20	+12 47	+20 44	+23 25	+19 55	+11 11	-00 23	-11 41	-20 30	-23 25
25	-19 01	-09 10	+01 44	+13 07	+20 55	+23 24	+19 42	+10 50	-00 46	-11 01	-20 42	-23 24
26	-18 46	-08 48	+02 07	+13 27	+21 05	+23 22	+19 29	+10 29	-01 09	-12 22	-20 54	-23 22
27	-18 31	-08 26	+02 31	+13 46	+21 16	+23 20	+19 16	+10 09	-01 33	-12 42	-21 05	-23 20
28	-18 15	-08 03	+02 54	+14 05	+21 26	+23 18	+19 02	+09 47	-01 56	-13 03	-21 16	-23 18
29	-17 59		+03 18	+14 24	+21 35	+23 15	+18 48	+09 26	-02 19	-13 23	-21 26	-23 15
30	-17 43		+03 41	+14 42	+21 44	+23 11	+18 34	+09 05	-02 43	-13 43	-21 36	-23 11
31	-17 27		+04 04		+21 53		+18 19	+08 43		-14 02		-23 07

Note: declination to north of the Equator is positive, to south is negative; thus for 11 Jan l99l, solar declination angle was 21 deg 50 min south of the Equator

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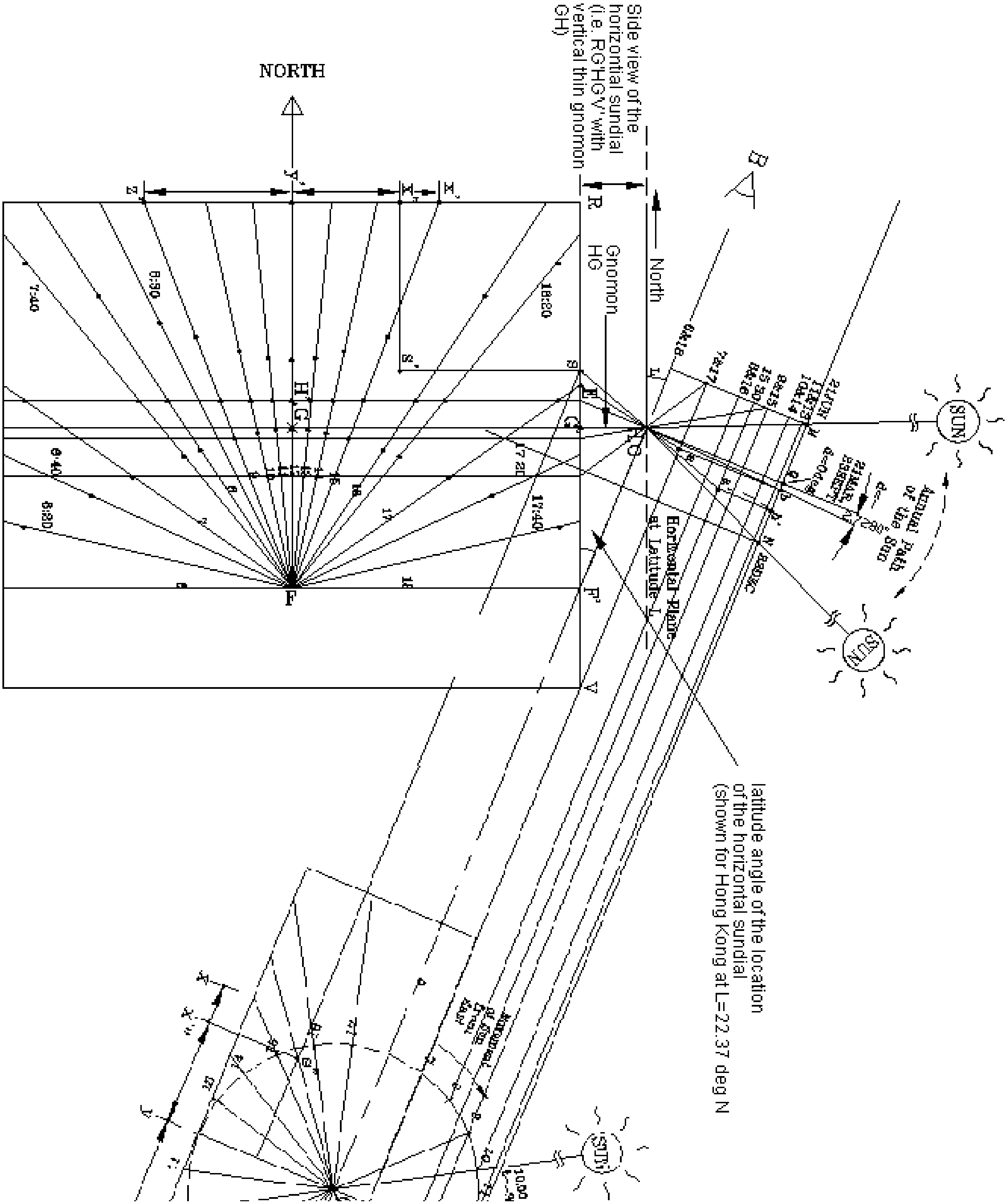
Fig.1 The Relationship of Solar Geometric Parameters Expressed with An Imaginary Spherical Sky Vault (For Northern Hemishpere)

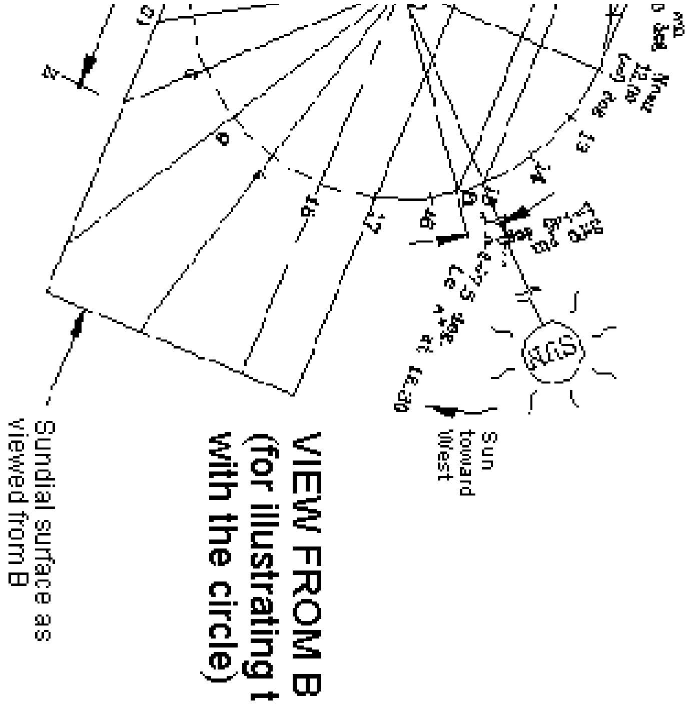
Fig.2 The Relationship of Solar Geometric Parameters in an Imaginary Cylindrical Sky Vault (For Northern Hemisphere)

Notes:

1. The diagrams are drawn with L = 22.37 deg N (the latitude of Hong Kong).
2. M, Q, N are the locations of the Sun respectively for Summer Solstice, Spring/Autumn Equinox, Winter Solstice.
3. O is a fixed reference point on earth surface and simultaneously the earth center (see text).

Fig.3 A proposed method of constructing a sundial (illustrated with a horizontal sundial for Hong Kong at 22.37 deg N)





Notes:

1. Apparent Solar Time is indicated.
2. A vertical thin Gnomon (style) is to be fixed at point G, with its tip at H' vertically above the marking surface, where H'G=FG x tan 22.37 deg. In the side view, Point H' is projected as Point H, and Point G as G'. Point H of gnomon coincides with Point O of the cylinder.
3. Northward bolded points forming a symmetrical curve about the N-S axis on the dial surface are for Dec 22, points forming a straight line are for Mar 21 & Sept 23, Southward points are for Jun21.
4. Length XY=Length X'Y' and Length YZ = Length Y'Z', Length Y'X'=Length YX"
5. Point E is 17 hours of Mar 14 & Sept 30 for Point S on the dial, with d= -2.73 deg. [Table 1].
6. Point S is 15:30 hour of Feb 18 & Oct 24, with d = -11.6 deg. [Table 1].

Sundials

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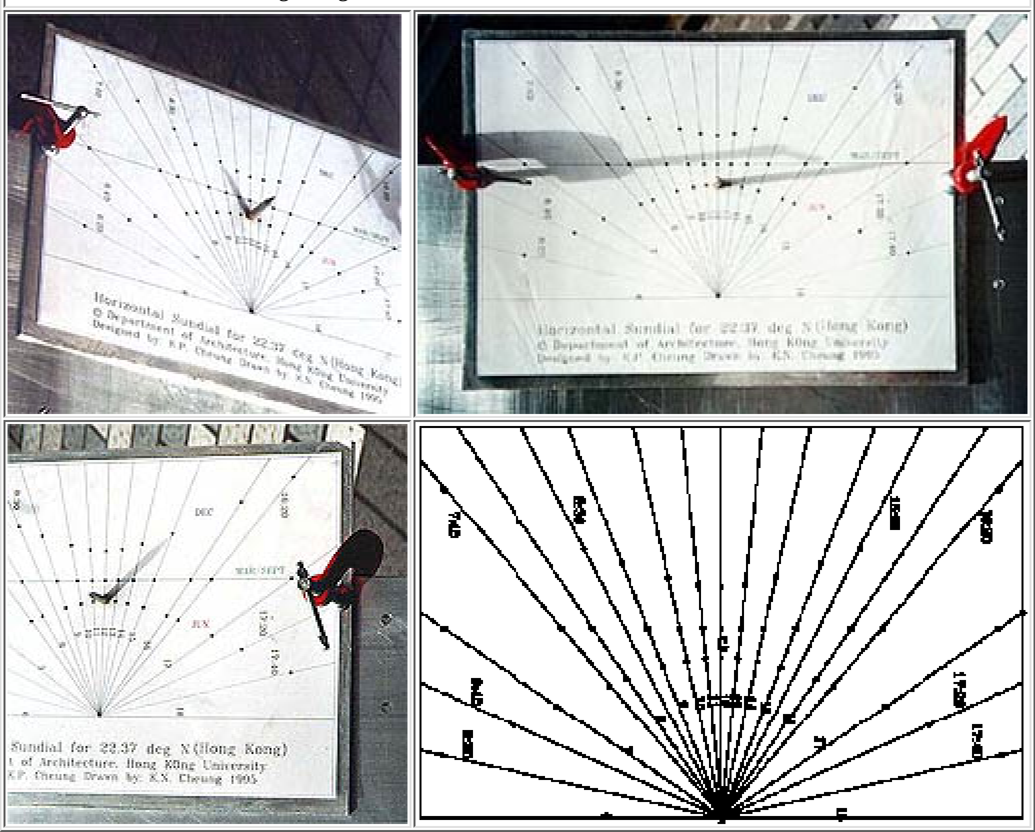
7. A paper on understanding how a sundial is constructed

Sundial surface marking is currently generated by computer techniques, and spherical trigonomerty has existed for thousands of years, used for sundial construction. Yet, if you are interested, you may like to have a glance at a paper called "understanding and constructing sundials with a hypothetical cylindrical sky vault of sunpaths" that I wrote in 1995. This manual graphic technique has been used to construct a horizontal sundial for Hong Kong shown below (photos P10A-P10D) in Summer 1995, with the sundial tested with the sundial tester. The last figure is for you to print it out to make a horizontal sundial for Hong Kong if you like.

Photos **P10A-P10D** - Horizontal sundial for Hong Kong. The last figure is for you to print it out to make a horizontal sundial for Hong Kong.



1 2 3 4 5 6 7 8 9 10 10.1 10.2 10.3 10.4 10.5 10.6 11 12

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8. A sundial tester

A heliodon which is assembled from precision machining tools - Sunlight-2 heliodon - can also be used to test a majority of sundials, (see earlier photos P9, P10A, P10B, P10C) using sunlight as the light source. Because this tester (i.e. the heliodon) inherits the dimensional precision nature of its components, its accuracy, or its error, is the assembled total accuracy or error of its components. Because thses components are the primary tools used to manufacture mechanical parts, no machined parts constituting to another physical sundial tester can be more accurate than this sundial tester assembled from the primary tools.

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1 2 3 4 5 6 7 8 9 10 10.1 10.2 10.3 10.4 10.5 10.6 11 12

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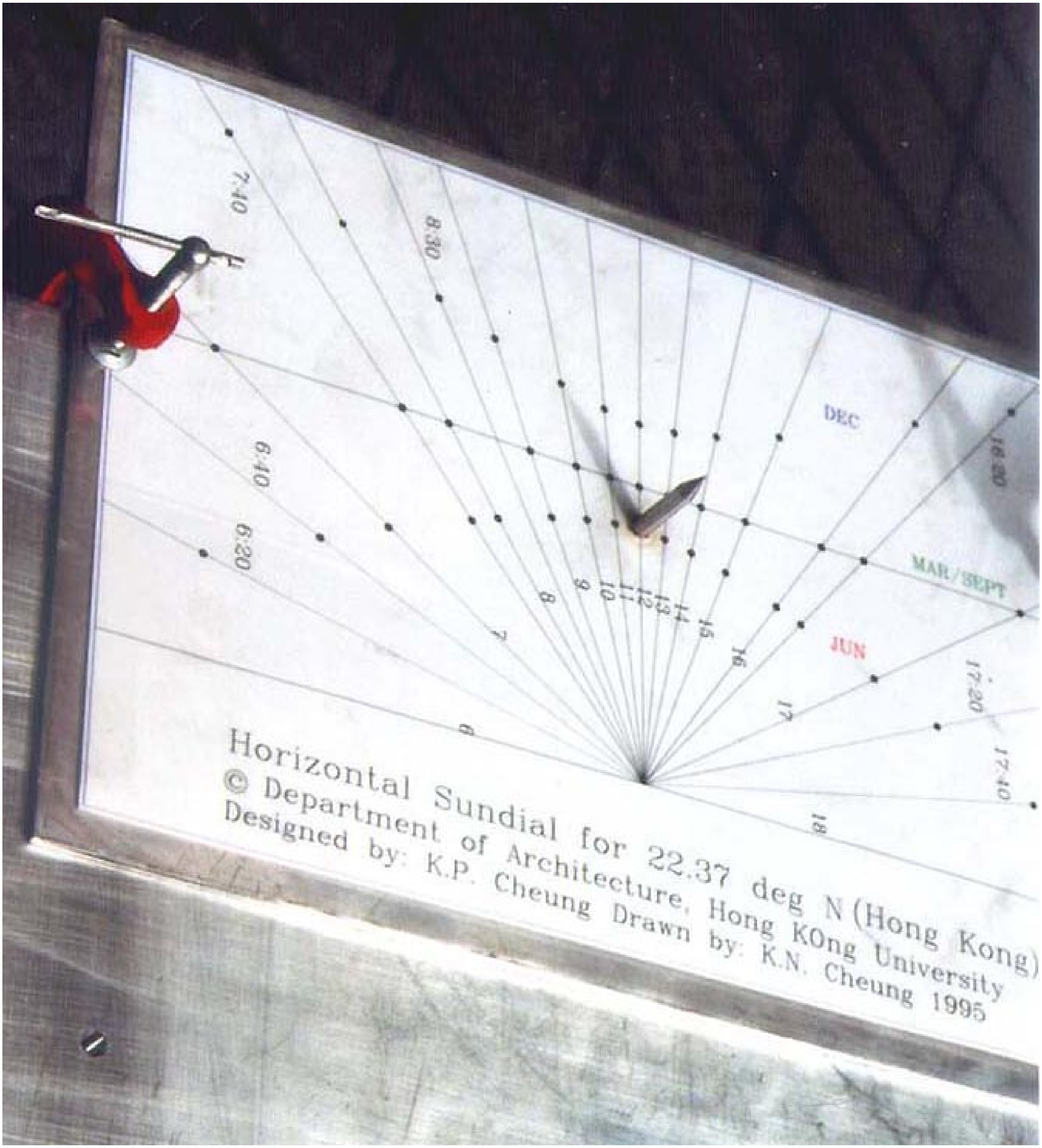
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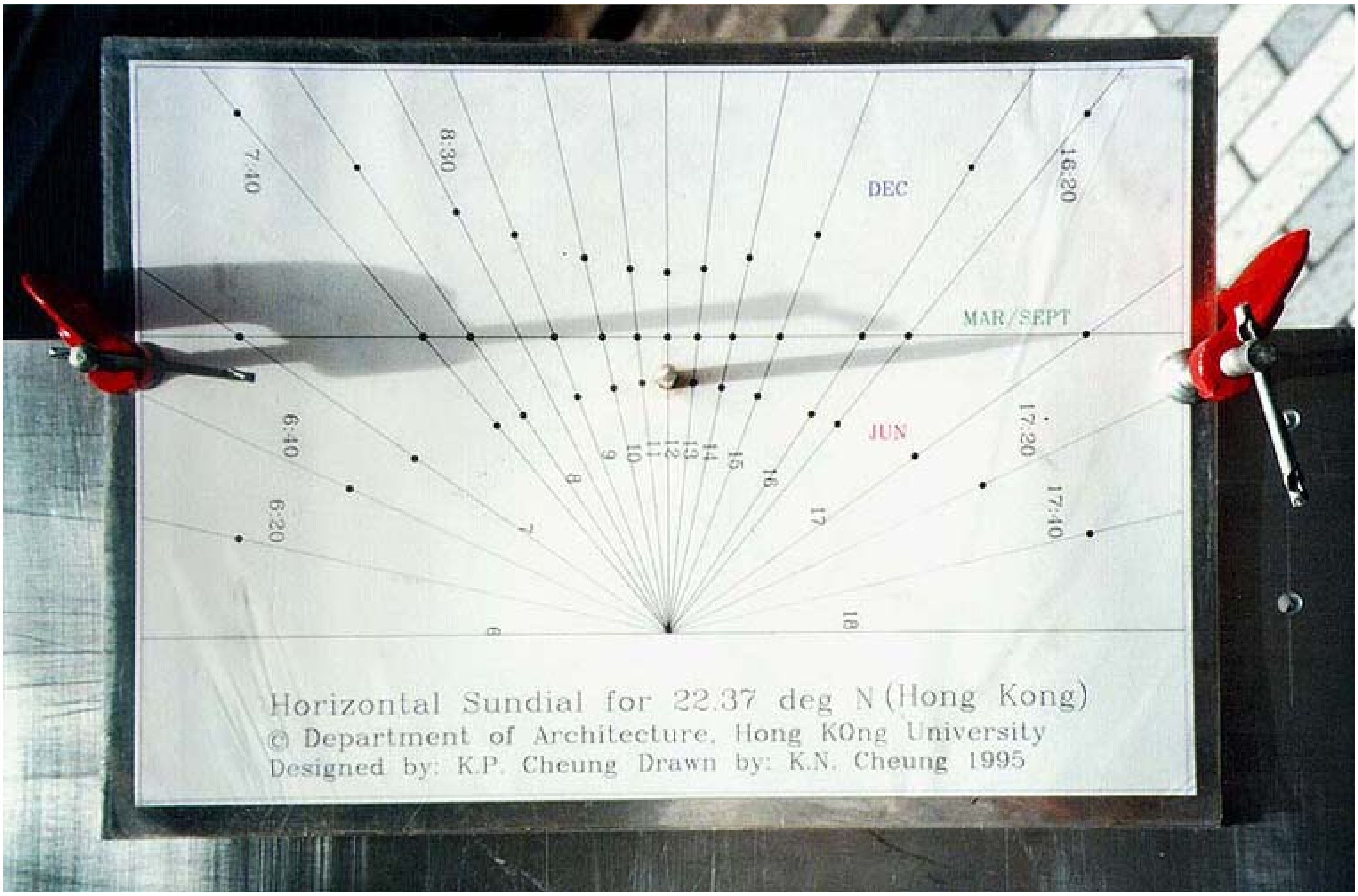
Horizontal Sundial for 22.37 deg N (Hong Kong)
© Department of Architecture, Hong KOng University
Designed by: K.P. Cheung Drawn by: K.N. Cheung 1995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Horizontal Sundial for 22.37 deg N (Hong Kong)
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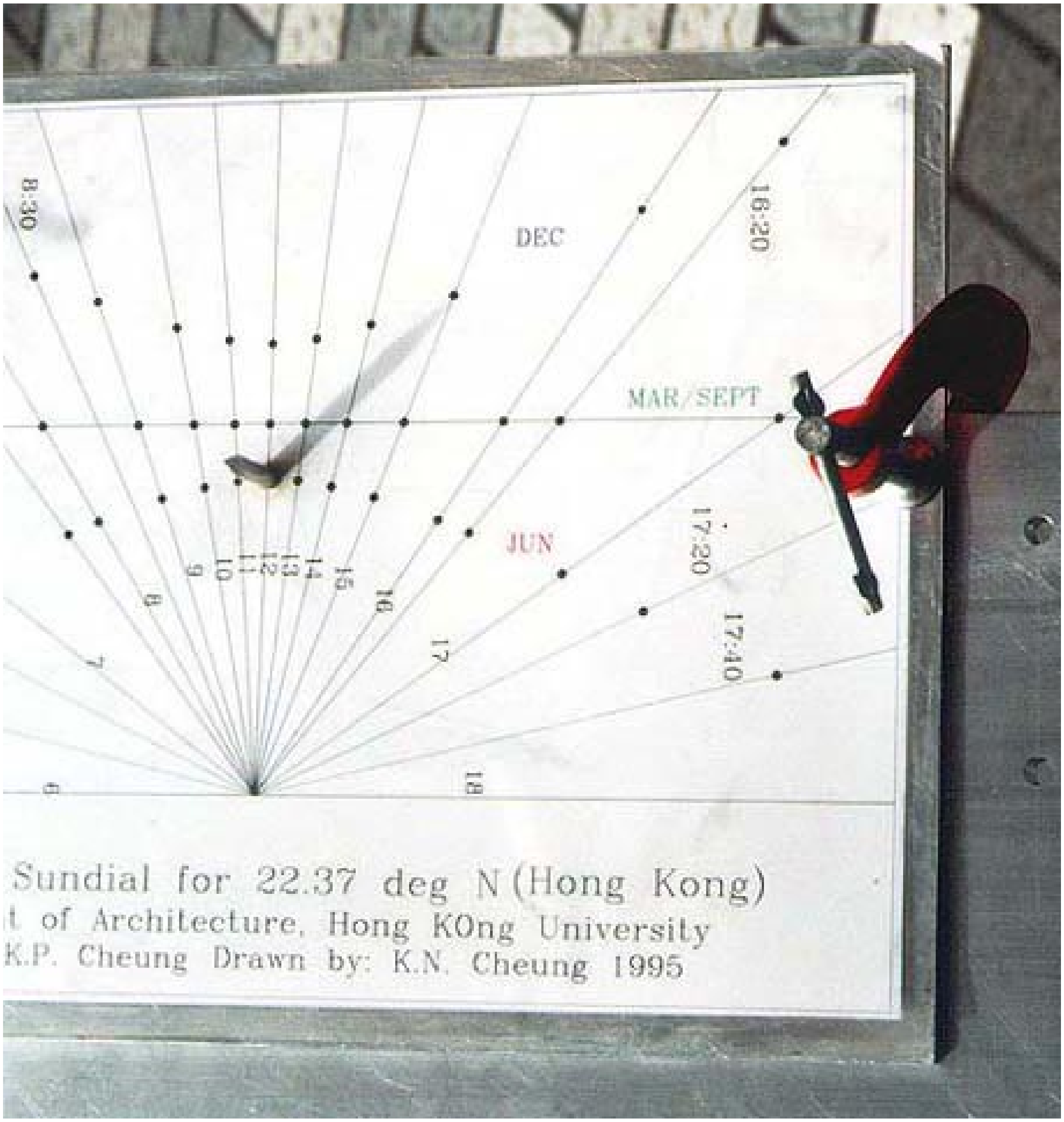
Designed by: K.P. Cheung Drawn by: K.N. Cheung 1995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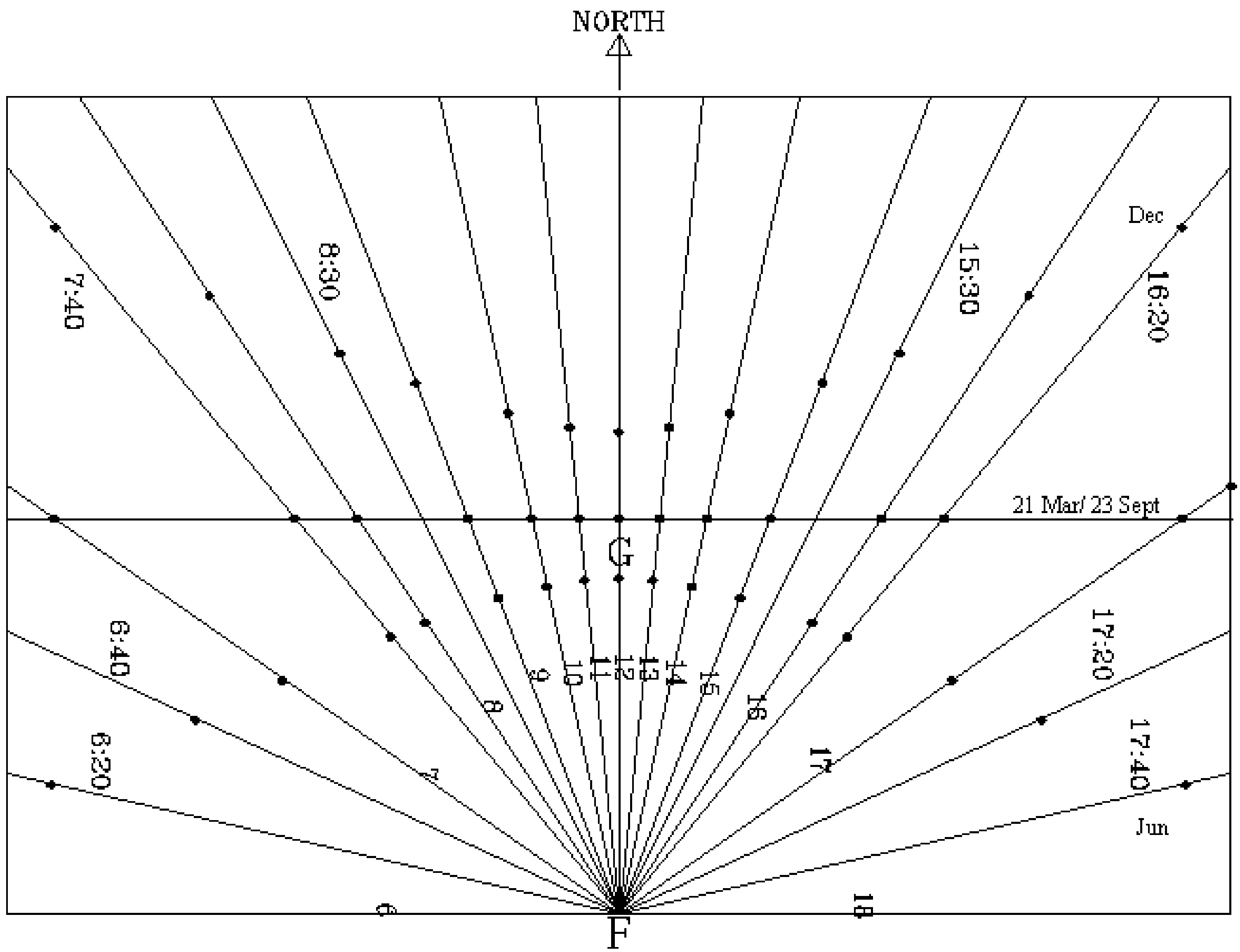
Sundial for 22.37 deg N (Hong Kong)
t of Architecture, Hong KOng University
K.P. Cheung Drawn by: K.N. Cheung 1995

P10D

To make a horizontal sundial for Hong Kong, erect a vertical pointer GH above point G such that HG=FG tan 22.37 deg



Notes:

1. Apparent solar Time is indicated.
2. A vertical Gnomon (style) is to be fixed at point G, with its tip at H above the marking surface i.e. above G, where HG=FG x tan 22.37 deg.
3. Northward points are for 22 Dec, straight points are for 21 Mar & 23 Sept, southward points are for 21 Jun.

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1. A rhapsody

Sundials have been used over thousands of years in various forms to tell time/day/season, when there is sunlight falling on it. Since the development of mechanical watches/ clocks in mid 1800s, sundials have largely become monumental. And often, inscriptions are found on sundials, inducing recollection and thoughts:

"Sometimes the heaven shines, and often is its golden complexion dimmed" - from a sonnet of William Shakespeare (1564-1616 A.D.).

"...... there is nothing new under the sun, ... there is an appointed time for everything" - from Chapters 1 and 3, Ecclesiastes, The Bible, narrated through King Solomon at about 1000 B.C.

"...... 時不利兮騅不逝......" (...... Oh the time is not favouring me, yet my fighting horse 騅 is not forsaking me ......). An inscription probably one would make on a sundial if it would be erected on the west side of Wu Jiang (......烏江- meaning River 烏), in memory of King Xiang-Yu (項羽), who emerged after the fall of Qin Dynasty (秦朝) in China at about 200 B.C.

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1 2 3 4 5 6 7 8 9 10 10.1 10.2 10.3 10.4 10.5 10.6 11 12

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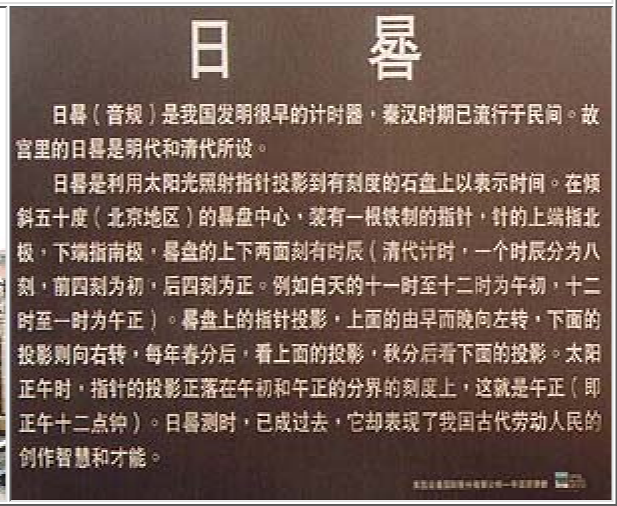
2. Sundials in China - A brief note

Although sundials existed in some form in China in Zhou Dynasty at about 800 B.C., and a very sophisticated water clock was made in Song Dynasty at about 1000 A.D., equatorial sundials and polar sundials commonly found in Europe and Arabian lands since Renaissance never existed in China till late Ming Dynasty at about 1600 A.D. when Catholic missionaries introduced them to the astronomical officials of China.

Photo P1, P2 - The equatorial sundial and its description erected inside The Forbidden City, Beijing (Photo taken in April 1997, courtesy of Dr Sam C.M. Hui)



In Song Dynasty in China (about 1000 - 1400 A.D.), there existed a popular type of portable "sundial" (See the replica photos).

P3, P4 - A replica of Song Chinese portable sundial made of wood (by courtesy of replica owner Rev. C.M. Kwok).

The dial surface is adjusted to incline at varying angles to the horizon by pivoting it at 13 different notches engraved on the base plate, determined according to the starting days of the 24 fortnight periods of The Old Chinese Agricultural Calendar (See Joseph Needham, Science and Civilisation in China, CUP, 1970, Volume 3 Section 19-25). Do you know why 13 notches were used to mark 24 fortnight periods? (Hint: Look at the Solar Declination Table and note that the South-most notch is for Winter Solstice, and the North-most notch is for Summer Solstice.)

The Compass is for setting the North-South alignment of the sundial. The dial surface is slanted up to face North generally. The shadow cast by the style on the circular hour division of the slanted dial surface tells the hour of the day. This dial looks like an equatorial sundial, but **it is not**. For an equatorial sundial (See the earlier Photos P1, P2 taken at The Forbidden City), the upper slanting dial surface facing the sky is for reading local solar time (URL: http://www.crest.org/staff/ceg/sunangle/) from Spring Equinox at 21 March, via Summer Solstice at 21 June, to Autumn Equinox at 23 September, and the lower slanting surface is for use in the other half of the year. The Song portable dial shown above uses only the upper dial surface for the entire year. for use in different latitudes, this sundial will give different hour readings of the same solar position. If I have time, I will use an accurate sundial tester, which is in fact the Sunlight-2 Heliodon, to test this Song portable sundial. I may expedite this test if somebody would request it for academic reasons.

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1 2 3 4 5 6 7 8 9 10 10.1 10.2 10.3 10.4 10.5 10.6 11 12

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3. Sundials in architecture

The role of sundials in archtiecture is two fold :-

- They can be made a physical feature, and they can also express the soft side of architecture as well. Architecture is certainly more than the physical existence and artistic virtue of objects. Architecture touches the heart of people in various ways, angles, seasons ..... Sundials, properly designed, inscribed and ornamented, will contribute in this aspect.

	A horizontal sundial at HKU.
	Swensen Sundial at University of Wisconsin, USA (Source: http://www.uwrf.edu/sundial/sundial575.8.gif)
	A Polar Sundial at HKUST. (Source: http://sunsite.ust.hk/hkust/campus/sundial.html)

- Architects in previous ages used sundials to note the time of day. Sundials then physically taught architects to know the sun path as part of their life. Naturally such architecture output coped very well with solar movement.

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4. Sundial web sites

Sundial web sites recommended :-

North American Sundial Society	http://sundials.org
Daniel Roth's Sundial Links Page	http://www.ph-cip.uni-koeln.de/~roth/slinks.html
Sundials on the internet	http://www.sundials.co.uk/index.htm

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5. Professor Gerhard Aulenbacher - a sundial craftsman and scholar.

In September 1996, I had the privilege to visit the Chairman of Arbeitskreis Sonnenuhren (i.e. Sundial Divison) of Deutsche Gesellschaft fuer Chronometrie e.V, Professor Gerhard Aulenbacher, (Contact: Eibenweg 48, D-55128 Mainz, Germany). He collected a lot of old sundial books (some were printed in 1700s), and made a number of replica of old sundials with his machine at the basement of his house. Professor Aulenbacher is finishing a sundial book.

Photos P5, P6 - Old sundial replica and related books of Professor Gerhard Aulenbacher.

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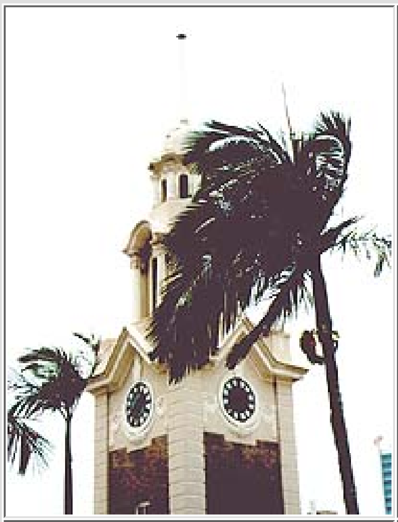
6. To understand how a sundial works

THE IMPORTANT STEPS to understand sundials, are:-

1. To identify the dial surface which can be of any orientation, any shape, and the marking on the dial surface
2. To identify the gnomon (or style) which is to cast a shadow (by sunlight, of course) on the dial surface
3. To identify a STRAIGHT LINE related to the gnomon that is PARALLEL TO THE AXIS OF THE EARTH. Sometimes this line physically exists, e.g. an edge of the gnomon of an old sundial **-** See Photos P7, P8 **-** on the Roof of HKU Main Building, and the dark string of the HKUST red sundial at http://sunsite.ust.hk/hkust/campus/sundial.html.

	**Photo P7** - The main building of Hong Kong University is designated a historically conserved building in Hong Kong. This building was opened on 11 Mar 1912 by the British governor of Hong Kong Sir Frederick J D Lugard. On the parapet wall of the West side of the roof of this building, there is a horizontal sundial, possibly of 25 years old, according to somebody who is with HKU for 30 years.
	**Photo P8** - A horizontal sundial humbly sits on the roof of HKU - Main Building, for all seasons, in sunshine or in shadow. The wedge of the gnomon is to be parallel to the axis of the earth.

In the equatorial sundial existing in The Forbidden City in Beijing (See Photos P1, P2), the gnomon (i.e. the pointer), which is normal to the dial surface, is parallel to the exis of the earth. This style is inclined at 40° to the horizon because Beijing is at 40° North. The dial surface, therefore, is inclined at 50° to the horizon, and is parallel to the equatorial plane of the earth. Refer to the diagrams of Sunlight-2 heliodons for solar geometries.

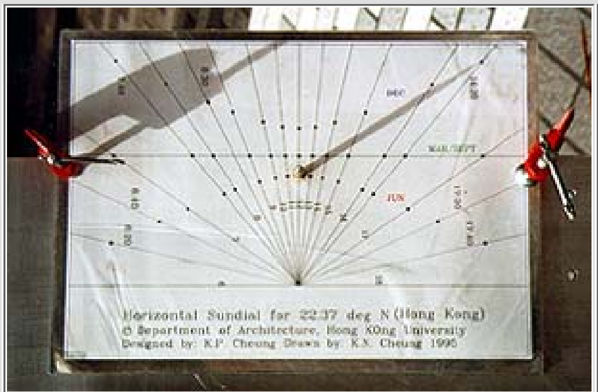


Photo P9- A horizontal sundial mounted on a sundial tester	**Photo P10**- Sunlight-2 heliodon, testing a horizontal sundial

In another design of a horizontal sundial for Hong Kong (shown mounted on a sundial tester which is in fact the Sunlight-2 Heliodon), the LINE PARALLEL TO THE EARTH AXIS is a virtual line joining the tip of the metal pointer and the meeting point of the straight hour lines. This virtual line inclines at 22.37° to the horizontal dial surface because Hong Kong is at 22.37°N.

Note that in some sundials, the gnomon may move (hence the line parallel to earth axis may move too), or a bright spot of sunlight falling on the dial surface tells the time/day instead of the shadow cast. Depending on the time(s) to be read viz. apparent solar time, mean sun time, local standard time (http://www.crest.org/staff/ceg/sunangle/), the gnomon may be of irregular shape.

4. Take the ASSUMPTION that there is practically no difference between topocentric observation (i.e. observing the sun at a location on earth surface) and geocentric observation (i.e. observing the sun fictionally at the centre of the earth) in relation to the variables of concern of solar geometric parameters (http://www.crest.org/staff/ceg/sunangle/index.html) for constructing sundials. Thus the sundial is interchangeable freely to be placed at a point on the surface of the earth and fictionally at the centre of the earth, to obtain the same accuracy. For general purposes including sundial construction, this assumption is acceptable because the distance between the sun and the earth far outweighs the diameter of the earth. This assumption is most prominently illustrated by those universal sundials which can operate for a large range of latitudes.

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9. A very accurate sundial

In Summer 1996, the sundial tester was used as a very accurate sundial by mounting onto it a Vernier height gauge and a pointer (i.e. a gnomon).

Photos P11, P12 show a very accurate sundial assembled from precision machining tools- in operation, and in setting.

The gauge is set parallel to the earth axis. The tip of the pointer will cast a shadow on a reference mark on the Vernier height gauge. Each day this reference mark has to be adjusted to receive the same pointer tip shadow. The daily adjustment read with the Vernier accuracy tells the solar declination. As the sun moves, the upper most turntable is adjusted to tell the hour change in one day by counting the angle that has changed between 2 moments when the pointer tip shadow falls on the same reference mark of the gauge. This adjustment can be read to an accuracy of 1/6 of a second of time. Only that human eyes and hands cannot move as quickly and precisely with the accuracies provided by this sundial assembled from precision machining tools, which are commonly used in the manufacturing industry.

This sundial may be classified as a polar sundial because the dial surface is the Vernier height gauge which is parallel to the earth axis.

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10. Other sundials that I have developed

The following sundials 10.1 to 10.4, primarily intended to be portable sundials are sundials that I designed between end 1993 and mid 1996. Sundial 10.6 is based on an existing heliodon called Solux.

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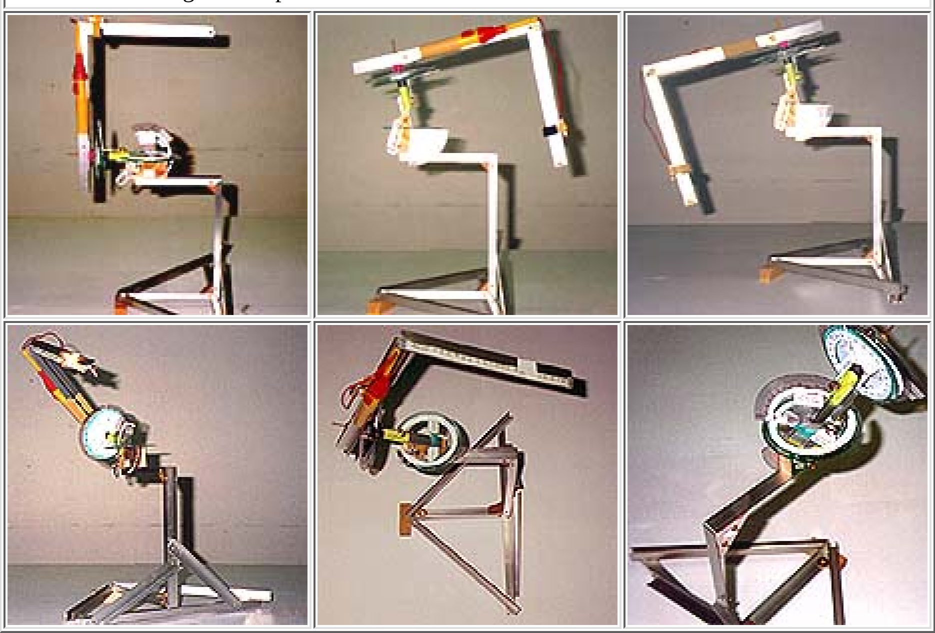
10.1 A Solar Tracker Sundial (February 1994)

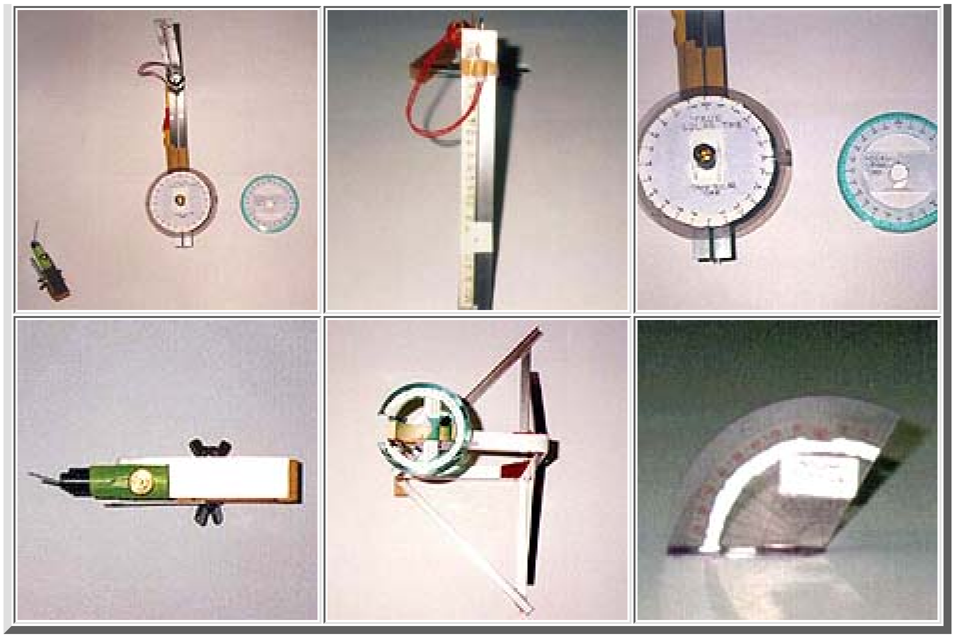
This is a universal sundial for any latitude/day/time. with 3 circular time scales, it reads apparent solar time, mean sun time, and local standard time (http://www.crest.org/staff/ceg/sunangle/index.html). To tell the day/time, first set it to the correct latitude, then allow sunlight to impinge onto a small white ball at the centre of the equipment (i.e. the centre of the horizontal plane, reference point O, as shown in Fig.2, Fig.3 of Sunlight-2 Heliodon) via the pinhole of a movable solid day selector that can slide on the day selector scale. In operation, the day scale arm has to rotate about the axis of the time scales, so as to follow the solar motion. This axis is to be parallel to the axis of the earth. It also reads solar altitude and azimuth. I made the prototype mainly by myself, with existing components as far as possible. Some components were toy parts of my daughters.

For indoor solar path demonstration, give power to a small 6V D.C. light bulb fixed at the desirable day of the day selector scale.

Photos P13-18 show the various latitude/day/time setting of this sundial prototype. Can you tell what are the setting in each photo?



Photos P19-P24 show the components of this sundial prototype



See A Paper by KP Cheung illustrating that this universal sundial can also perform as a universal solar chart, and works as a universal sun-earth direction-time relationship demonstrating device.

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10.2 A circular arc sundial (June 1994)

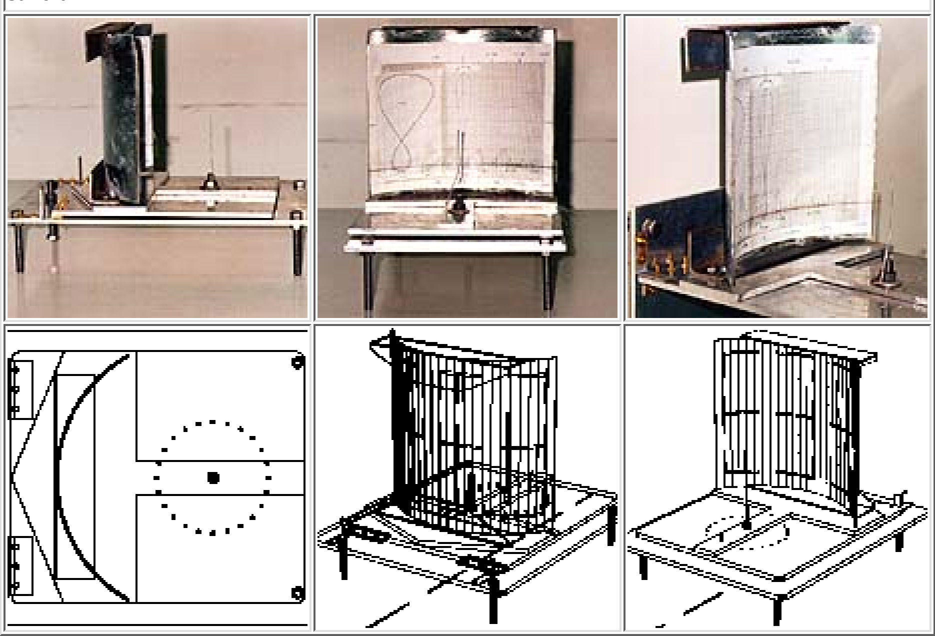
This is a universal portable polar sundial because the dial surface is parallel to the earth axis. The main features are:

- 24 holes are on the tiltable plate for fixing the rotatable arc to the appropriate reference hour.
- One co-ordinate of the arc surface reads time from minus 45 minutes to plus 3 hours, relative to the reference hour, and the other co-ordinate is for the days of the year.
- The marked green and red lines on transparent overlay, together with the basic time/day graph are for reading local standard time, mean sun time, and apparent solar time. The larger analemma is not part of the sundial surface, but attached for easy reference for the equation of time.
- The shadow of the tip of the gnomon falling on the arc tells the time(s) and the day.
- The reference hour setting is to be adjusted every 2 to 3 hours.
- It will read 24 hour sunlight hours for certain days in the arctic/antarctic regions.

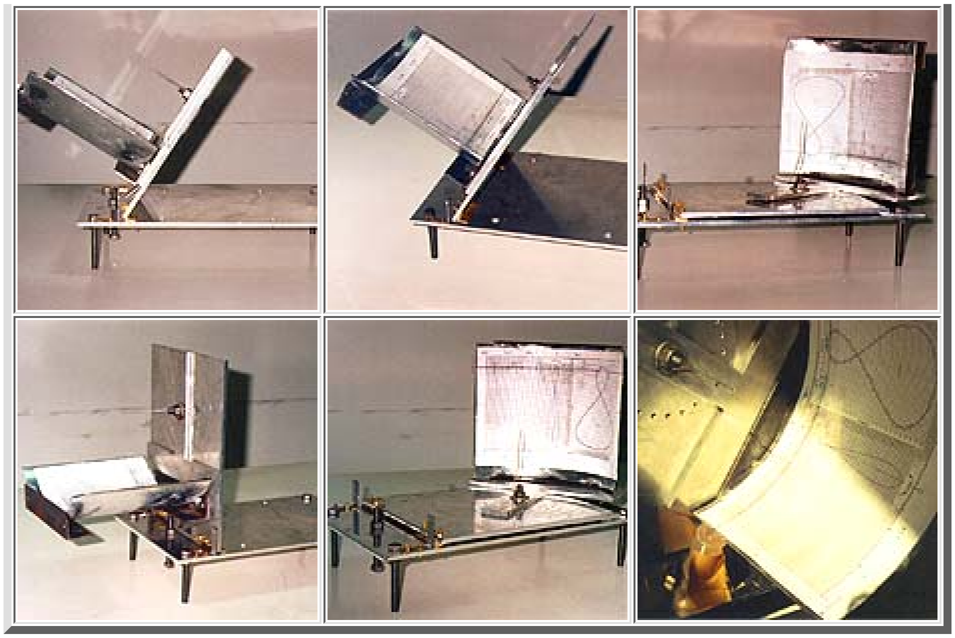
The photos P25-P33 show the prototype of this universal polar sundial. Can you tell the day/time/latitude (Northern/ Sonthern Hemisphere) settings of the various photos. (Hints: Select from: noon 32 deg N, North Pole 10 am, North Pole noon, South Pole 10 pm). The last photo is an actual setting for this sundial receiving sunlight in the morning in Hong Kong on June 1, 1994.

See A Paper by KP Cheung about this sundial.

P25-27- Photos of the circular arc universal sundial, and the related schematic diagrams of the sundial



Photos P28-P33- the circular arc universal sundial



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10.3 A solar tracker sundial attached to the globe (Summer 1994)

First of all, forget all the pictures in the globe except the spherical co-ordinates which are used as spherical solar azimuth and solar altitude co-ordinates. I marked on transparent plastic sheets (in small segments) the solar path. I then wrapped these segments around the globe to form the complete solar path.

The blue and red segment straps are marked with finer time interval lines and the analemma, red for March-June-September, blue for September-December-March.

The hollow tube has to be adjusted to track the sunlight which will impinge via the tube onto the solar path, seen at the surface of the globe. The tube and its mount are toy parts.

If the transparent plastic straps can be easily adjusted, it can also easily perform universal sundial functions.

See A Paper by KP Cheung, illustrating that this universal sundial can also perform as a universal solar chart, and works as a universal sun-earth direction-time relationship demonstrating device.

There is also a papaer on Lightless-1 Heliodon written by KP Cheung, relating closely to this sundial.

Photos P34-P38 show the sundial prototype set for the latitude of Hong Kong.

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10.4 Sunlight-1 Helioson as a sundial (July 1997)

Sunlight-1 heliodon can be used as a sundial by:

- setting the time scale axis parallel to the axis of the earth, and
- using the 2 parallel north-pointing edges of the adjustable latitude table for setting the solar declination angle [Table 1]

Solar geometric relationships for sundials.	

The trim diagram of Artlight-1 heliodon	Artlight-1 heliodon used as a sundial in Hong Kong (22.37°N), set at AST noon on 29 July, 1997	Artlight-1 heliodon/sundial tells the time as 3:15 pm AST on 29 July, 1997

This adjustable latitude table has to be rotated manually about the time scale axis yy (which is now inclined at 22.37 deg w.r.t. to the horizon) which is parallel to the earth axis. The rotation will make the 2 north-pointing edges of the adjustable latitude table to be parallel to sunlight. Read off the time scale for the time - AST.

This sundial tracks the sun, and therefore it is a solar tracking sundial. It can operate in all latitudes in Northern hemisphere and Southern hemisphere, therefore it is a universal sundial.

Provided that the components are manufactured with sufficient accuracy and fine adjustment of the components are possible, by trial and error, this sundial can work without a compass, without first knowing the latitude of the location, even without knowing the day and of course the time.

However a spirit level will be needed to set the baseplate horizontal.

The above illustrations are for working in the Northern Hemisphere. Do you know how to work with it as a sundial in Southern Hemisphere? [Hint: Please look at Sunlight-1 heliodon and the related paper]

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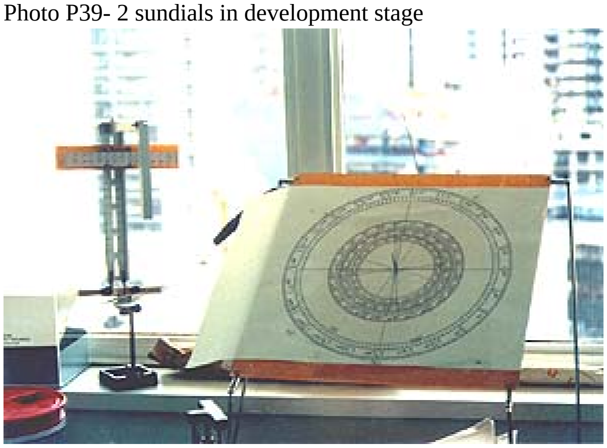
10.5 Sundials not yet completed: 2 sundials conceived in 1995:- (see P39)

Photo P39- 2 sundials in development stage



- on the right, half of an equatorial sundial, targeted to tell time(s) and a certain range of days; the other half of the dial is to be at the reverse side. The 4 time scales are for local solar time, mean sun time, local standard time (i.e. local watch time) and international standard time (http://www.crest.org/staff/ceg/sunangle/).
- on the left, a foldable and portable polar dial, intended to be put into one's pocket. A pinhole will allow sunlight to impinge on the day scale which is to be moved up and down for day adjustment. Reference hour(s) are adjusted by the circular paper time scales.

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10.6 Solux used as a sundial (Autumn 1995)

Solux was designed and made primarily as a heliodon. However, Solux can be used as a universal sundial. See A related paper by KP Cheung.

The following photo **P40** shows Solux as a sundial for Hong Kong (22.37 deg North) at 2:15 pm Apparent Solar Time (i.e. 2:10 Local Stardard Time) on 26 July 1997.

Solux can also perform the functions of a universal solar chart, and demonstrates sun-earth direction-time relationships.

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11. Sundial surface markers

Sunlight-1 heliodon can be constructed as a sundial surface marker by ading a laser pointer to it, provided that:-

- The laser beam (or its virtual extension) meets the axis YY of the time selector at 90°, and this meeting point also meets the axis of the time scale of this heliodon, and
- This meeting point is the location of the tip of the gnomon to be installed later after this sundial surface marker is removed and the heliodon components are sufficiently accurately manufactured.

Photos, from left to right, show the working demonstrations of the marker for an irregular sundial surfaces for Hong Kong (22.37°N), Nordkapp, Norway (71° 10' North) and San Martin (Argentina), Antarctic (68°11' South).

If you are not certain how this marker works, you may like to look at 7. A paper on understanding how a sundial in constructed, and also 6. to understand how a sundial works. (Hint: The axis of the time scale of Sunlight-1 Heliodon is set parallel to the axis of the earth, right at the locatin in which the sundial eis to be installed.)

Besides marking sundials for various latitudes in a factory, this sundial marker can work at site for marking a large dial surface, such as a wall, may it be a regular or irregular surface having regular or irregular texture.

Alternatively, since Sunlight-2 heliodon comprises primary precision manufacturing tools, and is an accurate version of Sunlight-1 heliodon, an accurate sundial marker can be obtained if a laser beam is fitted to Sunlight-2 heliodon similarly as fitted to Sunlight-1 heliodon above. Depending on the dimensions of the sundial to be made, this factory sundial marker adapted from Sunlight-2 heliodon will surpass the accuracy of other sundial markers manufactured with the related primary tools.

In fact, Artlight-2 heliodon, because of its precision nature, can be used directly for marking sundials which can tolerate tilting when mounted on it, using sunlight as the light source. No laser beam fitting will then be needed.

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12. A proposed nomenclature system for sundials

There is a need to devise a nomenclature system for sundials for sundial cataloguing and related inter and intra cultural and historical studies (see The draft of the skeleton of a related paper on sundial nomenclature).

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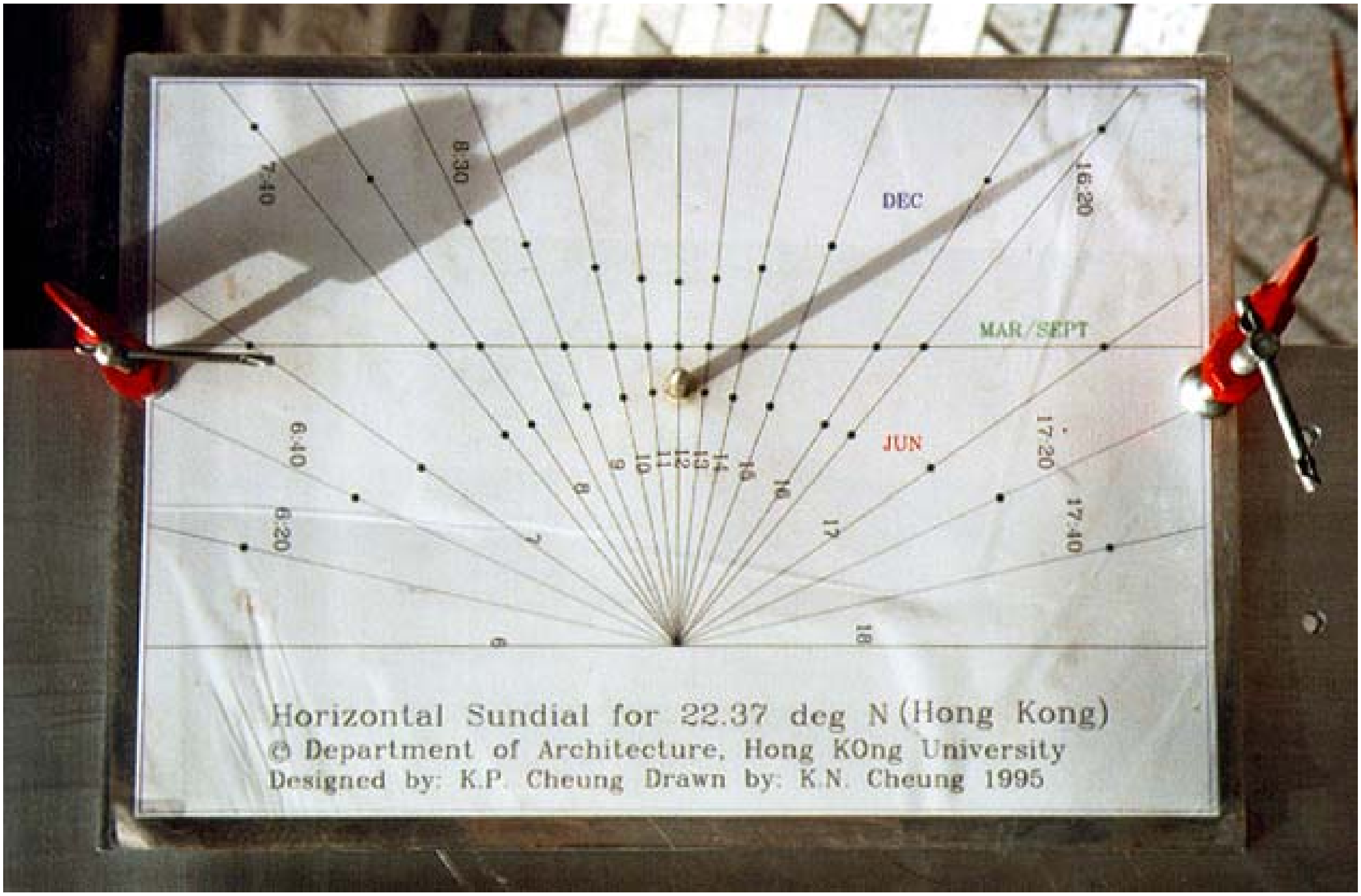
DEC
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18
Horizontal Sundial for 22.37 deg N (Hong Kong)
© Department of Architecture, Hong KOng University
Designed by: K.P. Cheung Drawn by: K.N. Cheung 1995

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After reading a textbook on Dufton & Beckett heliodon, in early Oct 93, I started with some simple tools to visualise how the sun moves about a horizontal and stationary building model in the latitude of Hong Kong. I then designed Artlight-1 heliodon in mid October 1993, which was manufactured in end Nov 93.

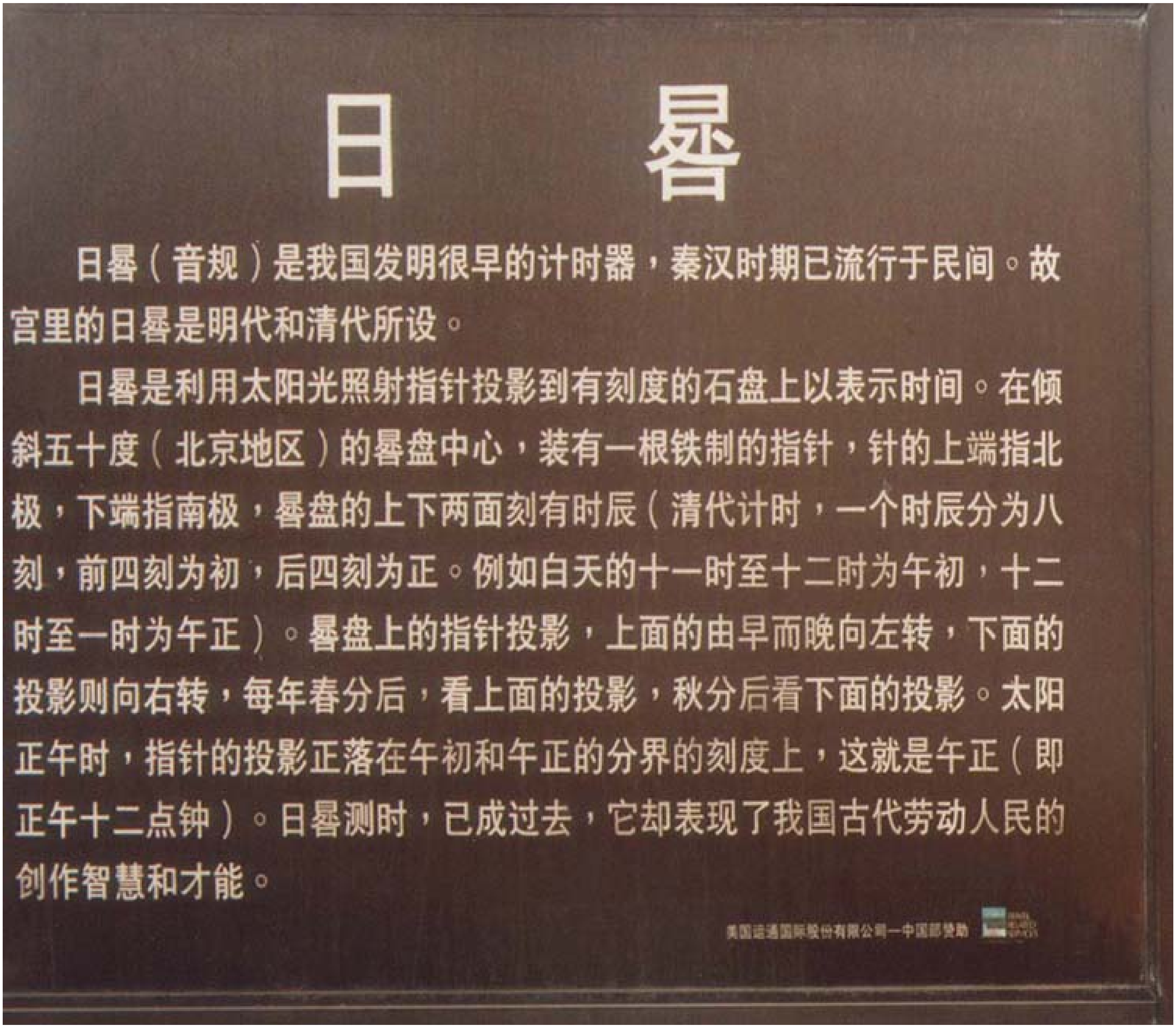
I became interested to explore on solar charts and conceived a solar chart based on a hypothetical cylindrical sky vault in Nov 93 (see A paper by KP Cheung - Mar 97, Architectural Science Review).

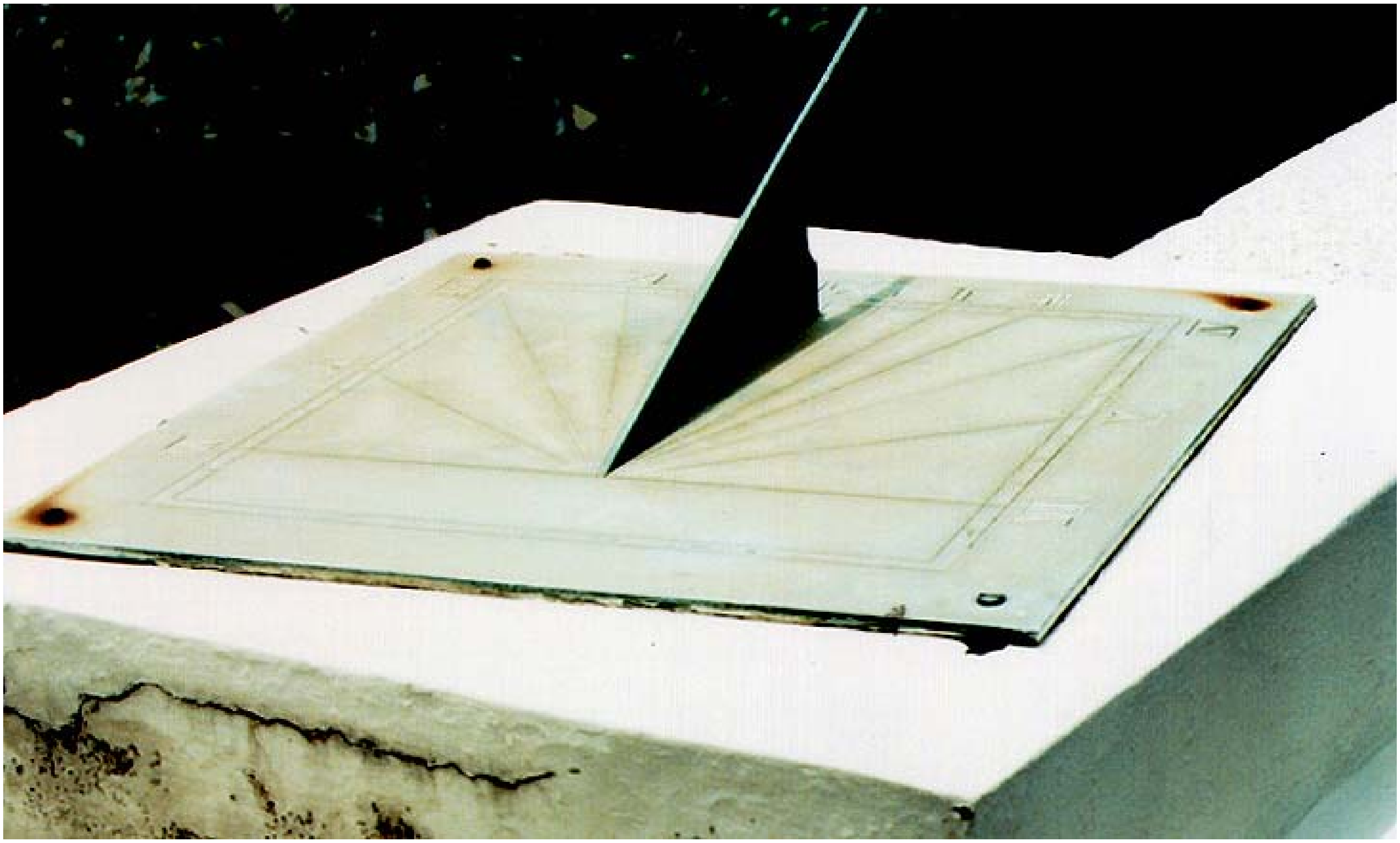
In end 93, I made a paper model to visualise how a movable one could be made to simulate solar movement as observed at different locations on the earth surface. In Feb 94, I then made a prototype with some toy parts of my daughters, mostly by myself, added with a few aluminium parts. This device can be used as a solar movement demonstrator and as a sundial.

Simple tools	Paper model	A prototype

The knowledge of sundials and heliodons are complementing, because sundials focus on receiving sunlight, while heliodons focus on simulating sunlight emission. In fact, I have incorporated sundial techniques into some heliodons I have developed. (e.g. see Sunlight-2 Heliodon)

I present below more about sundials:


日　晷
日晷（音规）是我国发明很早的计时器，秦汉时期已流行于民间。故宫里的日晷是明代和清代所设。
日晷是利用太阳光照射指针投影到有刻度的石盘上以表示时间。在倾斜五十度（北京地区）的晷盘中心，装有一根铁制的指针，针的上端指北极，下端指南极，晷盘的上下两面刻有时辰（清代计时，一个时辰分为八刻，前四刻为初，后四刻为正。例如白天的十一时至十二时为午初，十二时至一时为午正）。晷盘上的指针投影，上面的由早而晚向左转，下面的投影则向右转，每年春分后，看上面的投影，秋分后看下面的投影。太阳正午时，指针的投影正落在午初和午正的分界的刻度上，这就是午正（即正午十二点钟）。日晷测时，已成过去，它却表现了我国古代劳动人民的创作智慧和才能。
美国运通国际股份有限公司—中国部赞助



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NEW! The 400+ dials in the NASS Register of North American Sundials include 274 photos. Now you can browse these photos via thumbnail indexes.
Click on **Sundial Register** in the left frame, then Photo Index

Sundials on the Internet

"Sundials on the Internet" is the leading world internet site for information about all aspects of sundials, including projects you can do, books you can get, national societies you can join, pictures you can see, **sundials** you can commission or buy and sundial trails all over the world + our competition for new ones!

Our traffic statistics show counter visitors to our home page since 19 May 2000.- Please bookmark us - and come again!

See our new Solar Noon Calculator giving the exact time of local solar noon for you

Practical information	Introduction Set up a dial Finding your latitude and longitude Mottoes Frequent questions 5 projects to do (incl. 1 NEW project)	Mass dials/scratch dials Bevezetés a Napórákhoz (HU) Come preparare una meridiana orizzontale (I)	Faire un cadran solaire (F) Types de cadrans solaires(F) Tipos de relógios solares(P) Types Zonnewijzers(NL)
Other languages	Czech ◘ deutsch ◘ français ◘ magyar NEW ◘ italiano ◘ nederlands ◘ portugues ◘ español ◘ Index of foreign language pages ◘ Can **you** help translate some pages?		
Sundial pictures	New sundials ◘ Forthcoming sundials ◘ Links to pictures of sundials		
Sundials to buy	OutdoorDecor.com ◘ Spot-On Sundial ◘ ◘ Connoisseur Sundials ◘ **The Sunfair** ◘ **Christmas/ New Year gifts** NEW		
Commission a sundial?		Harriet James ◘ David Harber Sundials	
Technical information	Equation of Time Computer programs Declination of a wall Nature of time	Az idõkiegyenlítés (HU) L'equazione del tempo (I) La Ecuación del Tiempo (SP)	A fal tájolásának meghatározása (HU) De Tijdsvereffening(NL) Tijdsystemen(NL)
NEW full-text search	Search complete site!	Find: [ ] Submit Options	
Information sources	Sundial books ◘ Bücher(DE) ◘ Boeken(NL) ◘ BSS Bulletin ◘ Book Reviews ◘ NASS Publications ◘ Tijdschriften (NL) ◘ Sundial mailing list		
Sundial makers	**The Sundial Fair** ◘ List of makers worldwide ◘ Include your details? ◘ Arthur Wilbur Co ◘ Connoisseur Sundials ◘ Harriet James		
Sponsored by the British Sundial Society	BSS Home Page ◘ What we do ◘ Join us! ◘ BSS Bulletin ◘ "Make A Sundial" ◘ Advertising ◘ BSS Conference 2001		
Other societies	Full world list ◘ Netherlands ◘ Austria ◘ Österreich (A) ◘ N. America		

Sundial trails: in England	The City of London sundial trail NEW The London Thames trail Chipping Camden NEW Cotswolds trail Cambridgeshire Derbyshire NEW County Down, Northern Ireland NEW Hampshire seaports NEW Horniman (London) Leicester Time Trail NEW Oxfordshire East Sussex S. Norfolk Suffolk Test Valley (Hampshire) Winchester Isle of Guernsey
in Europe / Middle East	Austria : Österreich (A) Austria Belgium: Rupelmonde, Flanders NEW, France: Central Paris Brianconnais Finistère Pays de Buech Queyras (F) Queyras Germany: Gorlitz NEW Israel: Israel sundial trail NEW , Italy: Milan/Bergamo Milano/Bergamo(I) **Malta** **Netherlands** **Poland** Spain: Barcelona **Complete world list** NEW **Competition**
in the Americas	Seattle Toronto Kentucky Ottawa Ecuador NEW Ecuador (SP) NEW
in Australia	Sydney NEW Tasmania NEW
For you	Comments Feedback page Personals page
"Clocks" magazine articles by N. Ta'Bois.	Adjusting for Longitude The Analemma Calculating hour lines Disc dials Equinoctial dials Gnomon or style Greenwich meridian Hours and hours Latitude & sundials Meantime dials Minor adjustments The Noon Mark Pillar dials Ring dials Significant dials "Sun time & clock time"
Links	Other interesting sundial sites Wemaster's choice - a miscellany of links to other sites which we have found useful or interesting or both How to set up a reciprocal link This site is listed in the BBC Education Web Guide which brings you the newest and best websites for learning.

Please bookmark Sundials on the Internet so we can see you again!

http://www.sundials.co.uk/index.html

This home page was completely redesigned in March 2000. If you would like to see our previous home pages, they are kept posted for your interest (though without links) at home99.htm, home98.htm and home97.htm. We have come quite a long way since then!

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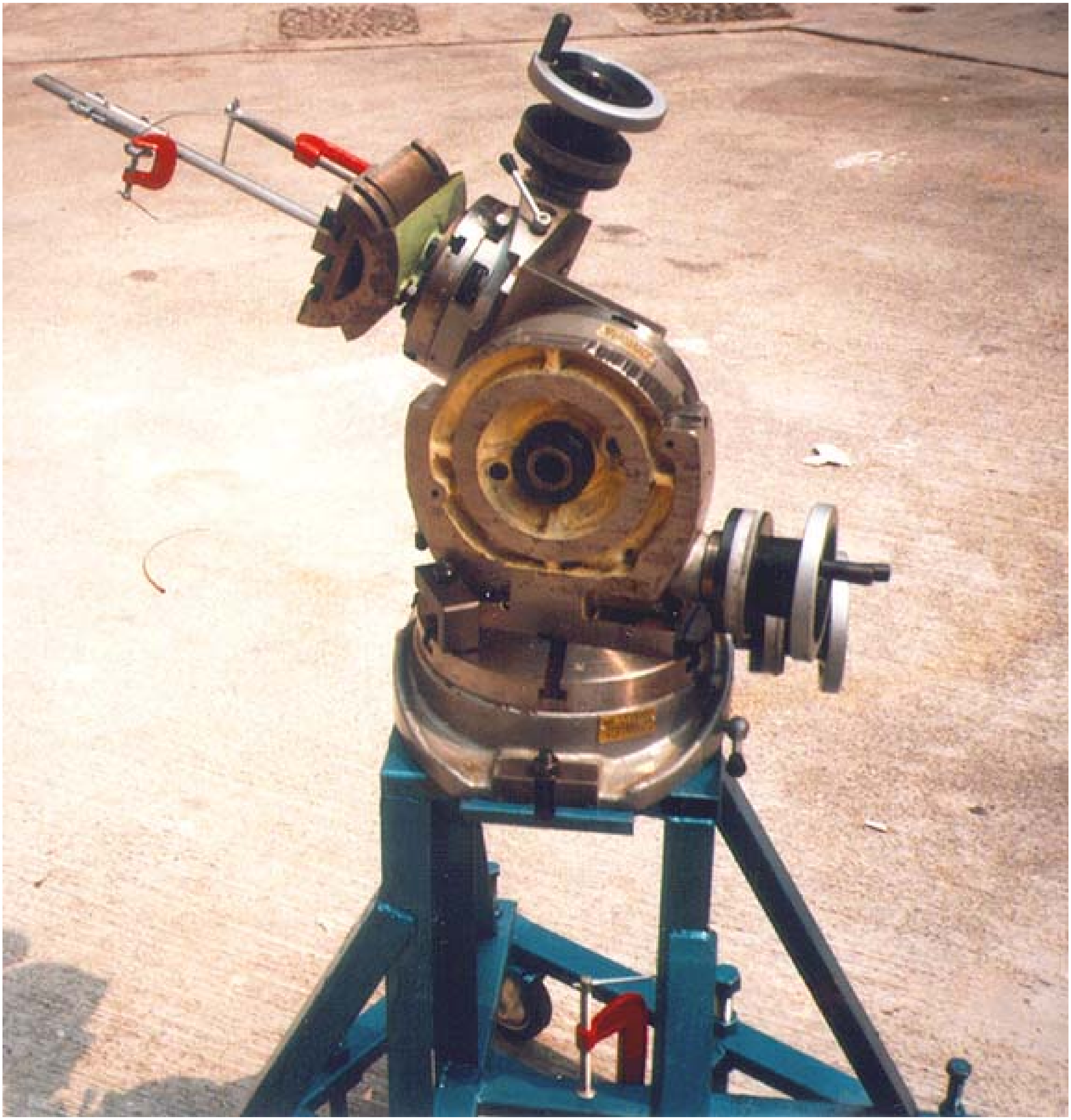
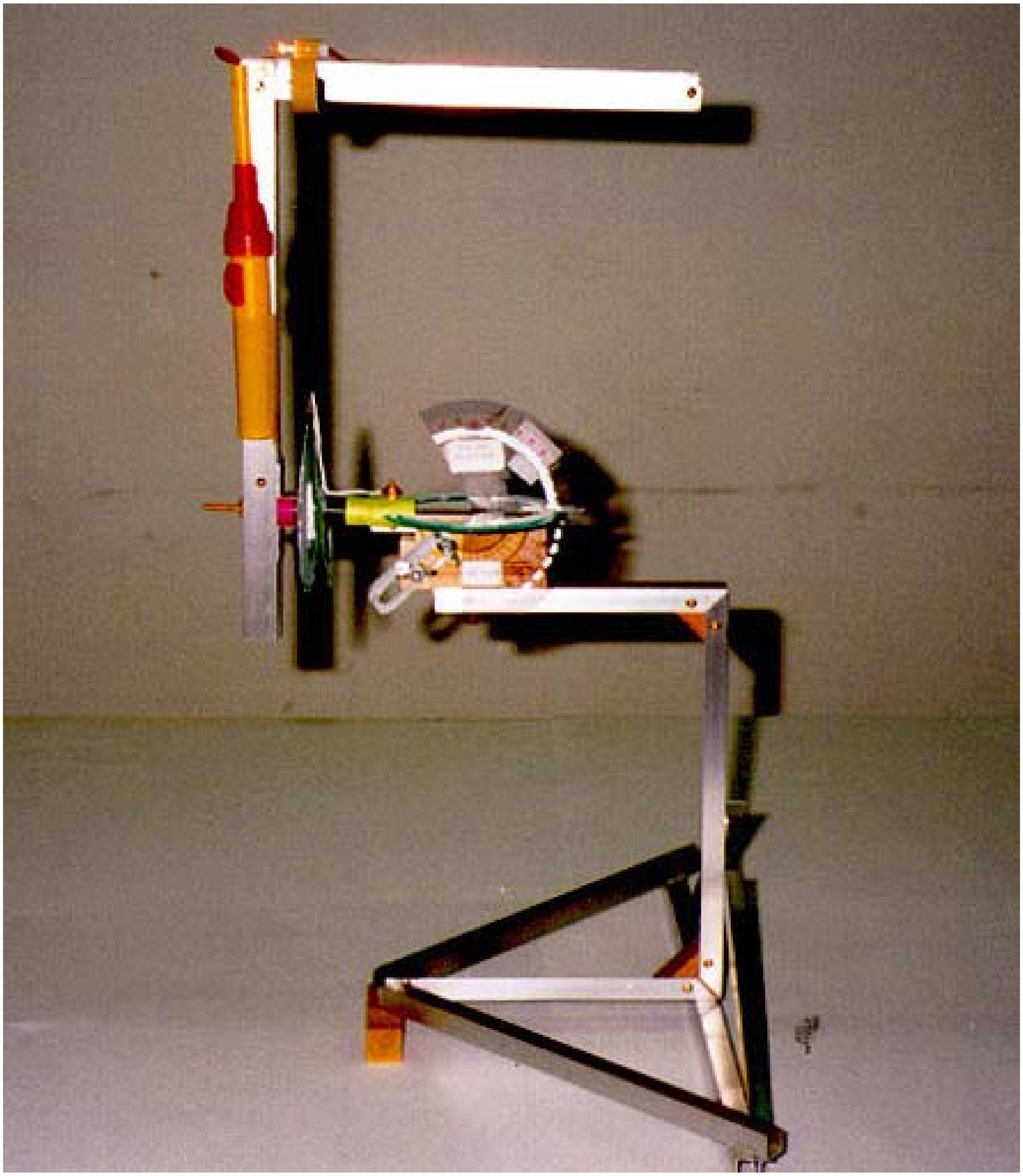
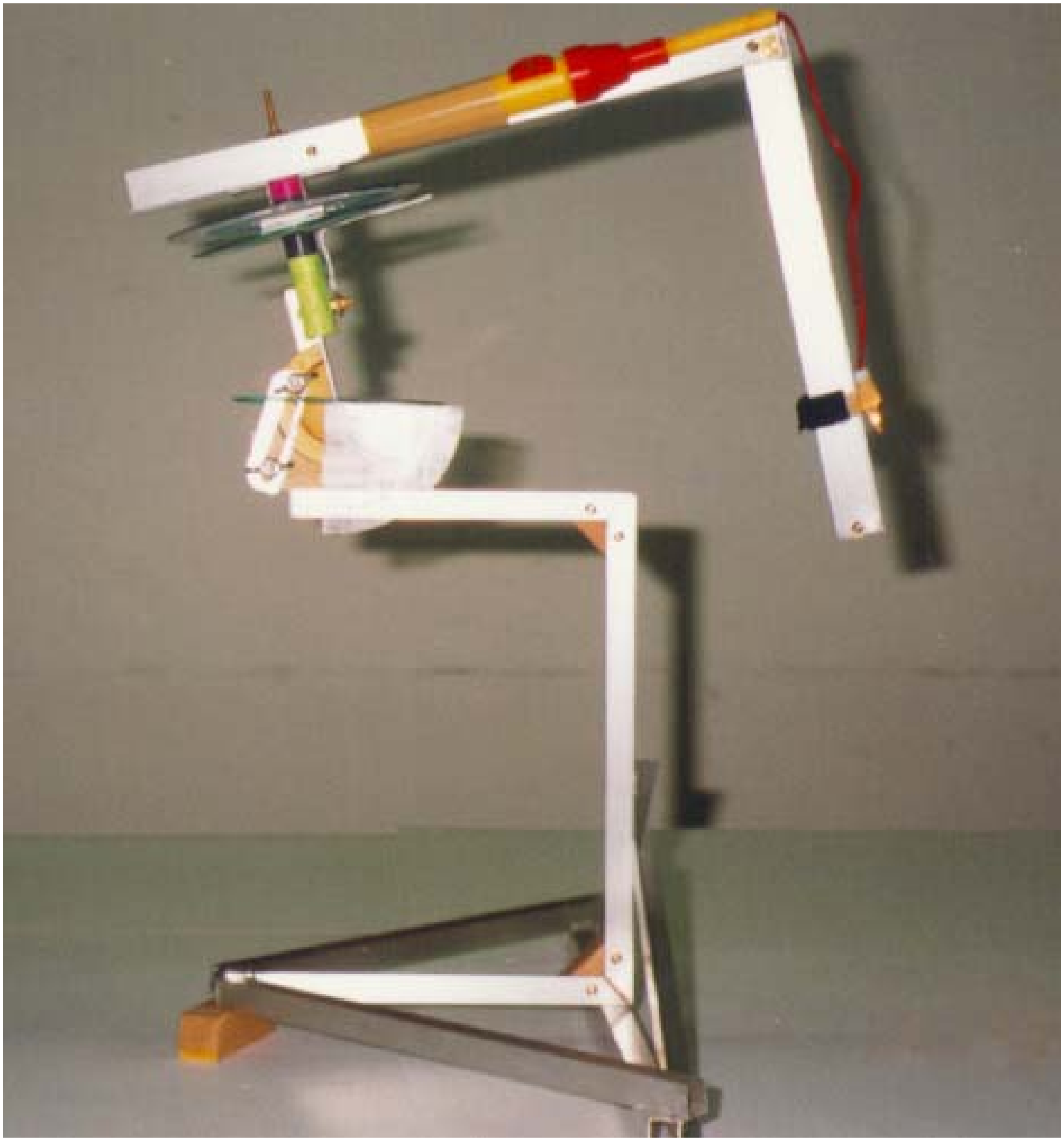
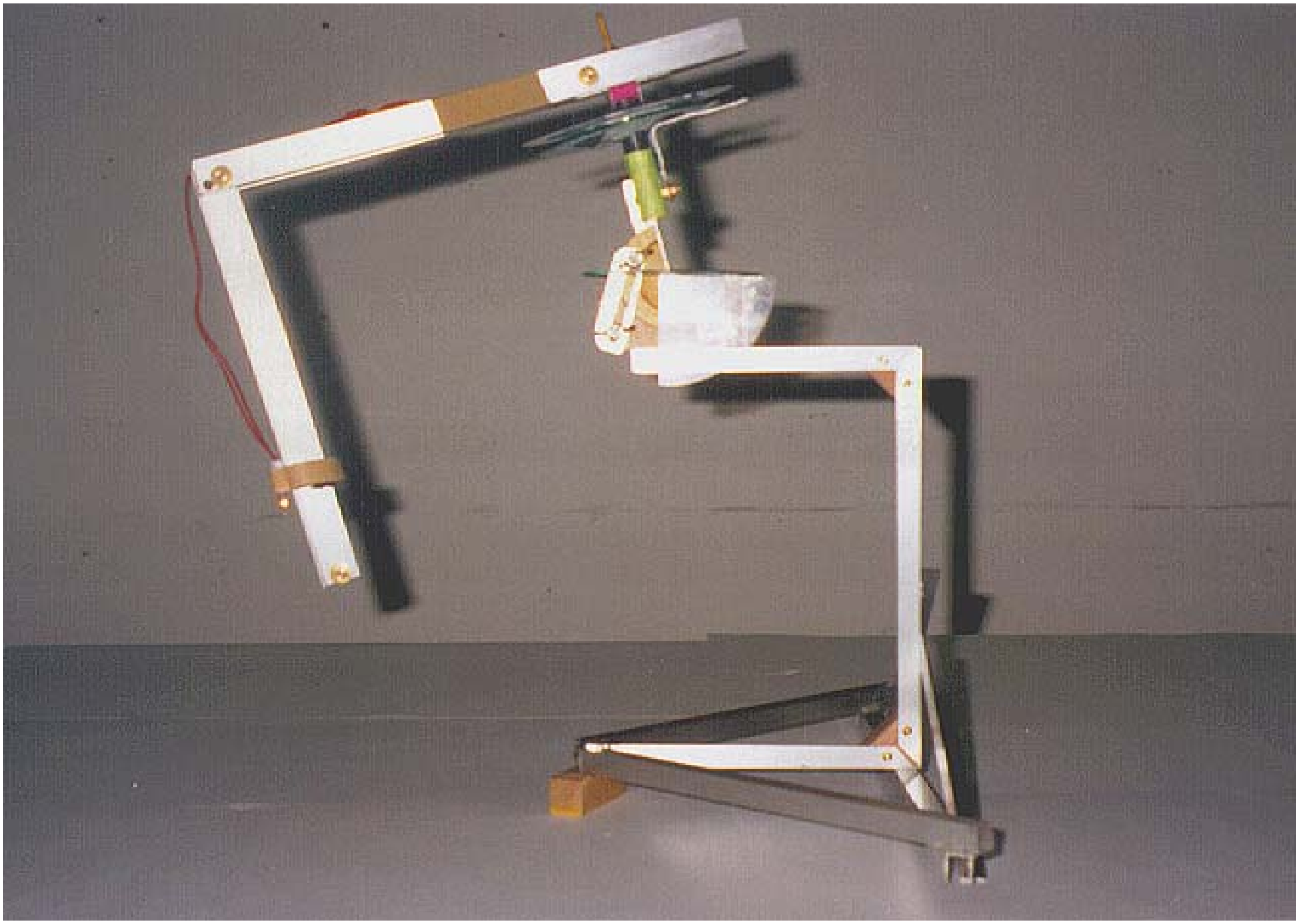
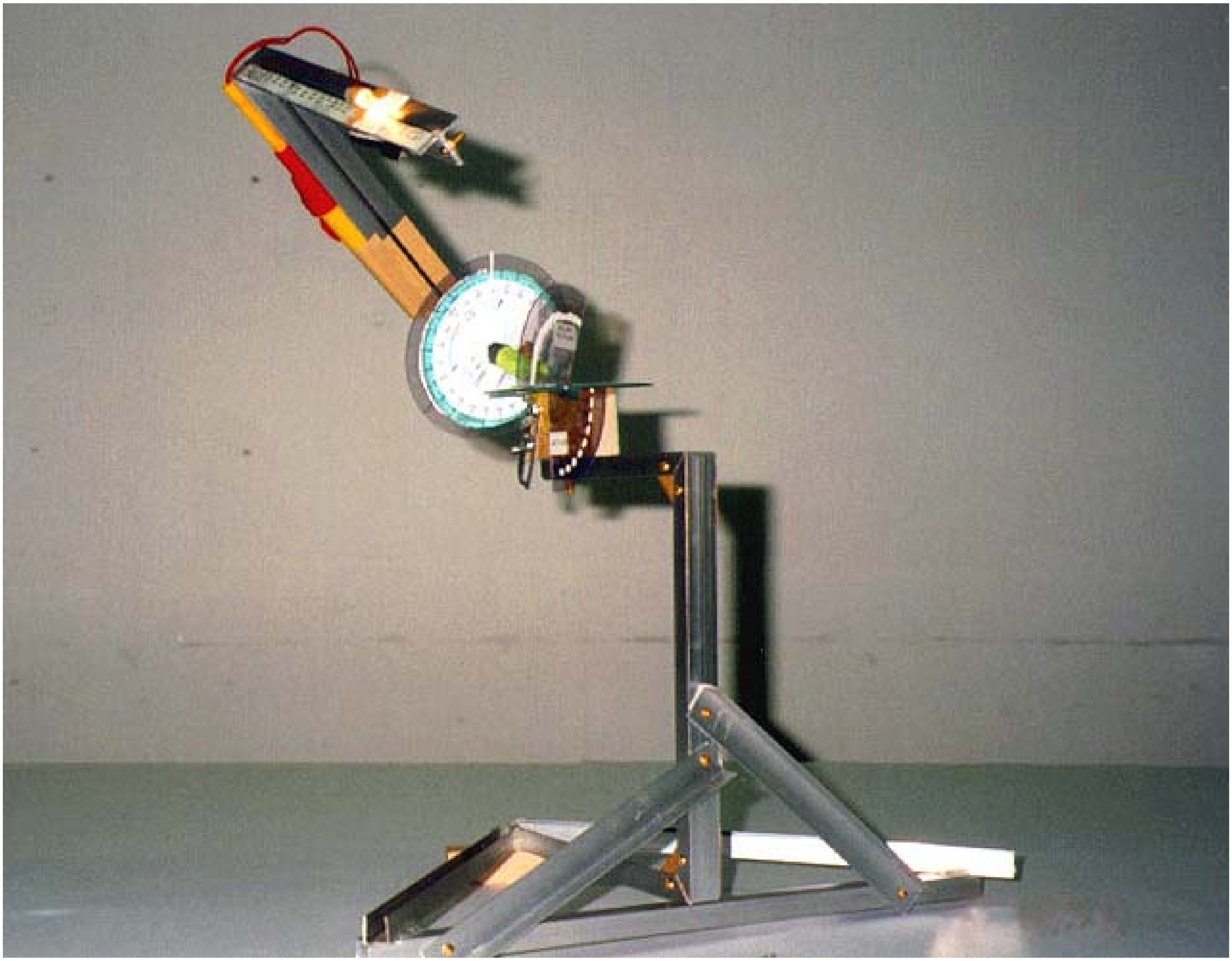
Comments/ suggestions/ problems, please get in touch by E-mail

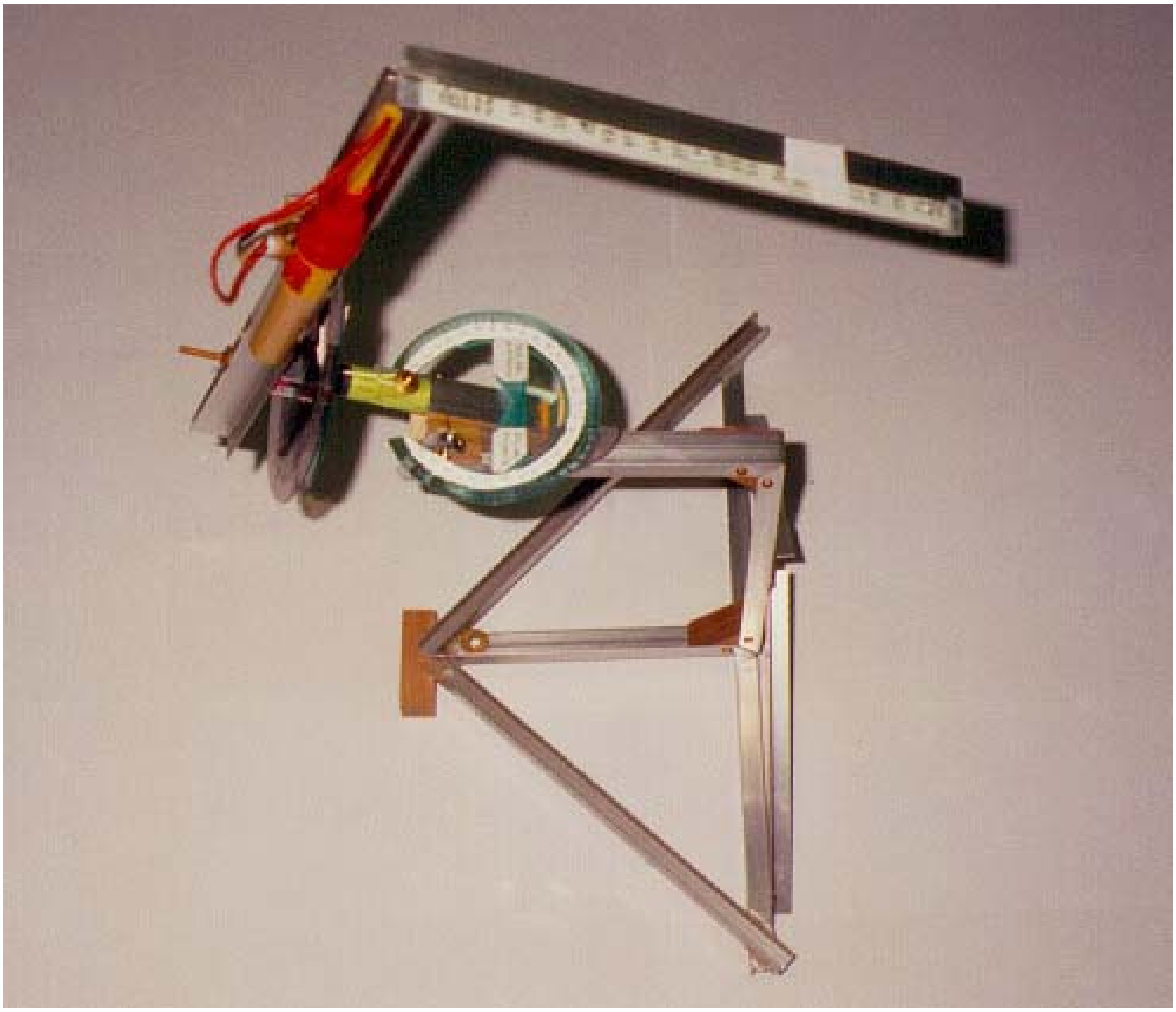


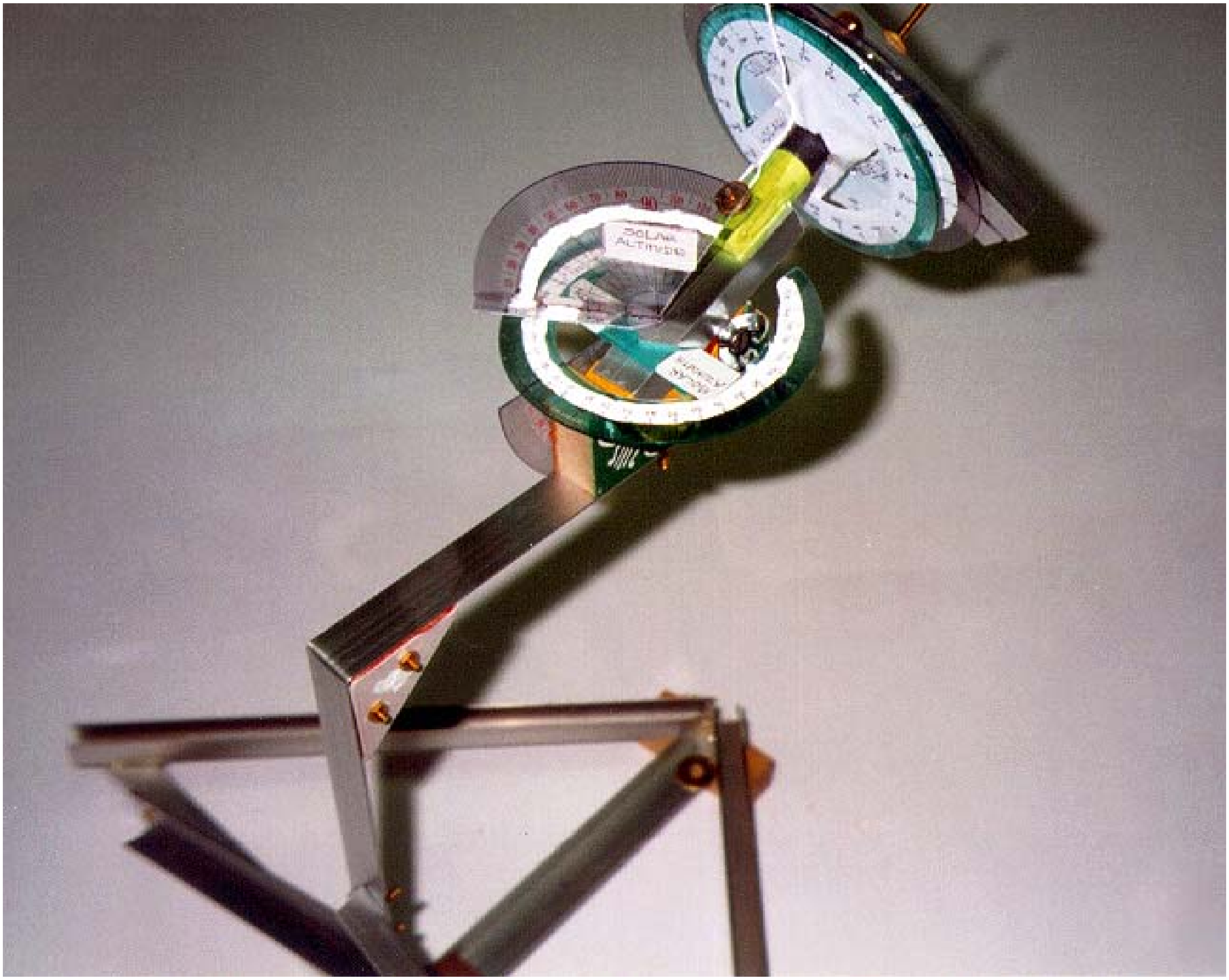


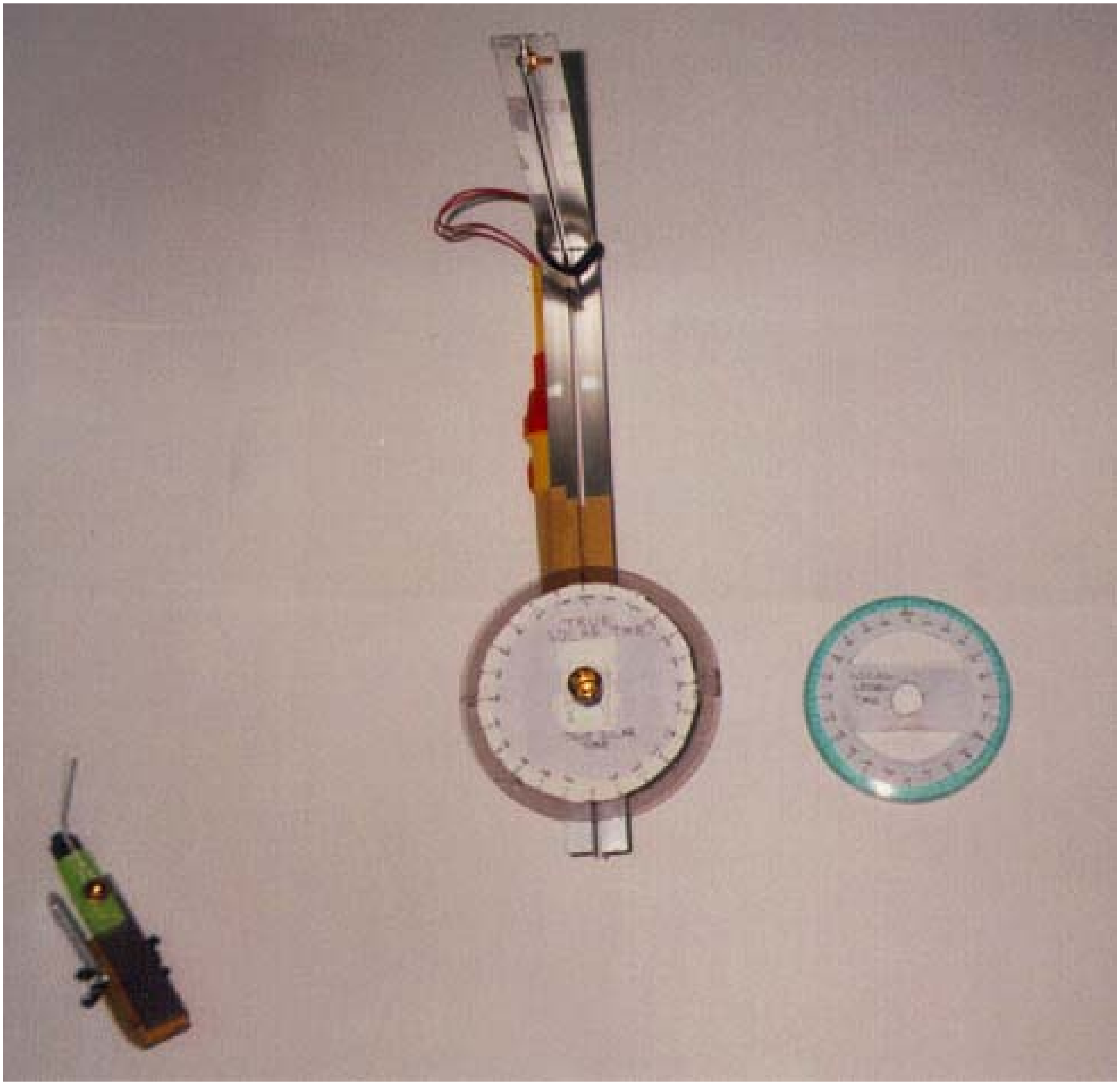


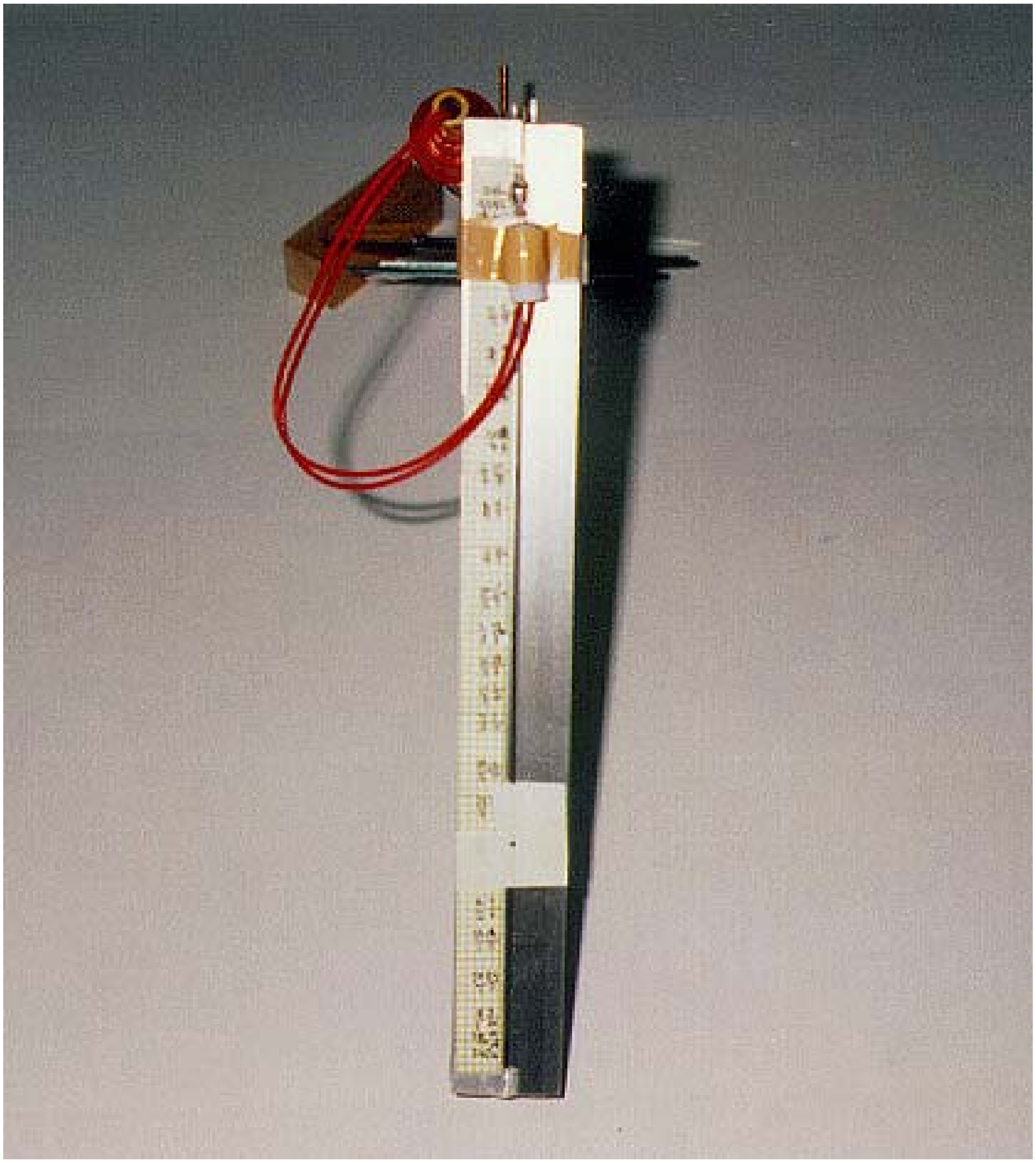


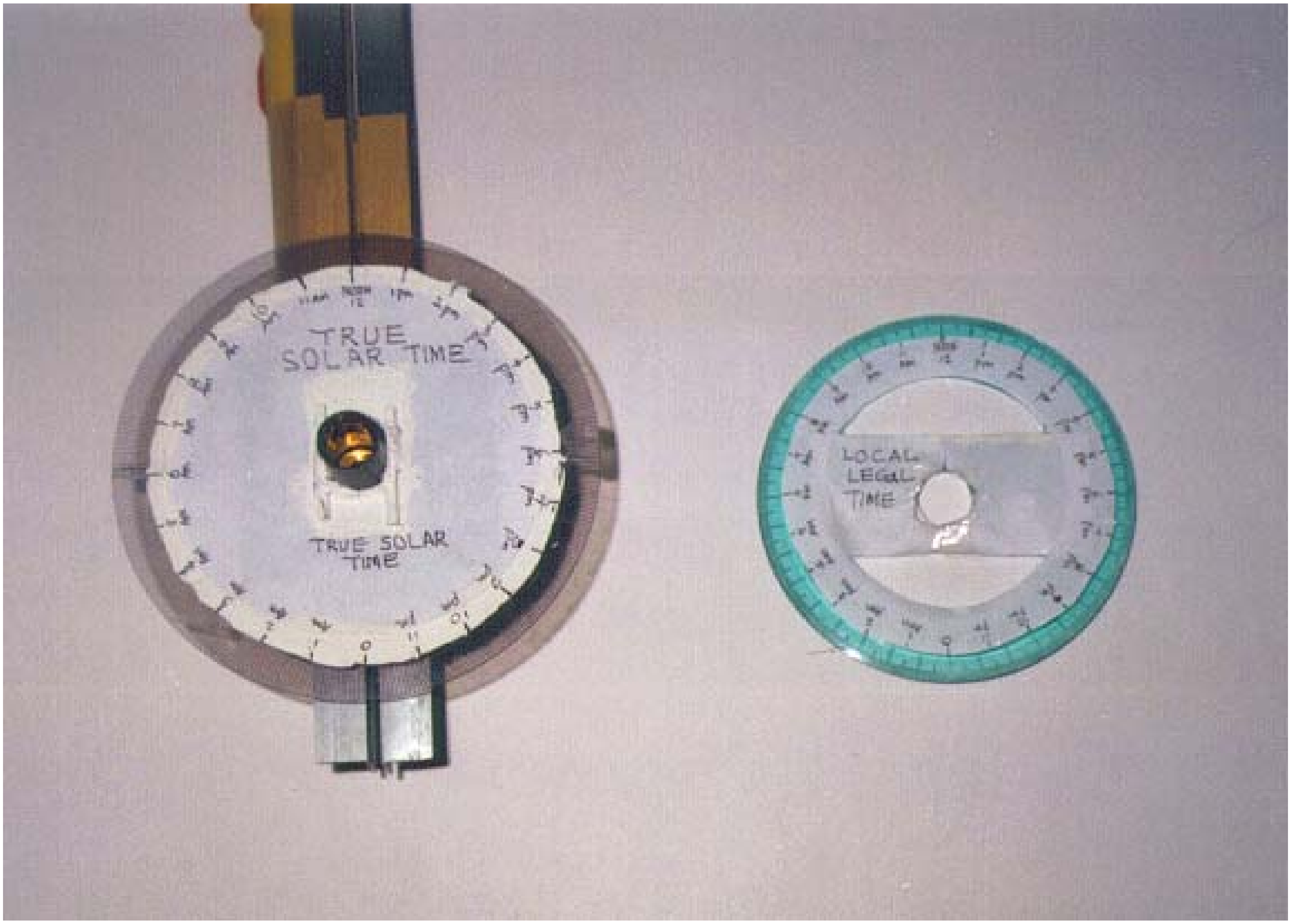


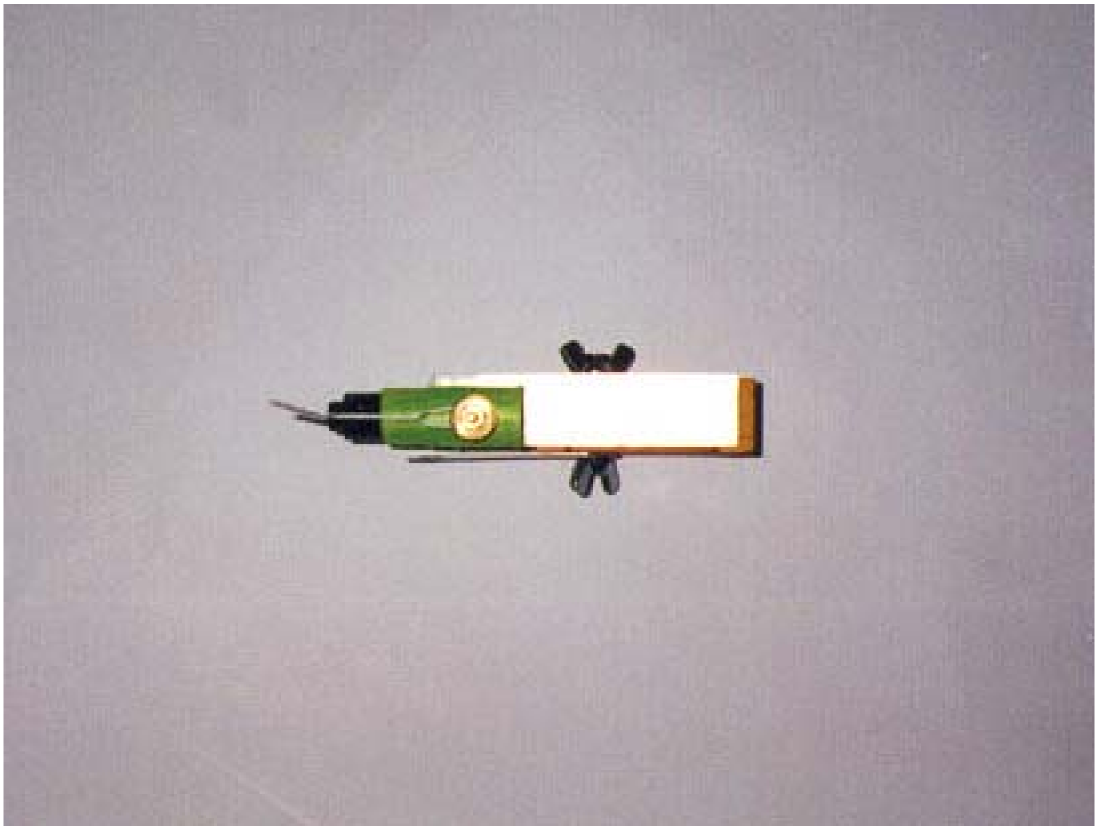


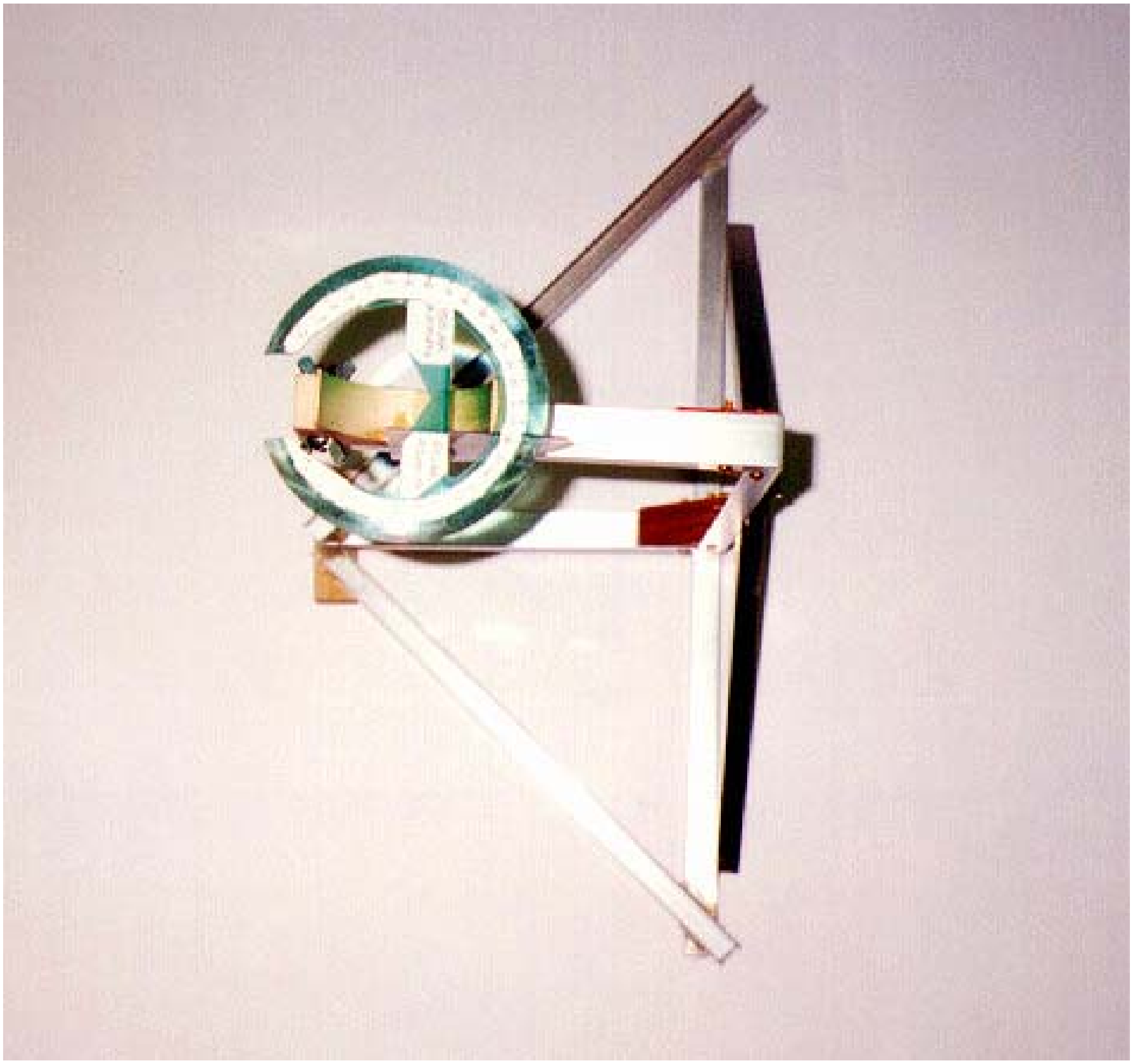


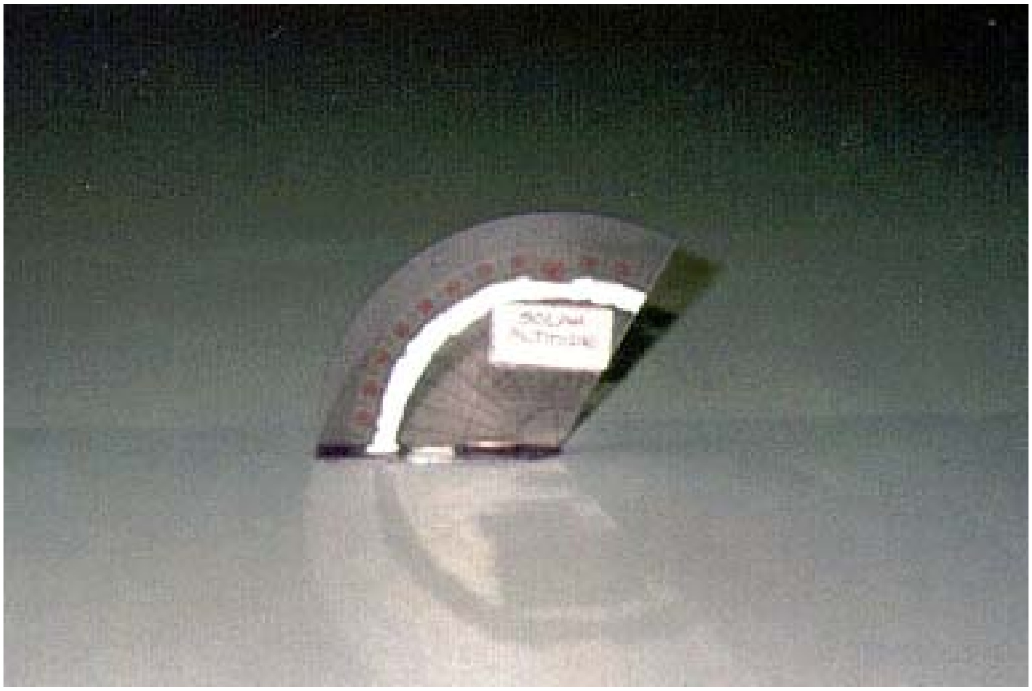





TRUE
SOLAR TIME
TRUE SOLAR
TIME
LOCAL
LEGAL
TIME







K.P. Cheung, Department of Architecture, The University of Hong Kong
This page started in August 1997

A PORTABLE UNIVERSAL SOLAR TRACKER SUNDIAL ATTACHED TO THE GLOBE, A UNIVERSAL SUN-EARTH DIRECTION-TIME RELATIONSHIP DEMONSTRATING DEVICE

1. Abstract

In an attempt to develop and make a portable universal sundial using additional overlays attached to the globe, it was found that with minor additions, other related functions can also be performed by the device. These functions and the sundial functions are also illustrated in this paper.

Because the globe is a common device, it will be cost effective to make it work as a sundial by adding plastic overlays onto it.

2. Introduction

Sundials have existed in various forms for about 3 thousand years, to tell time(s), days, with sunlight falling on them.

Watches are certainly superior in many ways than sundials in telling time. Yet sundials bring people back to closer relationships with the sun and nature. Particularly, universal sundials which are operable in a range of latitudes will certainly reinforce this purpose.

The original intent was to design a universal sundial by adding plastic overlays and other small components on the globe. In the design process, other interesting related functions operable by the device were also discovered.

3. Nomenclature

A	Solar Azimuth angle, A=0 deg for south direction, A is positive if the sun is due West and negative if the sun is due East.
AST	Apparent Solar Time, or true solar time.
d	the declination angle of the sun with respect to the centre of the earth, d=+23.5 deg at Summer Solstice and d=-23.5 deg at Winter Solstice. Different declination angles correspond to the different days of the year [Table 1, Table 2].
GMT	Geenwich Mean Time
h	Soar altitude angle
LST	Local Standard Time (also called standard time, or local legal time) - which is MST adjusted for the longitude of the location of solar observation with respect to its relevant time zone meridian.
MST	Fictional Mean Sun Time - AST corrected with the equation of time as shown by the analemma [Fig 2, Table 3].
NL	A latitude on the Northern Hemisphere of the real earth, with a latitude angle NL.
O	Centre of the spherical sky vault (traditional) [Fig 1], containing the sun path, i.e. the location of the eye of an observer who is regarded to be extremely small as compared with the diameter of the sphere.
OQ, OM etc.	alphabets with a line underneath mean a line joining the points denoted by the alphabets
SL	A latitude on the Southern Hemisphere with a latitude angle SL
t	hour angle, t=0 deg for solar noon (i.e. AST, apparent solar time = 12:00 noon), for one hour, the hour angle elapsed is 15 deg., t is positive for AST p.m. and negative for AST a.m.

UT Universal Time

4. Existing Engineering Principles

It is long established that since the sun is very far away from the earth and this distance is very large compared with the dimensions of the earth, it makes practically no difference (i.e. considering the dimensional accuracy of the mechanical equipment one would normally use, including the one described in this paper) between an observer on the surface of the earth (i.e. topocentric observation) and a fictional one at the centre of the earth (i.e. geocentric observation), for observing the solar azimuth angle, solar altitude angle and the apparent solar time (i.e. true solar time).

The sun path lines [Fig 1] are shown in relation to a fictional geocentric observer at 0. This figure equivalently represents the path of the sun relative to the earth which is now almost zero in dimension at the position 0.

Of particular interest to a traveller going from one latitude to another on the earth surface is to know AST, h, A (i.e. on topocentric observation), when there is sunlight as he travels with an instrument for finding AST, h, A, L and the North-South orientation.

Such an instrument is easier to be developed, considering AST, h, A to be practically the same for both topocentric and fictional geocentric observation, i.e. transposing the observer from the surface of the earth to the centre of the earth fictionally while keeping the same horizontal planes for finding AST, h, A.

5. Engineering Principles and Equipment Design for this sundial

The topocentric observer and the fictional geocentric observer has practically therefore become the same point 0 [Fig 1], which is the centre of the imaginary spherical sky vault.

The sky-vault of the sun-path is commonly considered to traverse a part of an imaginary spherical surface. The sun travels with respect to an observer 0 on the surface of the earth (i.e. topocentric observation) from d=+23.44 deg to -23.44 deg from Summer Solstice to Winter Solstice and vice versa, year by year.

Plastic transparent straps (See Photos of Sundial 10.3) following the curvature of the globe were made for the annual solar path, with AST day curves marked on them. Also 2 other plastic transparent straps were made for further overlaying onto the annual solar path, for adjustment of the equation of time, one strap for use in June-Sept-Dec, the other for Dec-Mar-Jun. These additional straps can be sector straps as they can be moved about the surface of the globe at intervals as time changes. These straps can also be suitably located to read off LST (See Illustration 6.1).

A hollow tube, having its centre line passing through the globe, was attached to the globe with a rubber band encircling the globe.

Read about Lightless-1 heliodon (i.e. Heliodon 10.1) and its related paper. The universal solar chart demonstration in that heliodon is a 2-dimensional presentation, while this sundial is 3-dimensional. Both of these devices use spherical co-ordinates of A, h. Make the maps of land and oceans of the globe disappear in your mind. But only see the longitudes as solar azimuth (i.e. A) co-ordinates and the latitudes as solar altitude (i..e h) co-ordinates.

6. Illustrations [See Photos of Sundial 10.3]

6.1 Illustration on reading AST, MST, LST, a, h and setting North-South orientation when there is sunlight - i.e. the equipment assembly is also used as a sundial

Suppose that the observer is in New York City (40°43'N and 74°W), and the date is February 25 [Ref. 1].

Adopt the following procedures for setting AST, MST, LST:

- To avoid confusion, always start with 12:00 noon, AST, i.e. apparent solar noon
- Equation of time for February 25 (if slow, add. If fast, subtract, to obtain MST) = 0.13 slow
- Mean solar time of local meridian, MST = 12.13 p.m.
- Correction for difference between local meridian and standard time zone meridian (75°W long.) at rate of 1° = 4 minutes (If standard meridian 0:04 lies to west, subtract the correction; if to east, add.), LST = 12:09 p.m.

- Thus, a watch, set to US Eastern standard time in New York City, will ready 12:09 p.m. when the sun arrives over the local meridian of the city on February 25

When the equipment is correctly set for the latitude and is correctly aligned in the North-South orientation, sunlight will impinge through the hollow tube cast a bright spot on the globe surface. Read off AST, MST, LST, a, h, with proper setting of the straps. In this way the equipment acts as a sundial.

6.2 Illustration for use as universal solar charts

Common solar charts are graphs plotted on a flat surface for relating h, A, AST, North-South direction for a given latitude. One latitude is given one solar chart.

With the straps properly attached to the globe, point to the required d and AST, h and A are read off from the relevant scales.

The latitudes can be adjusted as required. The equipment can be used therefore as an equivalence of a series of solar charts.

In fact in addition to reading AST which is also provided by the common solar charts, MST, LST can be read off in this equipment by putting on the related straps.

6.3 Illustration for use as a demonstrator of the relationship of h, A, d, NL, SL, AST, MSL, LST when there is no sunlight due to obstructions, but the sun can otherwise be seen as above the horizon

This is same as Section 6.2 above.

6.4 Illustration of the directional relationship of the sun to an observer when the sun is below the horizon at various moments of AST, MST, LST

This is same as Section 6.3 above, except that h, A are not applicable.

7. Conclusion

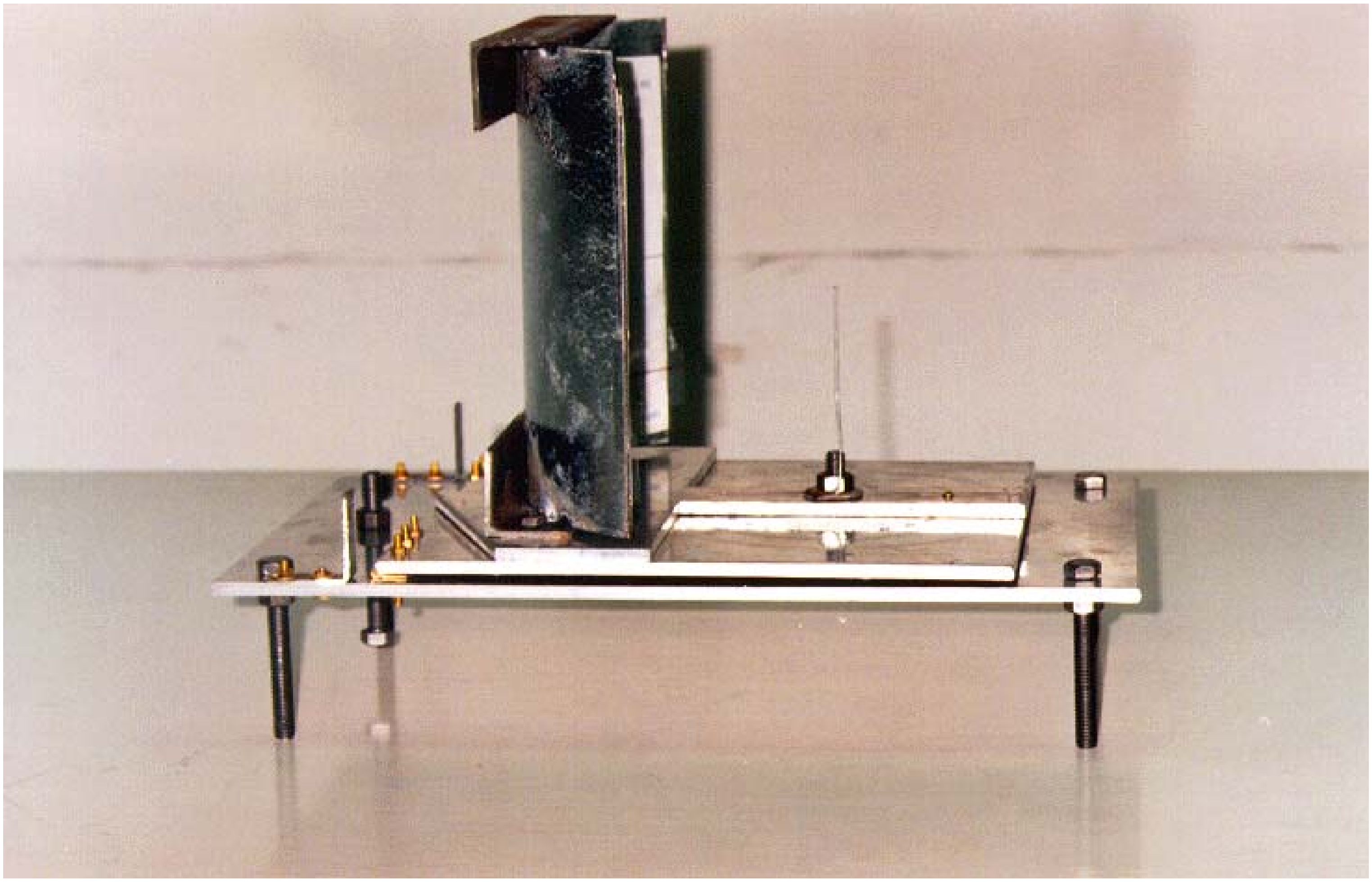
A device capable of performing as a universal sundial (i.e. in Northern / Southern Hemisphere), and other related functions are reported.

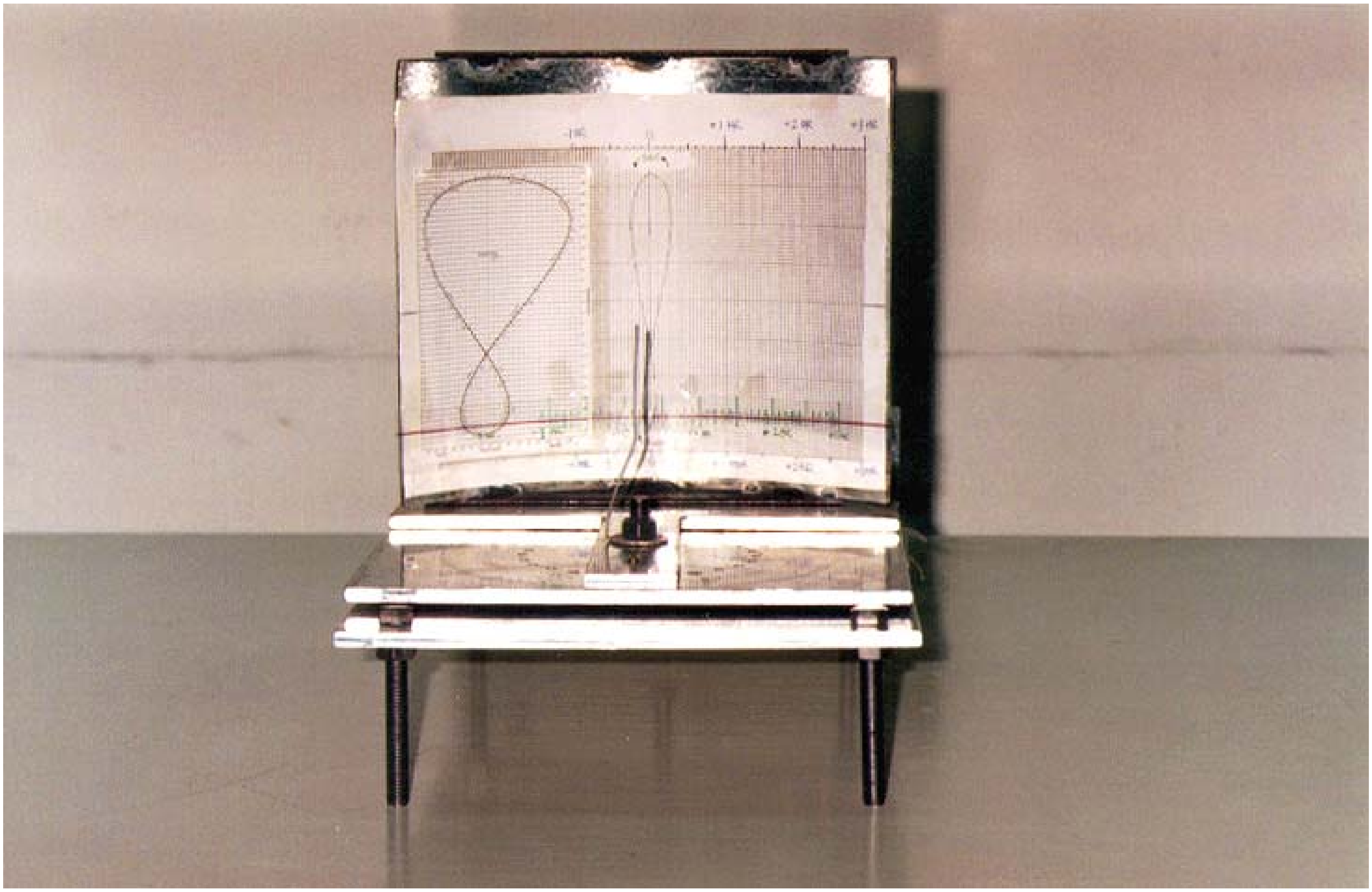
This device will contribute as a teaching tool in the related subject.

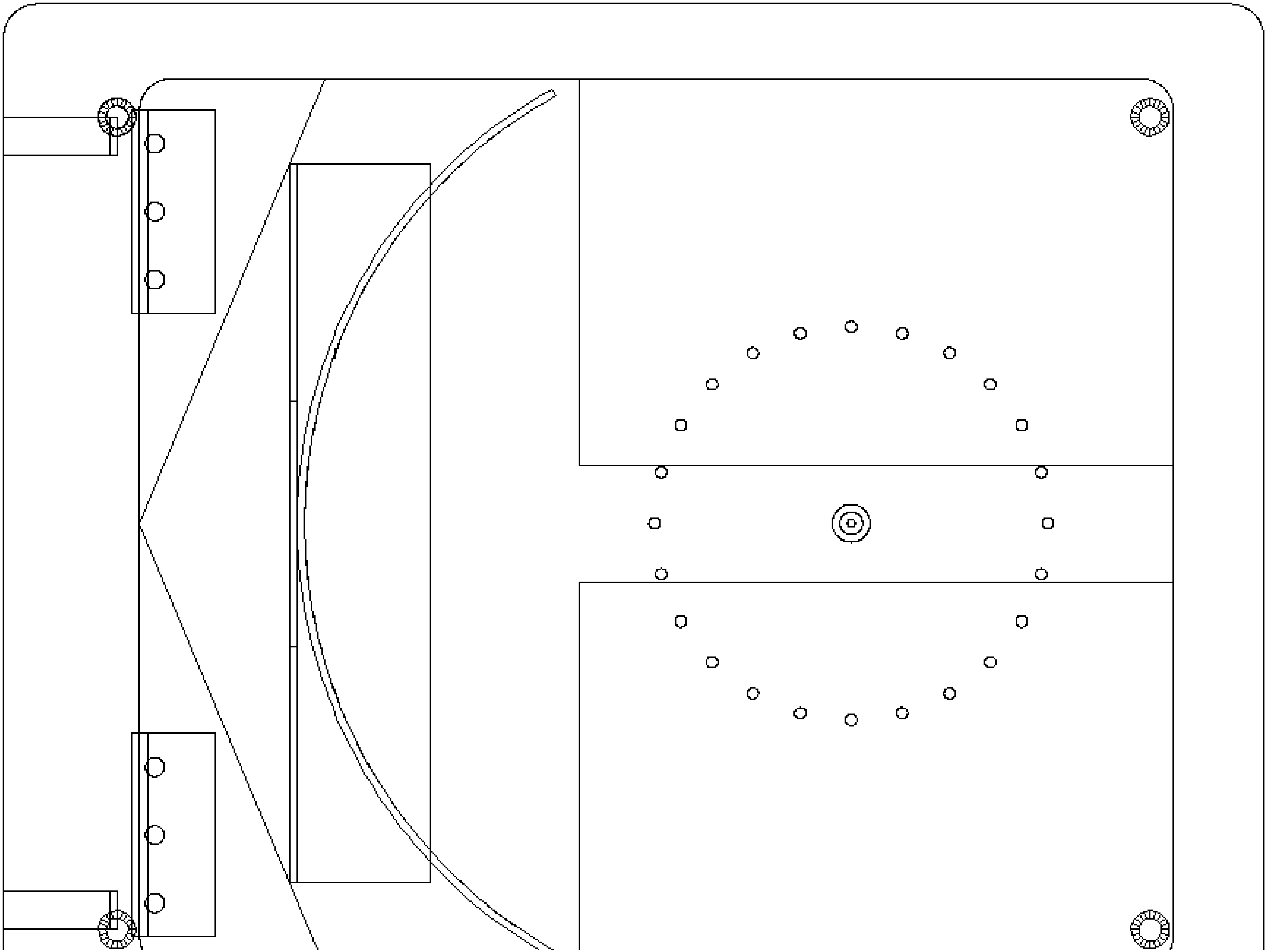
It is also seen that the globe gains an additional value, because with the additional components, it can perform as a universal sundial, and as a demonstrating device for other related functions.

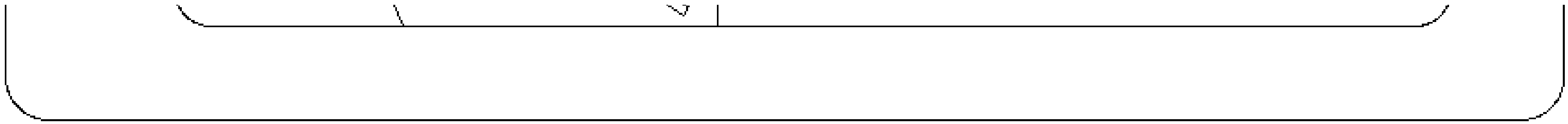
8. Reference

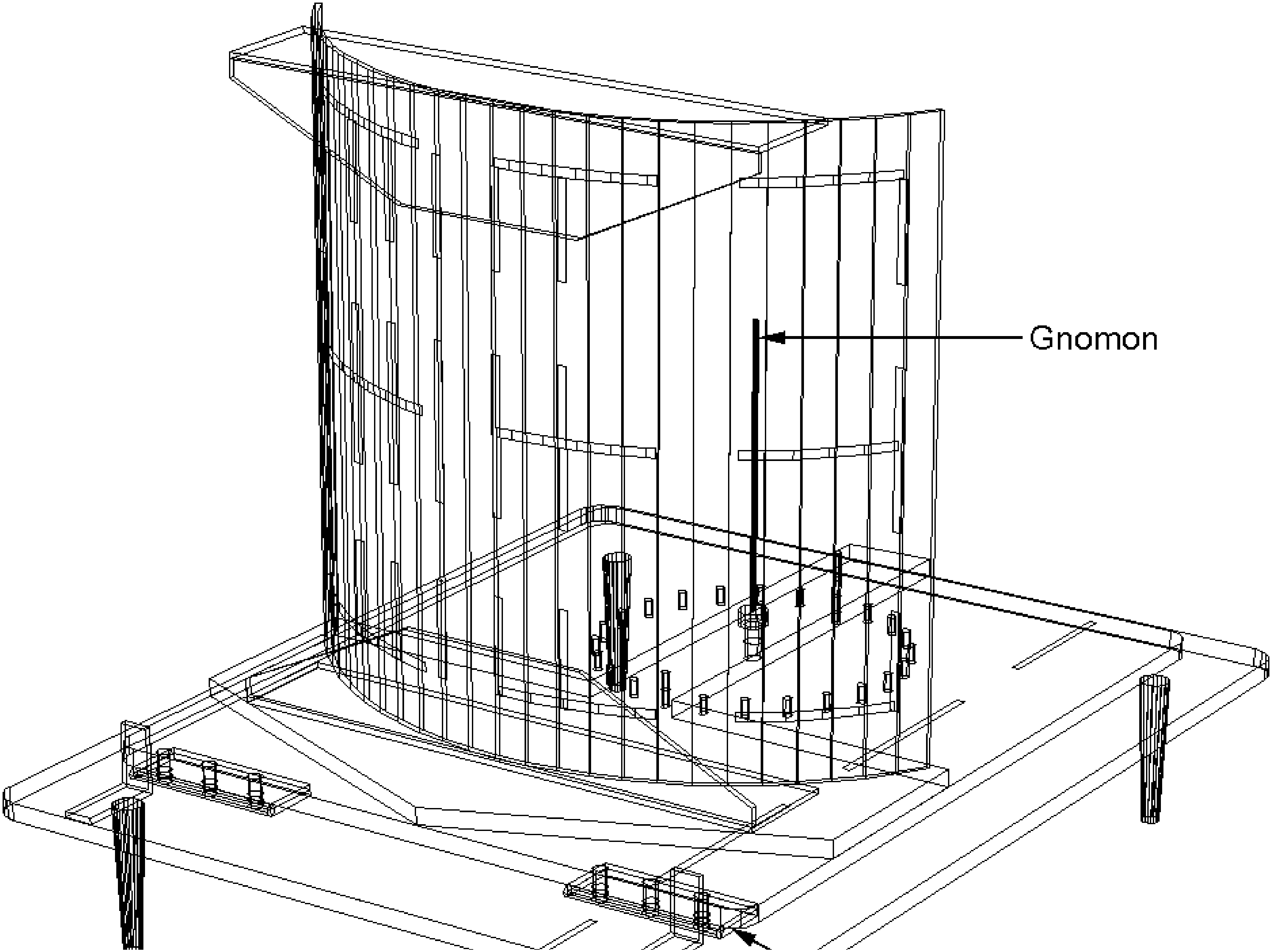
1. Strahler AN. Physical Geography. 4th ed. Wiley 1975. pp 83
2. Olgyay & Olgyay. Solar Shading Device. Princeton University Press. 1957. pp 29 -30

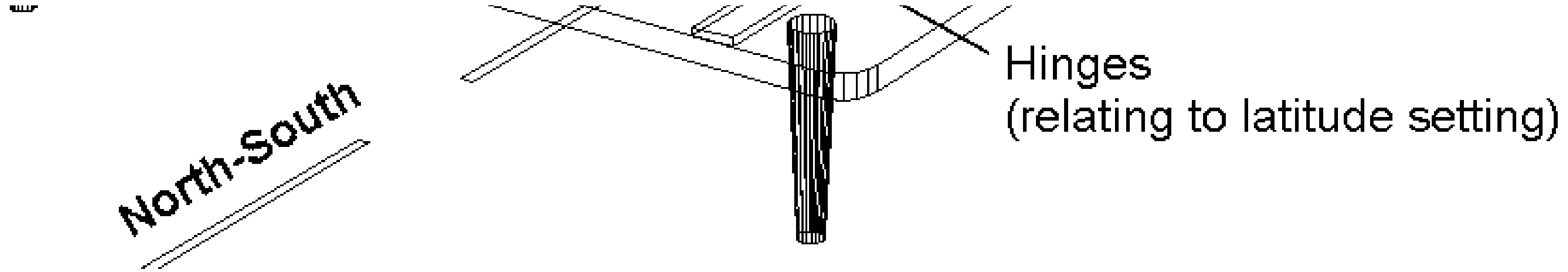


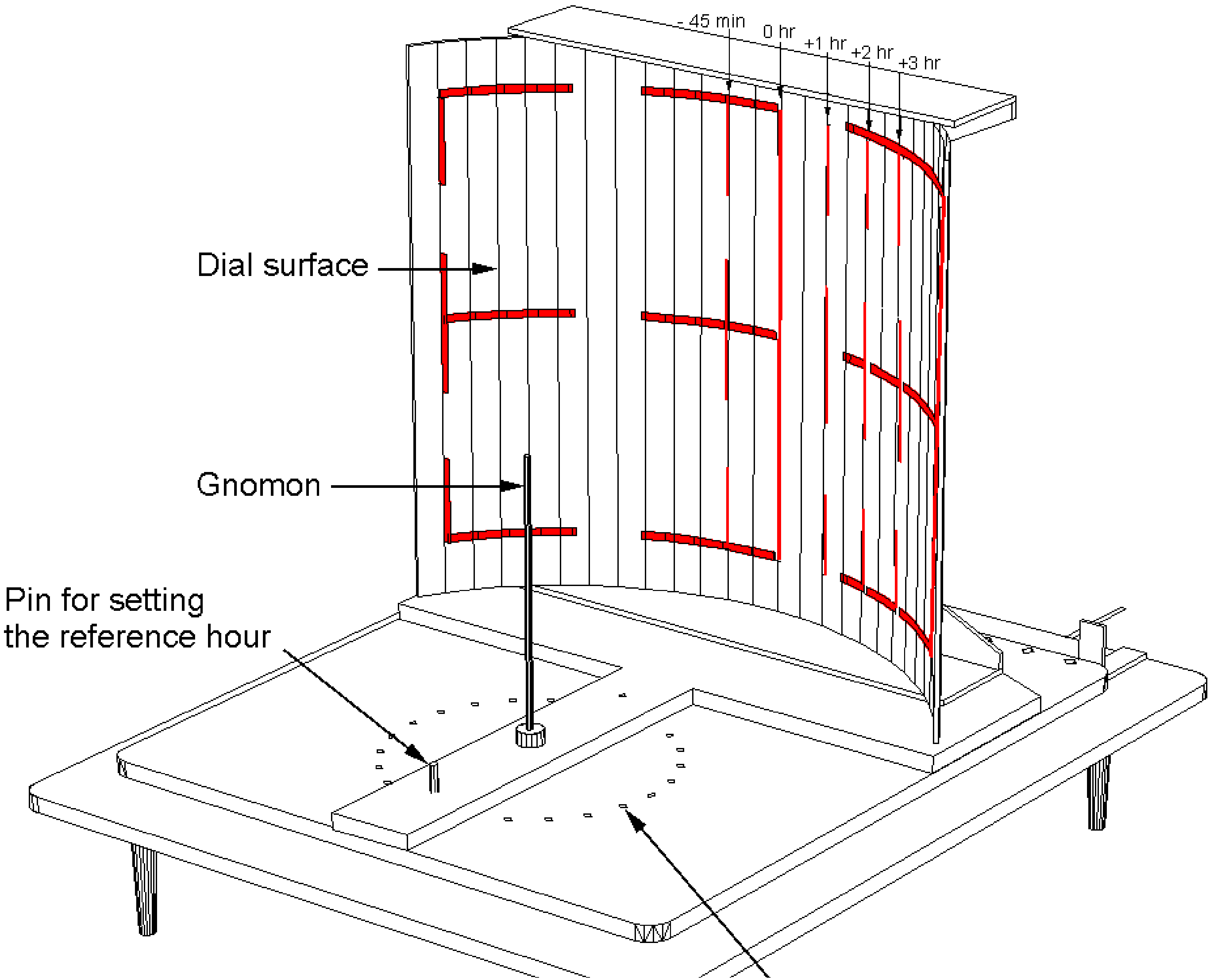


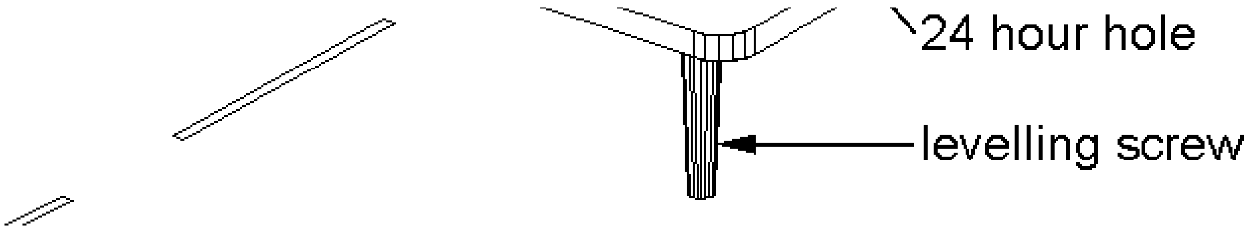


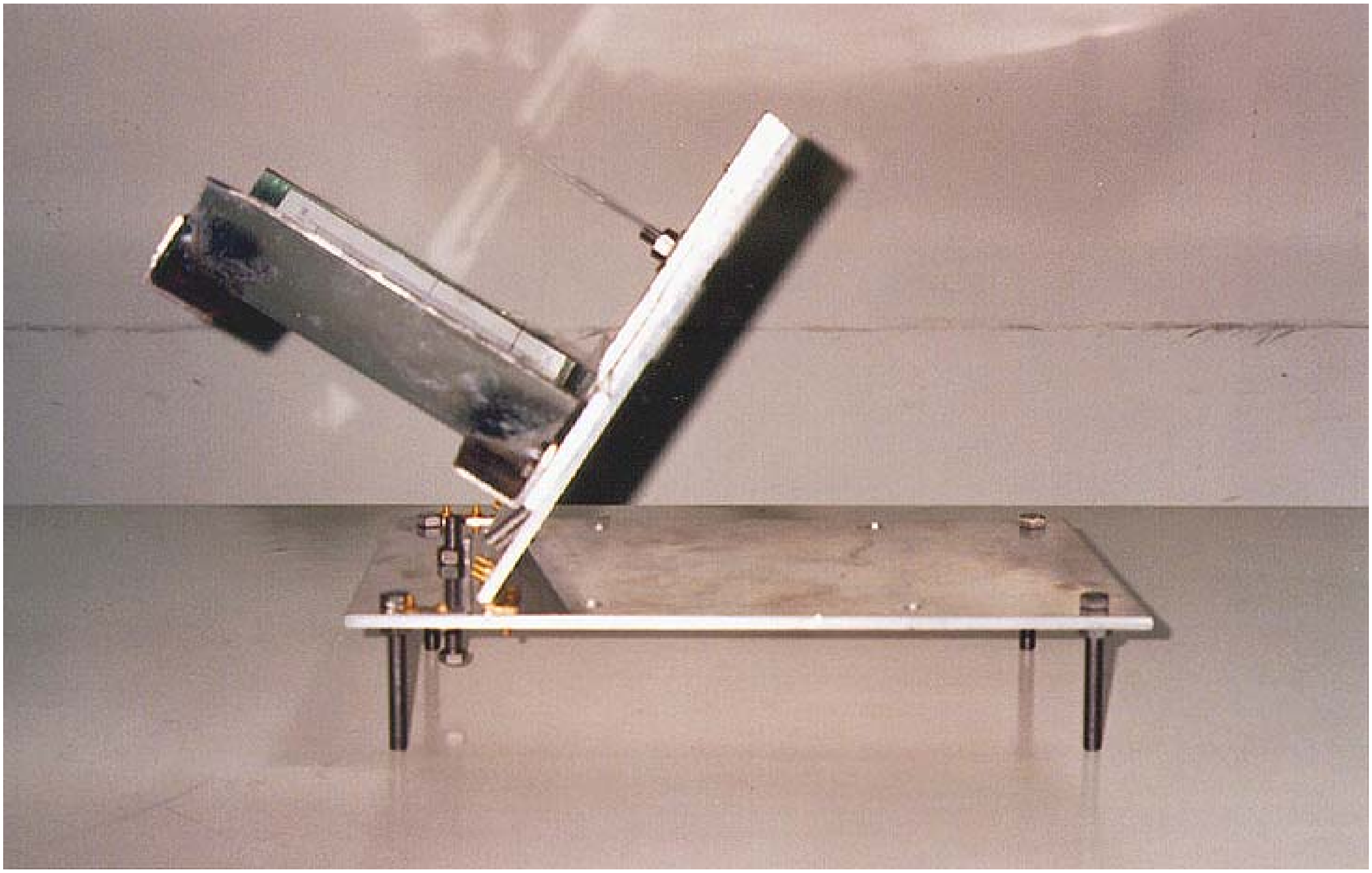


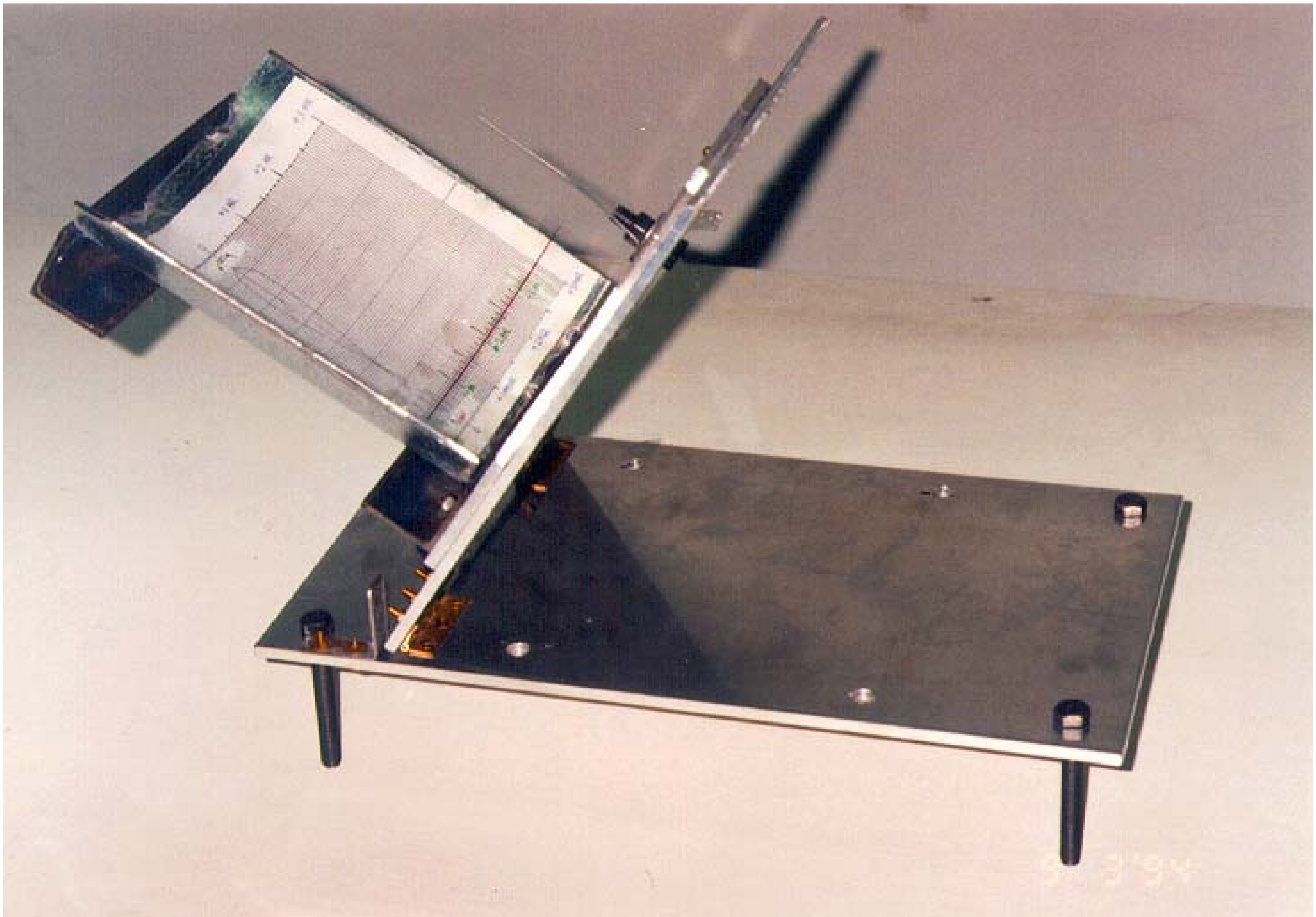

Gnomon

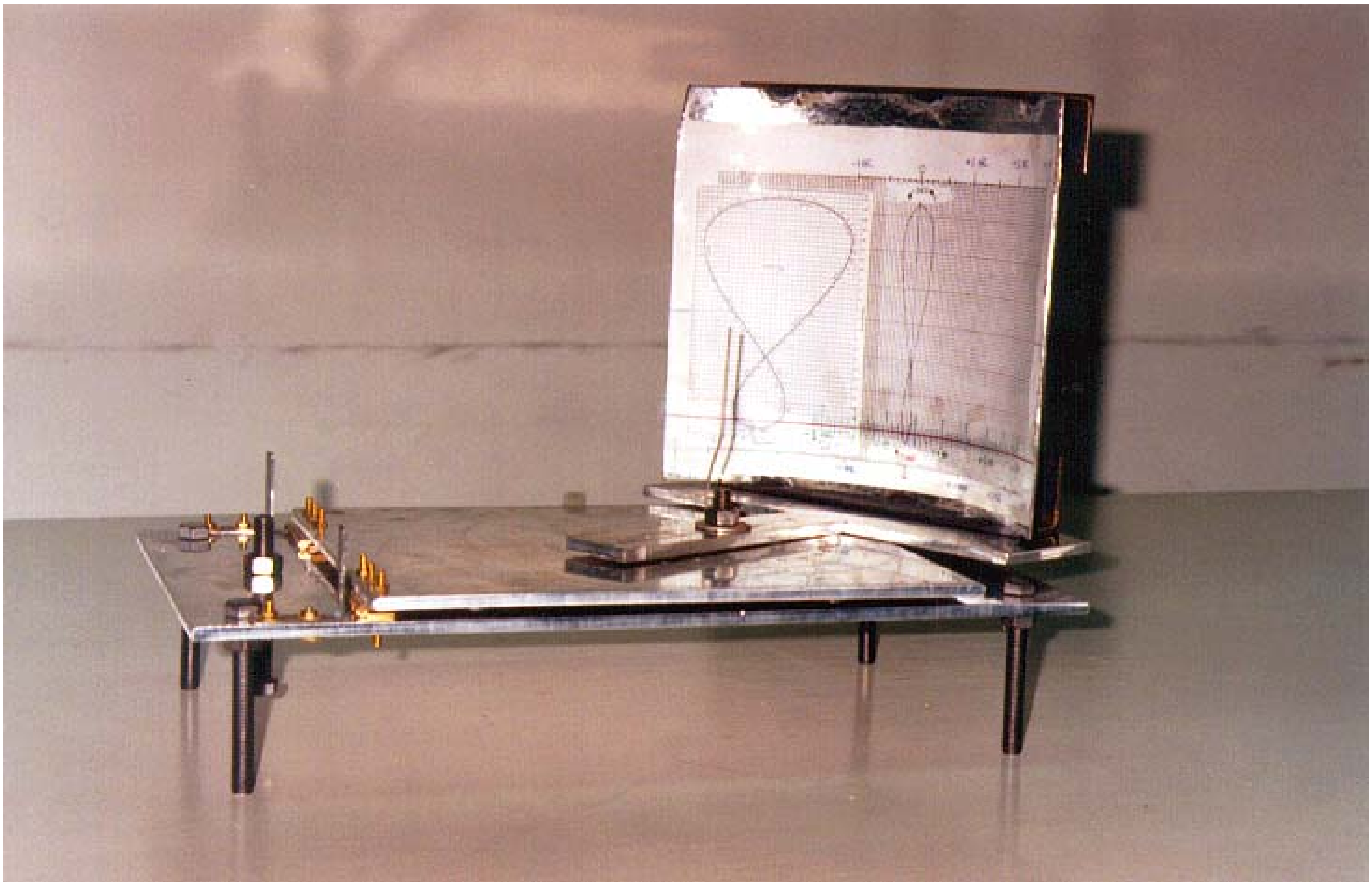

North-South
Hinges
(relating to latitude setting)

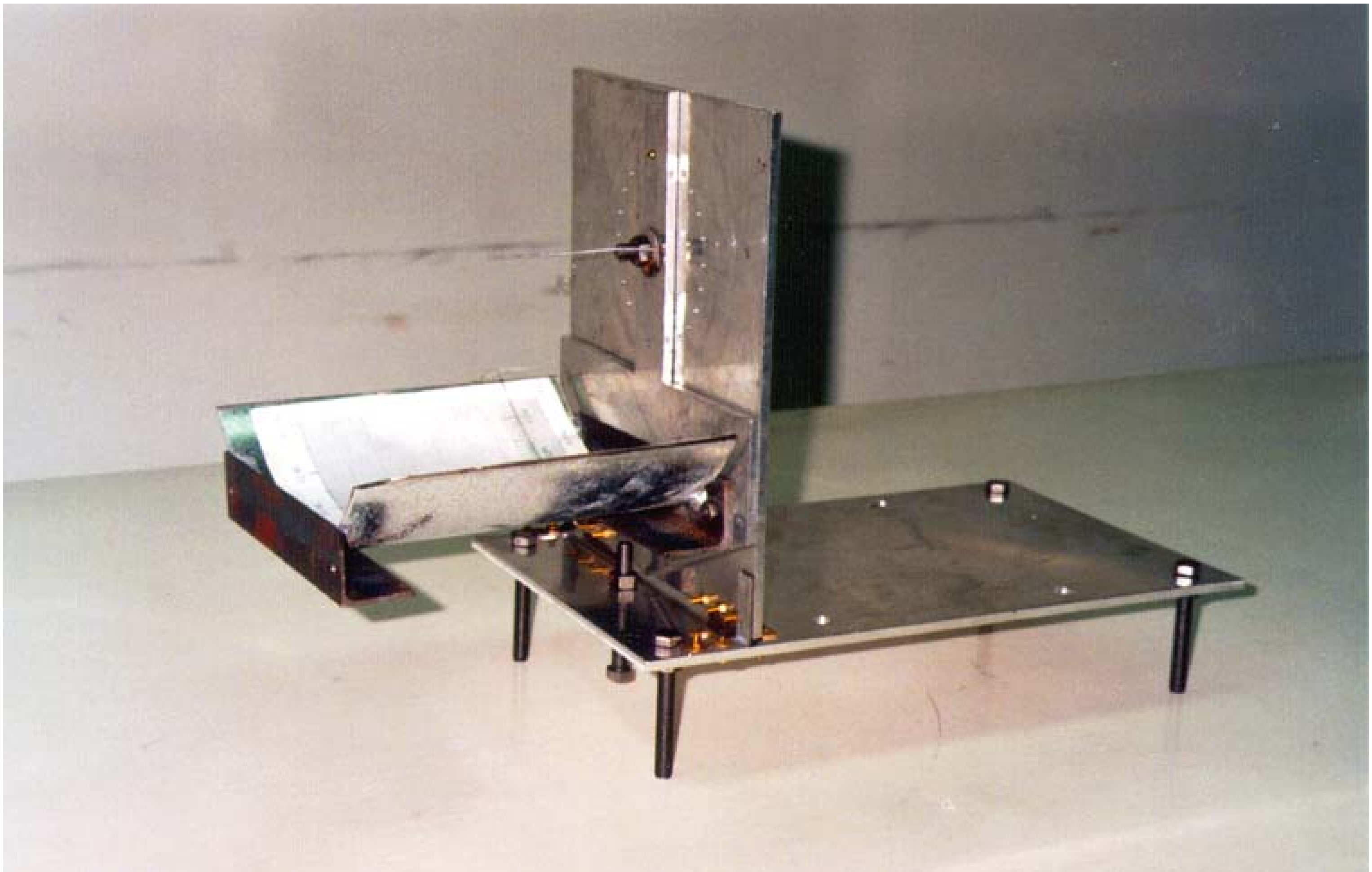

- 45 min
0 hr
+1 hr
+2 hr
+3 hr
Dial surface
Gnomon
Pin for setting
the reference hour

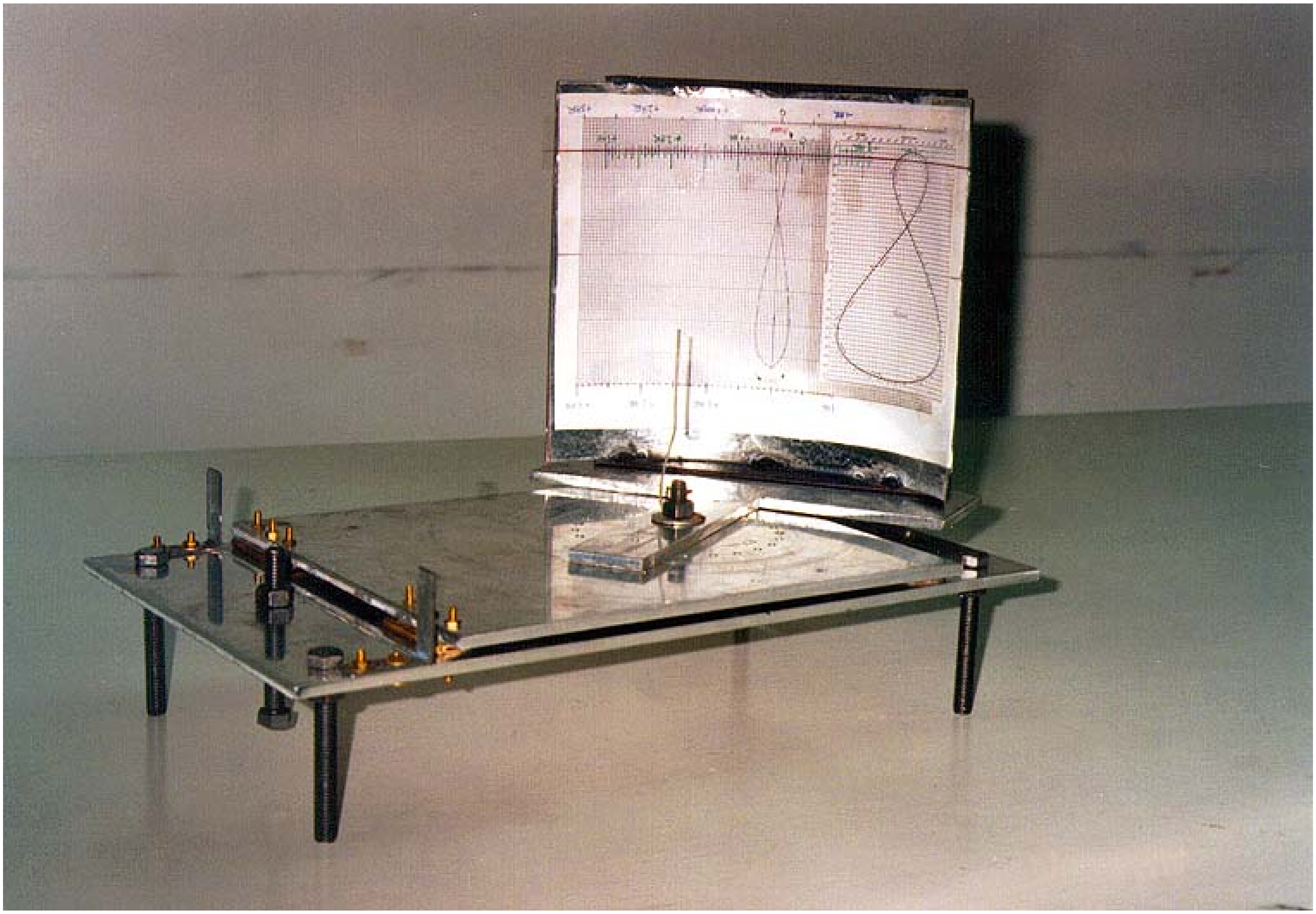

24 hour hole
levelling screw

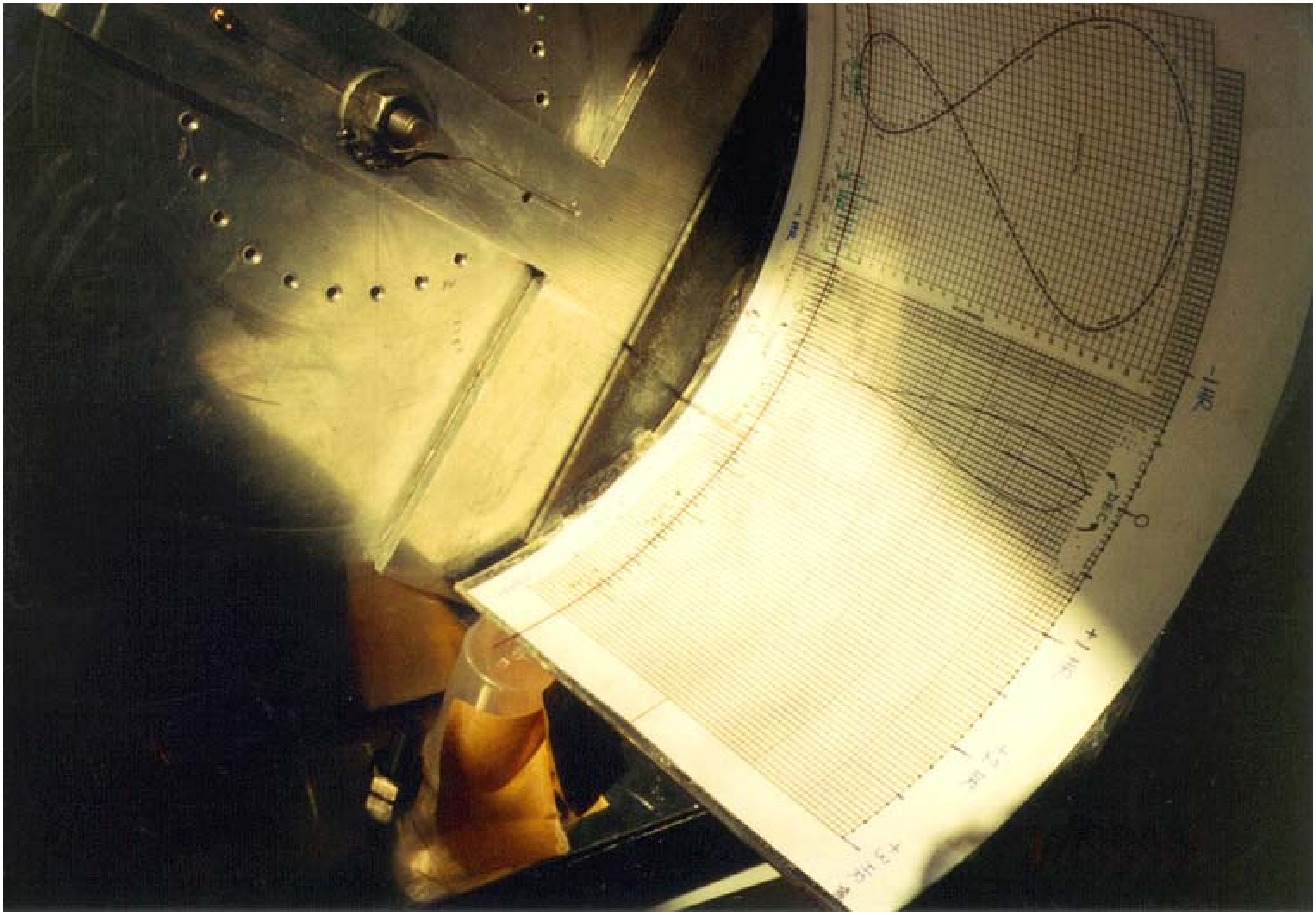


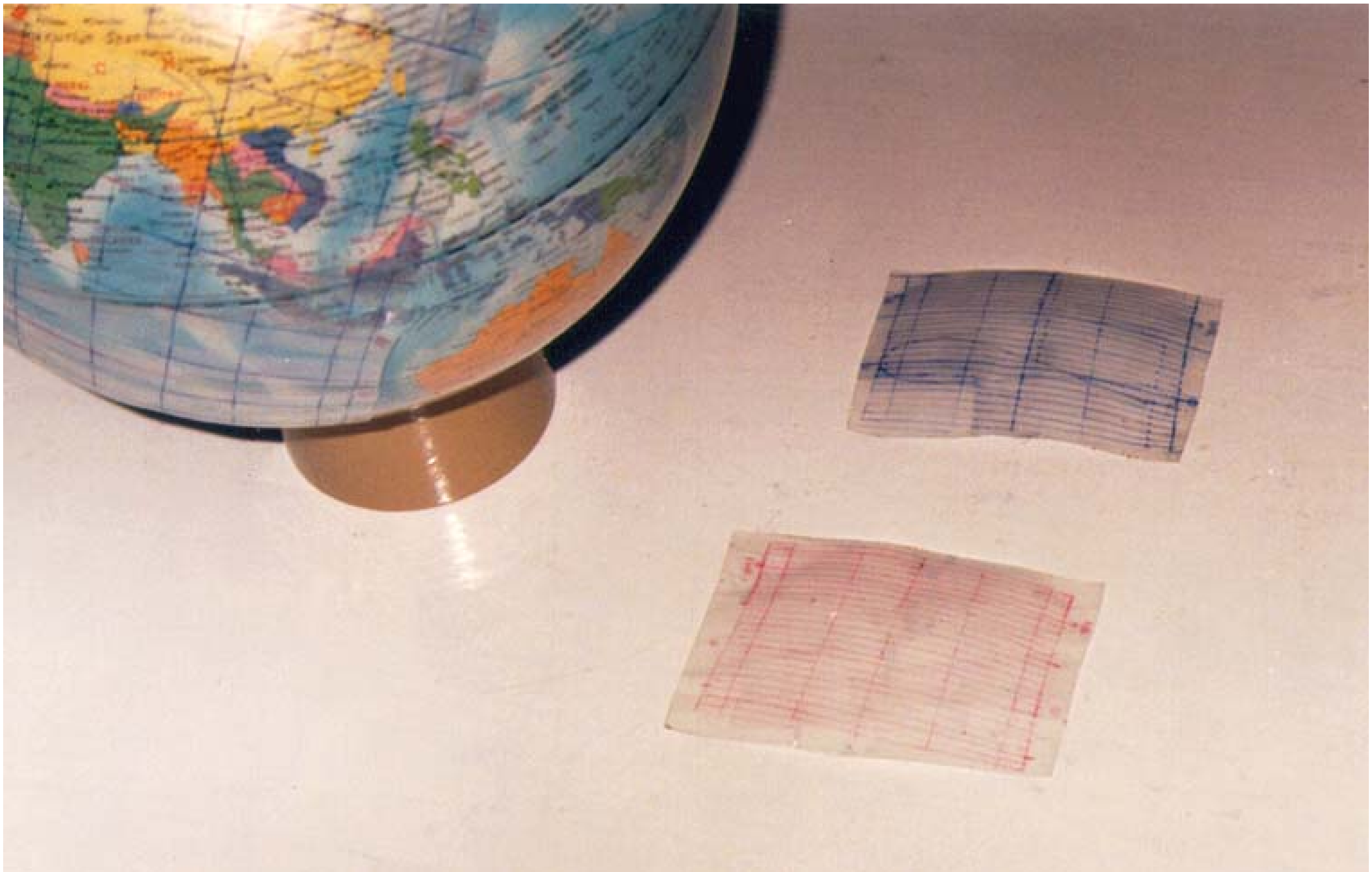






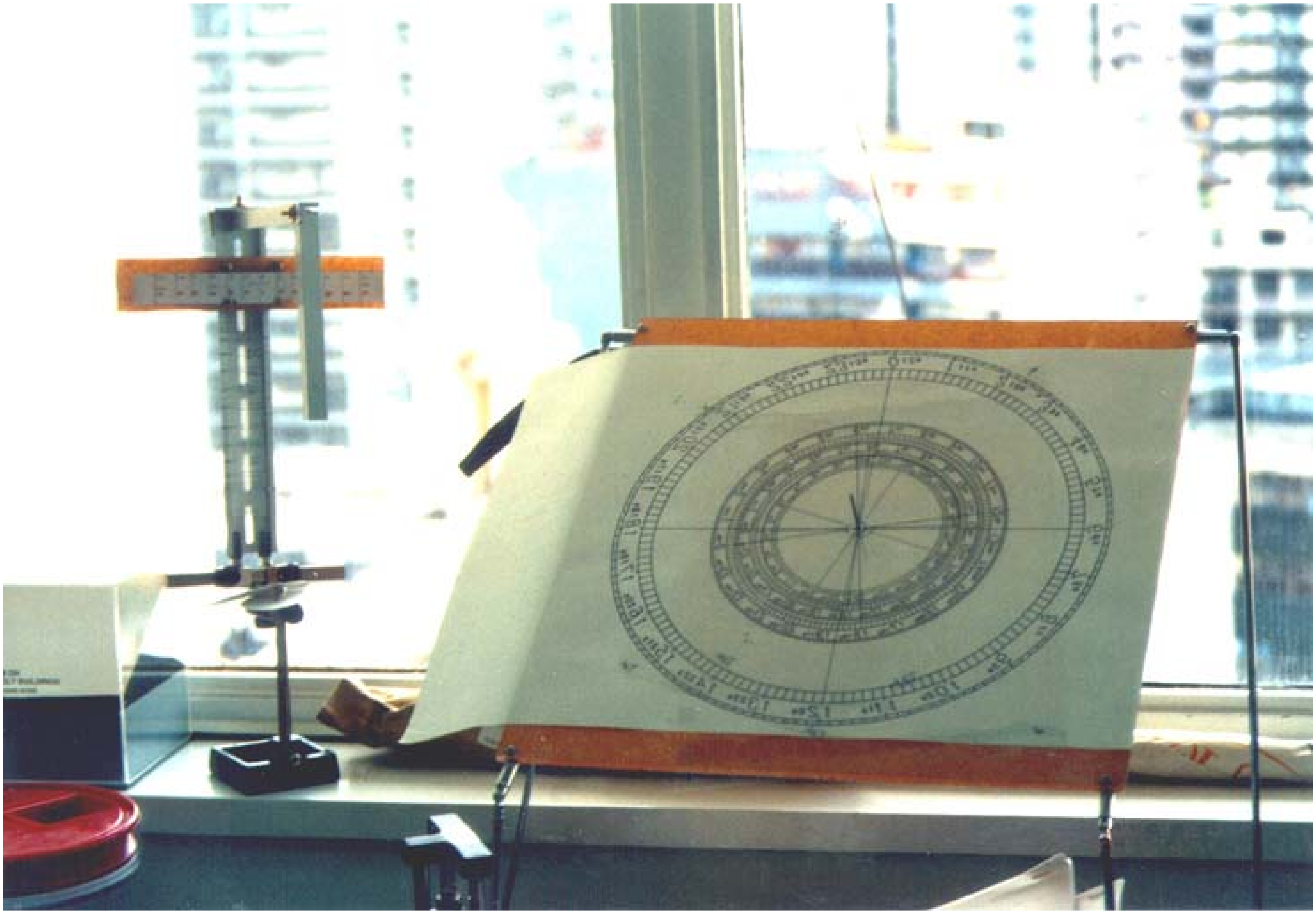







NORTH
PACIFIC


INDIAN
OCEAN



K.P. Cheung, Department of Architecture, The University of Hong Kong
This page started in July 1997

AN APPRAISAL OF SUNDIAL TECHNOLOGY WITH A PROPOSED NOMENCLATURE SYSTEM FOR SUNDIALS

(Note: This is the draft of a paper not yet completed)

ABSTRACT

Before mechanical watches became popular, sundials were commonly used in telling time, with primitive ones appeared not later than 1500 B.C. (Rohr, 1963). Sundials excelled in their cultural and technology expressions in various ages, especially from 1400 A.D. to 1900 A.D. (Whipple 1988, Gouk 1988, Lloyd 1992). Yet the past sundials lacked in the following areas, viz. expressing graphically the full range of geographical parameters and sundial dimensions in an easily understandable way to the user, availability of tester for sundial, the pursuit for enhanced accuracy of sundials, a rationalised nomenclature system for sundials.

This paper attempts to discuss these areas, particularly a proposal on a nomenclature system for sundials.

1. INTRODUCTION

There are various types and forms of sundials collected in Museums (Whipple 1988, Adler 1994), maintained in existing historic sites (Mayall 1938a), erected in contemporary buildings (Adzema 1978a, Swensen 1995).

These existing sundials, however have not address all of the following areas of concern for sundial technology.

1.1 Geographical parameters

Basic geographical parameters related to sundials are:-

- Time (Apparent Solar Time, Standard Time adjusted with equation of time and time zone meridian calculation)
- Day (i.e. solar declination angle)
- latitude (s)

1.2 Sundial components

A sundial is made up of the following 2 basic components which are mounted / fitted by accessories to perform the sundial functions for relating the above geographical parameters:-

- A gnomon(s) in casting bright spot (i.e. point form) or / and shadow (i.e. a point shadow or / and a line shadow); with the gnomon to be fixed or / and movable
- Availability of the sundial and its components and relative ease of manufacture and assembly
- Operation independence of the sundial (i.e. if a compass, spirit levels or other accessories are needed)

- Portability of the sundial
- Availability of Verification Tool / Testing Tool for the sundial
- Dial surface which is movable or / and fixed, which is plane or / and cylindrical or / and spherical or / and otherwise; with its orientation (i.e. fixed orientation or movable orientation) to be identified making reference to the horizontal plane and the meridian plane of the locality

1.3 In assessing a sundial, the following items are of interest:

- The range (i.e. full range or partial range) of the geographical parameters taken care by the sundial, including the universality in latitude application.
- Can the full range of the geographical parameters of the sundial be related with sundial dimensions and illustrated graphically for reasonably easy understanding by the user and others interested
- Do mathematical equations exist for relating the geographical parameters and the sundial dimensions
- Accuracy of the geographical parameters by design principle of the sundial (e.g. dimensions of gnomon and its distance from dial surface), by manufacture and / or assembly, by reading the sundial by the user and the repeatability of these accuracies.
- Can a generalised nomenclature system for sundials (i.e. a well organised and rationaled system that can tell most, if not all of the above areas of concern) be formulated.

REFERENCE

Adhler 1994

Adzema 1978a

Gouk

Lloyd

Rohr (1963)

Swensen (1995). Richard D. Swensen Sundial. Physics Building. University of Washington, Seattle, USA. http://www:

Whipple

BACKWARD HOME

Fig. 2 The analemma

The analemma is a graph which gives both the declination of the sun and the equation of time for every day of the year.

(Taken from p.82, Physical Geography, 14th edition, Wiley 1975, by AN Strahler)

Fig.1 The Relationship of Solar Geometric Parameters (For Northern Hemishpere)

Notes:

1. The diagrams are drawn with L=22.37°N (the latitude fo Hong Kong)
2. O is an observer on earth

Frequently Asked Questions

about Sundials

Hosted by Bob Terwilliger

1. What is a sundial and how do they work?

Books to read

- Albert Waugh: ***Sundials, Their Theory and Construction***
  - Waugh is perhaps the best "first book", but it uses logarithms in the computations - simply ignore them.
- Newton and Margaret Mayall: ***Sundials: Their Construction and Use***
- René Rohr: ***Sundials: History, Theory, and Practice***

Web Sites

- What is a Sundial? - The Franklin Institute Online
- Sundials - History, Theory, and Types of sundials from The Royal Observatory, Greenwich
- Sundials - Sundial history From the National Institute of Standards and Technology
- A Glossary of Sundial Terms - By John Davis

- **Return to top**

2. How can I make my own sundial?

- All the Books to Read include instructions for making sundials.

- Before you start

- Make a horizontal dial with a straightedge, compass, and protractor
  Includes links for equatorial and vertical dials

- a similar graphic approach

- Some simple trigonometry for a horizontal dial

- How long should my gnomon be?

- Use a shareware CAD program and special macros written by NASS members

- Special Software for making Sundials
  - zw2000
  - Shadows

  A note on materials: For anything in metals you would have to explore for sources, but for ordinary projects, you can probably get weather-proof boards similar to plywood from your local sign shop. They might also be able to provide durable vinyl numerals etc. which can be custom made from computer files.

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3. I have a sundial. How do I set it up?

There are two steps to setting up a sundial

- Check your dial, and align it to True North - Although there are exceptions, most common dials must be oriented with regards to north
- Correcting a dial to your latitude - Assumes a commercial mass produced dial.

- Can I just twist my dial for Daylight Savings Time?
  In general, it won't work for most common horizontal sundials.

  If you have a bowstring equatorial, or similar dial, you may be able to rotate the shadow receiving surface 15º, or one hour, toward the east.

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4. Why doesn't my sundial tell clock time?

- The latitude correction
- The longitude correction (time zone offset)
- The Equation of Time

- **Return to top**

7. What is the best way to buy a sundial?

In order to be a true solar timekeeper, a sundial should be made specifically for the location where it is going to be used. Avoid the mass produced commercial horizontal dials available from landscape and gardening supply houses. Some commercial bow-string equatorial dials can be adapted to your location. Find out before you buy.

See the question I have a sundial. How do I set it up? in this FAQ for some of the problems with mass produced horizontal dials. Some of these dials are not even laid out correctly and will not function under any circumstances.

Makers who will custom design and build a sundial for you can be found here on the NASS Links page under **Artisans**.

Or... Make your own, and join the fascinating world of Dialing!

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8. More advanced questions

- What is the Equation of Time?
  - A simple explanation
  - Analemma
  - An indoor analemma

- **Return to top**

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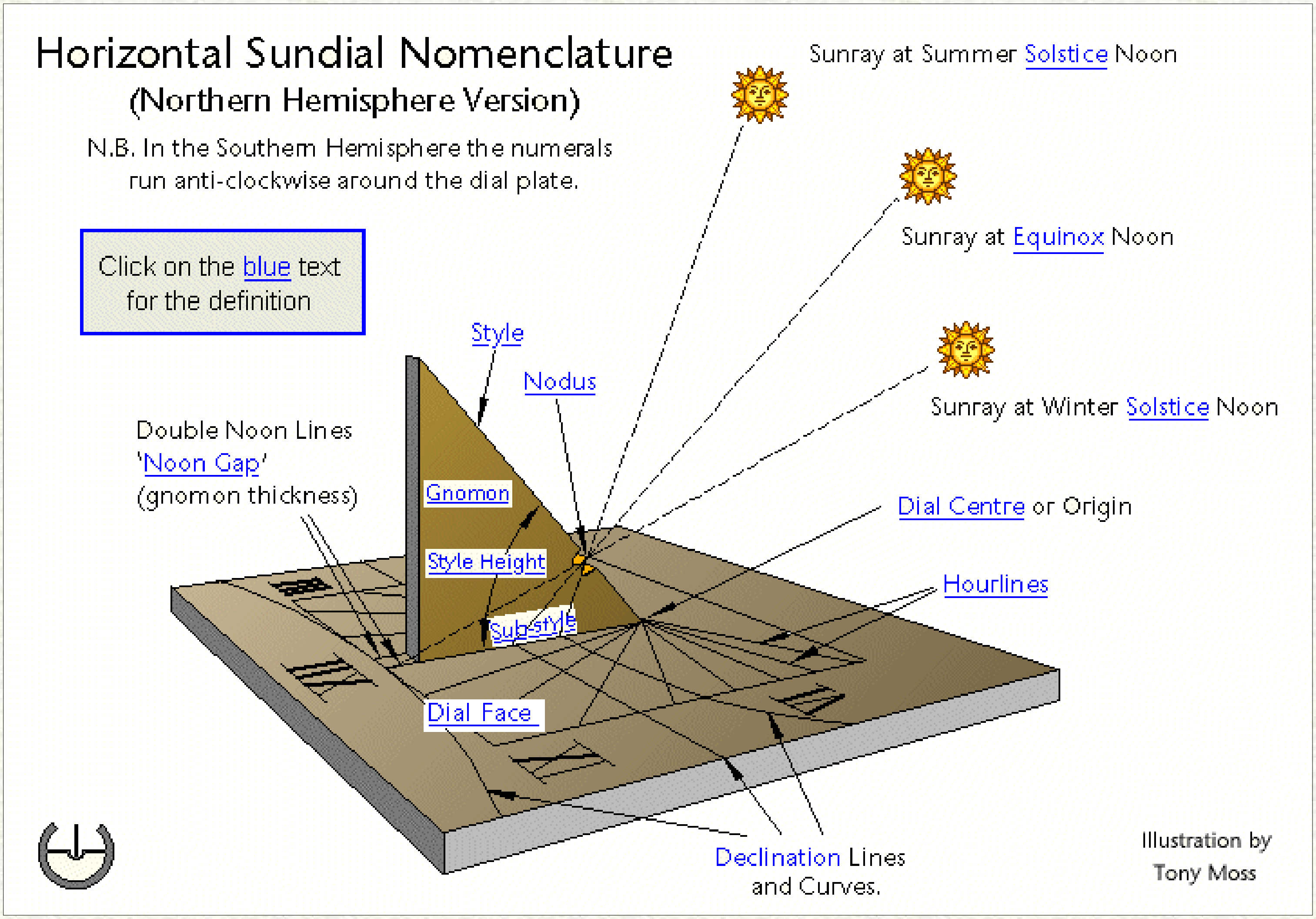


This illustration and abbreviated glossary are excerpted from that of the **British Sundial Society**, written by **John Davis**. Used with permission. You are encouraged to explore the complete glossary.

altitude (of the sun): the angular distance of the (centre of) the sun's disk above the observer's horizon.

altitude dial: any dial which uses the sun's altitude, rather than its azimuth, for indicating the time. Usually does not need to be aligned N-S. Examples are analemmatic dials, ring dials, and shepherds' dials.

axis (of the Earth's rotation) or **polar axis**: the line running through the true North and South poles about which the Earth rotates.

azimuth (of the sun): the angle of the sun, measured in the horizontal plane and from true south. Angles to the west are positive, those to the east, negative. Thus due west is 90°, north is ±180°, east –90°.

centre (of a dial): the point where all the hour lines, and a polar-pointing style, meet. In simple horizontal or vertical dials, this point coincides with the root of a (thin) gnomon. In the case of a thick gnomon having two styles, there are two centres to the dial.

declination (of the sun): the angular distance of the Sun above or below the celestial equator. Its value follows an annual sine wave like curve, varying between 0º at the equinoxes and ±23.4º (approx.) at the solstices. It has positive values when the Sun is above the celestial equator (summer in the Northern hemisphere) and negative when below.

dial face (or dial plate): the physical surface on which the hour lines and furniture lie. It (usually) supports the gnomon.

ecliptic (plane): (pron. e-clip-tic) the plane that the Earth's orbit traces during a year. The orbits of the Moon and the planets are also close to this plane. It is a great circle on the celestial sphere.

Equation of Time: the time difference between Local Apparent Time (apparent solar time) and mean solar time at the same location. Its value varies between extremes of about +14 minutes in February and –16 minutes in October. It arises because of the elliptical orbit of the Earth, and the tilt of the Earth's axis to the ecliptic. The preferred usage by diallists is:

mean solar time = apparent solar time + EoT

but this sign convention is by no means universal and the opposite sign is used in modern almanacs. Irrespective of the sign convention adopted, sundials will always appear slow compared to mean time in February, and fast in October/November.

equator: the great circle of the Earth (or other celestial body) which is equidistant from the poles. It has, by definition, a latitude of 0º.

equator, celestial: the intersection of the extended plane of the Earth's equator with the celestial sphere.

equatorial plane: the plane through the Earth defined by the equator.

equinoxes: (vernal or spring, autumnal or fall) literally "equal nights" i.e. equal amounts of daylight and night-time. The Sun's declination at the equinoxes is 0º. The vernal equinox is around 20-21 March, the autumnal equinox is around 22-23 September.

furniture: all features on a dial face other than the hour lines and their numerals are referred to as dial furniture. This may include declination lines and curves, a compass rose, Equation of Time graphs or tables, mottoes etc. Other common furniture includes: date, maker's and/or benefactor's name, coats of arms, and latitude and (rarer) longitude.

gnomon: (pron. no-mon) the physical structure of a sundial which casts the shadow (from the Greek for "indicator"). The gnomon today is most-often polar pointing (sometimes described as an "axial gnomon"), although it may also be horizontal or vertical. The distinction between gnomon and style made (and encouraged in this Glossary) in modern dialling literature is not the one used in early works, and the two words are still sometimes used interchangably.

horizontal dial: the common or garden sundial with a horizontal dial face and polar-pointing gnomon.

hour angle: Local Apparent Time expressed as the angular position of the Sun in its daily track. Measured from noon, it increases by 15º per hour with increasing time (i.e., morning hours are negative). Beware, this convention is not universal.

hour line: the line on a dial face indicating the shadow position at a particular time (includes fractional as well as whole hours).

latitude: The angular position of a place north or south of the equator. Positive values in the Northern hemisphere, negative in the South (i.e., the South Pole = -90º).

Local Apparent Time: solar time, as derived from the real Sun at any particular location. It is the hour angle of the Sun + 12 hours. Some authors (non-UK) may refer to it a Local True Time.

longitude: the angular location of a place on the Earth's surface measured east or west of the Prime meridian though Greenwich, England. Longitudes W are positive, E are negative.

Mean Solar Time: the authoritative (by the National Physical Laboratory) definition is: a measure of time based conceptually on the diurnal motion of the fictitious mean Sun, under the assumption that the Earth's rate of rotation is constant.

nodus: a point which casts a shadow to indicate the time and/or (more often) the date on a dial face. It may take the form of a small sphere or a notch on a polar-pointing gnomon, or it may be the tip of a gnomon with an arbitrary (usually horizontal or vertical) orientation.

noon, solar : the time when the sun is due south of the observer's location. At solar noon the sun is at it's highest altitude, or angular distance above the observer's horizon. Not to be confused with 12:00 standard time.

noon gap (or **gnomon gap** or **split noon**): the gap in the hour scale of a dial to account for the finite thickness of the gnomon. It is positioned on the dial face where the Sun is in the same plane as the gnomon, i.e. at noon for horizontal or direct S dials.

orbit (of the Earth): the path of the Earth around the sun. For dialling purposes, this is taken as elliptical, with a very small eccentricity, i.e., it ignores the small perturbations due to the effects of the Moon and other planets.

poles (N and S of the Earth): the locations on the Earth's sphere with latitudes of +90º (N) and –90º (S).

pole, celestial: the points where the Earth's axis meet the celestial sphere. The stars appear to rotate around these poles.

solar time: the same as Local Apparent Time.

solstices: (Summer, Winter) literally, "Sun stands still". In the Northern hemisphere, they represent the beginning of summer (on or around 21 June) and the beginning of winter (on or around 21 December). They are the days with the shortest and longest night-times and correspond to the extreme values of declination.

sphere, celestial: an imaginary sphere, arbitrarily large and co-centred with the Earth, on which all the stars appear to be fixed.

style {stile}: the line in space which generates the shadow edge used to indicate the time on the dial face. Note that a gnomon with finite thickness will have two styles (one along each of the upper edges) which will each be operational for parts of every day. If the gnomon is in the form of a long rod, the style will be the virtual line running along the centre of the rod and the dial is read by estimating the centre of the shadow.

style height: of a polar style is the angle that the style makes with the sub-style line. Note that this is an unusual use of the word "height", and **style angle** could be regarded as a better term.

sub-style (line): the line lying in the dial plane which is perpendicularly below (or behind for a vertical dial) the style.

vertical dial: any dial in which the dial face is vertical.

Sundial Types

Most planar (flat) sundials are categorized by the orientation of the face - the surface that receives the shadow.

- Horizontal
- Vertical - including declining and reclining
- Polar
- Equatorial and Armillary
- Polyhedral - combining various orientations on multiple faces
- Analemmatic
- Other Types

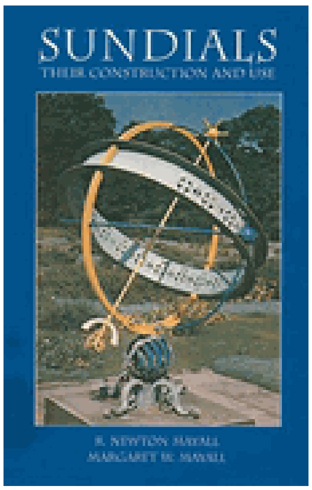
Links

The Sundial site of Frans Maes - Explore the left frame.

Sundial Types - François Blateyron

Types of Sundials - Sundials on the Internet

By Subject > Science and Mathematics > General Science



Zoom

Sundials: Their Construction and Use

R. Newton Mayall
Margaret W. Mayall

(Usually ships in 24 to 48 hours)

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Y
Avai

ISBN: 048641146X
Page Count: 320
Dimensions: 5 3/8 x 8 1/2

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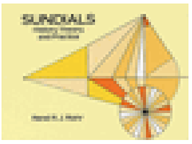

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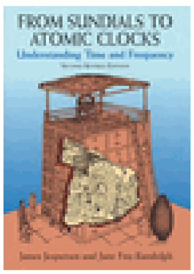

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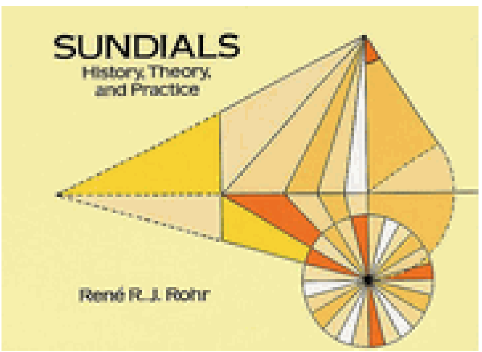

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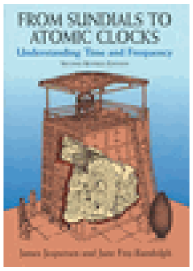

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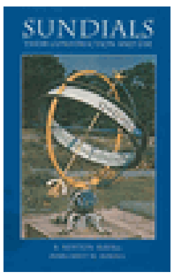

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Sun Clocks

What Is a Sundial?

B-r-r-r-ring! Your alarm clock is telling you that it's time to get out of bed and go to school. Sometimes we wish that clock would just disappear!

Have you ever wondered how you would keep track of time if all the clocks in the world really did disappear? Long ago our ancient ancestors were faced with just such a problem. Clocks, as we know them today, hadn't been invented yet.

How did man first learn to measure time? The difference between the dark nights and the daylight was probably the first division of time recognized by early peoples. They would also have noticed that the sun came up over the eastern horizon and went down again below the western horizon bringing darkness to their world.

During the day they saw that the shadow cast by a tree, a rock, or even their own body was long early in the morning and grew shorter and shorter until it disappeared when the sun was overhead in the middle of the day. They also would have noticed that the shadow grew longer again, on the other side of the tree, as night came.

After awhile they were able to tell how much of the day was over by looking at the shadows. The first timepiece was probably invented by a person who put a stick in the ground and made marks in the dirt to show where the stick's shadow was every hour.

The shadow stick is the earliest form of sundial. People judged the time of day by the length and position of the stick's shadow. The technical name for a shadow stick is gnomon,(NO mon) which is Greek for "the one that knows".

The ancient Egyptians built tall stone towers called obelisks. Everybody could tell the time by looking at the obelisk's shadow. Obelisks were sometimes called "Cleopatra's Needles".

How Do Sundials Work?

As the earth turns on its axis, the sun appears to move across the sky. The shadows the sun casts move in a clockwise direction for objects in the northern hemisphere. If the sun rose and set at the same time and spot on the horizon each day shadow sticks would have been accurate clocks. However, the earth is always spinning like a top. It spins around an imaginary line called its axis. The axis runs through the center of the earth from the North Pole to the South Pole. The earth's axis is always tilted at the same angle.

Every 24 hours the earth makes one complete turn, or rotation. The earth rotates on its axis from west to east. The earth's rotation causes day and night. As the earth rotates, the night side will move into the sunlight, and the day side will move into the dark.

On the earth's yearly trip around the sun the North Pole is tilted toward the sun for six months and away from the sun for six months. This means the shadows cast by the sun change from day to day.

Because the earth is round, or curved, the ground at the base of a shadow stick will not be at the same angle to the sun's rays as at the equator. Because of this the shadow of the shadow stick will not move at a uniform rate during the day.

Eventually man discovered that angling the gnomon and aiming it north made a more accurate sundial. Because its angle makes up for the tilt of the Earth, the hour marks remained the same all year long. This type of gnomon is called a style. After this discovery, people were able to construct sundials that were much better at keeping accurate time.

The History of Sun Clocks

Many types of sundials evolved as man worked towards creating accurate timepieces.

Egyptians began using a T-shaped "time stick". It consisted of one vertical stick and one crossbar The names of five hours were written on the stick in hieroglyphics. In the morning the stick was placed so that it faced east. The shadow of the crossbar would then fall across the stick and move toward the crossbar until noon. In the afternoon the stick was turned to face west.

Around 1500 BC smaller Egyptian timepieces were created. The sundial was a smaller version of the obelisk. The discovery of small, portable versions of sundials tells us that taking time with them became important to the Egyptian people.

In the Middle Ages peasants in northern Europe used sundials carved into the bottom of their wooden clogs. To tell time, the peasant would take off his shoe and stand it up facing the sun. The hour was told by the shadow the heel cast on the dial.

Another medieval European device for telling time was the hand dial. The gnomon on this sundial was just a stick. It was held at angle by a person's thumb. The gnomon was held in his left hand in the morning and the hand was held horizontal to the ground, pointing west. In the afternoon the gnomon was held in the right hand and the hand was pointed east.

In the quest for better accuracy throughout the shifting position of the Earth during the year, sundials changed from flat plates to more detailed forms.

During the Renaissance period sundials changed rapidly and many various designs were created. In addition to having hour and minute marks for telling time, other features were sometimes added. Some sundials had markings to indicate the seasons, the calendar date, the times of sunrise and sunset, Zodiac signs, and the points of the compass.

People continued to make sundials long after clocks were invented. Sundials could be counted on to keep accurate time, and they were often used to set the time on clocks that had stopped! The sundial was still the most popular way of keeping time until watches were invented making it easier for people to tell time wherever they were.

Today most people who have sundials in their gardens use them for decoration rather than as a way of keeping time. Thanks to the invention of the digital wristwatch, people no longer need to carry around a portable sundial. But sundials should not be forgotten by modern man. The sun will always rise in the morning and set at night, making sundials remain one of the most reliable methods of telling time.

Go back one level

- Astronomical instruments
- Comets, meteors and asteroids
- Explorers and leaders
- General astronomy
- Greenwich
- Life at sea
- Life in the 17th century
- Navies and warships
- Navigation
- Periods and events
- Ports, docks and dockyards
- The Royal Observatory
- Space exploration
- Stars
- Timekeeping
- The universe
- Vessels
- The solar system

Sundials

History of the sundial

From time immemorial Man must have realised that the changing length of the shadow of an object indicated the time of day - that the shadow shortened towards noon and lengthened again towards evening. No doubt the first crude sundial consisted of no more than a vertical stake in the ground. Eventually Man must have realised that the changing length of the shadow could be used, probably with stone markers, in the same manner as we use the hands of a clock today. This notable step forward in Man's attempt at measuring time was at least 3,500 years ago as the earliest known sundial, found in Egypt, dates from that time.

The day was then subdivided into 12 parts which we refer to as 'temporary hours'. Of course the temporary hours would vary in length, being longest in summer and shortest in winter, although in the Mediterranean lands the difference is nothing like as noticeable as it would be in the British Isles. In the latter case an 'hour' in summer would have been twice as long as an 'hour' in winter!

It was not until the 13th century that an Arab named Abul--Hassan introduced the idea of making all hours of equal length, and it was not until the 15th century that these equal hours were in general use.

During the Renaissance period the development of sundials proceeded rapidly and many varied and ingenious designs were produced. In addition to having hour and minute marks for telling the time, other features were often incorporated. Thus the 'furniture' of a dial might also consist of markings to indicate the seasons, the calendar date, times of sunrise and sunset, the signs of the Zodiac and the dates of the Sun's entrance into each sign, the position of the Sun relative to the horizon (azimuth and altitude), and the points of the compass. A few dials were made which also carried a crude form of tide table indicating the time of high tide at certain named ports when the Moon was observed in a particular direction. However, sundials were gradually superseded by clocks though it is recorded that the French railways regulated their clocks by sundials right up to the end of the nineteenth century.

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See also:

- Astronomy

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1. History of the sundial
2. Sundial theory
3. Types of sundial
4. Sundials in Cambridge

Useful pages

- The equation of time

Related websites

- A comprehensive list of sundial links on the internet.
- The British Sundial Society.
- The Tercentenary Sundial and the Greenwich Water Tanks

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Ä

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Sundials

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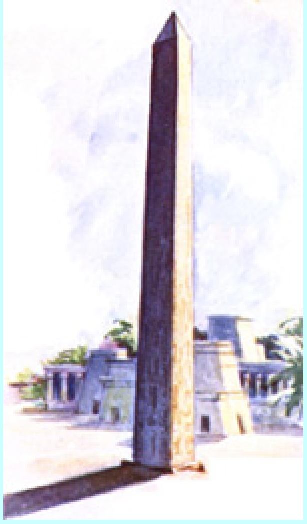

Not until somewhat recently (that is, in terms of human history) did people find a need for knowing the time of day. As best we know, 5000 to 6000 years ago great civilizations in the Middle East and North Africa initiated clock-making. With their bureaucracies and formal religions, these cultures found a need to organize their time more efficiently.

After the Sumerian culture was lost without passing on its knowledge, the Egyptians were the next to formally divide their day into parts something like our hours. Obelisks (slender, tapering, four-sided monuments) were built as early as 3500 B.C. Their moving shadows formed a kind of sundial, enabling citizens to partition the day into two parts by indicating noon. They also showed the year's longest and shortest days when the shadow at noon was the shortest or longest of the year. Later, markers added around the base of the monument would indicate further time subdivisions.

Another Egyptian shadow clock or sundial, possibly the first portable timepiece, came into use around 1500 B.C. to measure the passage of “hours.” This device divided a sunlit day into 10 parts plus two “twilight hours” in the morning and evening. When the long stem with 5 variably spaced marks was oriented east and west in the morning, an elevated crossbar on the east end cast a moving shadow over the marks. At noon, the device was turned in the opposite direction to measure the afternoon “hours.”

The *merkhet*, the oldest known astronomical tool, was an Egyptian development of around 600 B.C. A pair of *merkhets* were used to establish a north-south line by lining them up with the Pole Star. They could then be used to mark off nighttime hours by determining when certain other stars crossed the meridian.

In the quest for more year-round accuracy, sundials evolved from flat horizontal or vertical plates to more elaborate forms. One version was the hemispherical dial, a bowl-shaped depression cut into a block of stone, carrying a central vertical gnomon (pointer) and scribed with sets of hour lines for different seasons. The *hemicycle*, said to have been invented about 300 B.C., removed the useless half of the hemisphere to give an appearance of a half-bowl cut into the edge of a squared block. By 30 B.C., Vitruvius could describe 13 different sundial styles in use in Greece, Asia Minor, and Italy.

Hours Calendar Water Clocks

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A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

Introduction Dial types Hours (types of) Time (types of) Illustration

Symbols Equations Chronology Sources Appendices

The BSS Sundial Glossary

Several letters to the BSS Bulletin in 1999 suggested that a sundialling glossary would be useful in furthering the society's aims. It is hoped that this resulting glossary will fulfil two objectives. The first of these is to provide newcomers to dialling with a reference document which will explain the many strange terms or unusual usages of common words which they will come across in the dialling literature.

The second objective is to try to produce definitive meanings of the terms which diallists sometimes use rather loosely, and which can therefore lead to some confusion. Thus when several words have the same meaning, the preferred use is described here. Likewise, an attempt has been made to produce a standardised set of symbols for the most widely used terms in dialling equations.

Choices between different meanings have been made on the basis of adopting the most common modern usage found in the literature (particularly those items shown in the Sources section) as long as this does not produce confusion. Alternative usages, spellings or conventions which may be met, particularly in early dialling works, have been given where possible, but it is hoped that future authors will adopt the preferred definitions given here.

As English is used in countries other than the UK, there may be alternative definitions overseas. However, this glossary has been assembled with collaboration from the North American Sundial Society and, via the medium of the internet, diallists worldwide, so it is not expected that there will be major differences in terminology throughout the majority of the English-speaking world.The alphabetical section of the glossary consists of over 190kb, please watch the status bar of your browser and wait for the entire document to load.

John Davis - BSS Glossary Editor

UPDATES TO THE EDITOR

It is proposed to update this glossary periodically, so that it will develop along with the science of dialling. If you have any comments, corrections or additions, please inform the editor at john.davis@btinternet.com or at the address below.

John Davis
Orchard View, Tye Lane
Flowton,
Ipswich IP8 4LD
UK

May 2000

SCOPE

The glossary contains mainly terms which are directly related to dials and dialling. Additionally, excursions into the fields of astronomy, horology, optics and solar sciences have been made where it seems useful. Some comments on the history of dialling are made, but there are no direct entries for famous diallists, except where something is named after them.

NOTATION

Words thus are links to entries in this glossary or other internal references.

Bold text indicates a definition.

~ indicates a repeat of the entry word.

Symbols in square brackets **[*x*, X]** give the preferred symbol and abbreviation. See section on **Symbols** for a full list.

Alternative spellings or terms to the preferred ones are shown in brackets thus: {dialing}.

Pronunciation of unusual words is shown with a simplified phonetic scheme thus: **gnomon** (pron. no-mon). If no pronunciation is given for an entry, it is pronounced as it is written (following normal Oxford Dictionary rules for English pronunciation).

A note on the Southern Hemisphere. This glossary has been written primarily for the Northern Hemisphere, since this is where the majority (but not all) of the BSS membership resides. Gnomons in the Southern Hemisphere generally point to the S celestial pole, and the hour numbers on a horizontal dial run anti-clockwise rather than clockwise. The notation and equations used in the glossary are consistent as long as the sign conventions are followed, but the reader must mentally change N to S in the text.

PRINTED VERSION

This Glossary is also published by the British Sundial Society as a printed book which is now available.

ACKNOWLEDGEMENTS

I would like to thank the numerous members of the BSS and the NASS who helped with the definitions of terms, and who provided encouragement to the project. These include, in no particular order, Margaret Stanier, David Young, Patrick Powers, John Carmichael, Harvey Frey, Tony Wood, John Ingram, Doug Bateman, Frank and Rosie Evans, David Scott, Fer de Vries, Gianni Ferrari, Tony Baigent, Chris Lusby Taylor, Mac Oglesby, Vit Planocka, Daniel Wenger, Gordon Taylor, Michael Lowne, Sara Schechner, Robert van Gent, Tony Moss, Allan Mills, Thibaud Taudin-Chabot, Gerald Stancey, Mike Cowham, Gloria Clifton.

WEB DESIGNER

Conversion of the printed version for this website has been a complex and demanding task, undertaken by BSS member Robert Terwilliger who is also the Webmaster for the North American Sundial Society.

Glossary: a list with explanations of abstruse, antiquated, dialectal or technical terms.

Before You Start

Latitude and Longitude

You will need to know your latitude - and if you wish to include a longitude correction (time zone offset) - you will need to know your longitude. If you don't know them they can be found from Internet sources.

IMPORTANT Some sites will indicate longitudes **west** of Greenwich (i.e. in North America) as **negative**. Most methods of sundial construction require west longitudes entered as **positive**.

If you live in the western hemisphere, do not use the minus sign when considering your longitude

Correcting for your position in your Time Zone

When solar time became inadequate for railway timekeeping, a system of time zones was initiated creating 24 time zones, each 15° wide - within which all clocks would tell the same time. (Basic arithmetic: The earth's 360° circumference was divided into 24 one hour segments, and the result was 24 time zones each 15° wide.)

However, the sun moves across each artificial time zone at its own pace.

If you wish your sundial to compensate for its position in its 15° time zone and approach **Standard** (clock) **Time**, you will need to apply a **longitude correction**.

This correction is determined by the relationship between the longitude of your sundial and the longitude of the central meridian of your time zone. The central meridians of all 24 time zones can be found in the table below.

If you are setting up a commercial sundial, the longitude correction will not be built into the dial, but it will be a constant amount which you must apply at each reading. If your longitude is west of your central meridian, add four minutes to the time on the dial for each degree. If you are east of your central meridian, subtract. This correction can be built into your dial if you are making one.

Even after the **longitude correction** is applied, your dial will not consistently tell **Standard Time** due to The Equation of Time which varies throughout the year. See below.

Time Zone	Number (offset)	Central Meridian	Locations

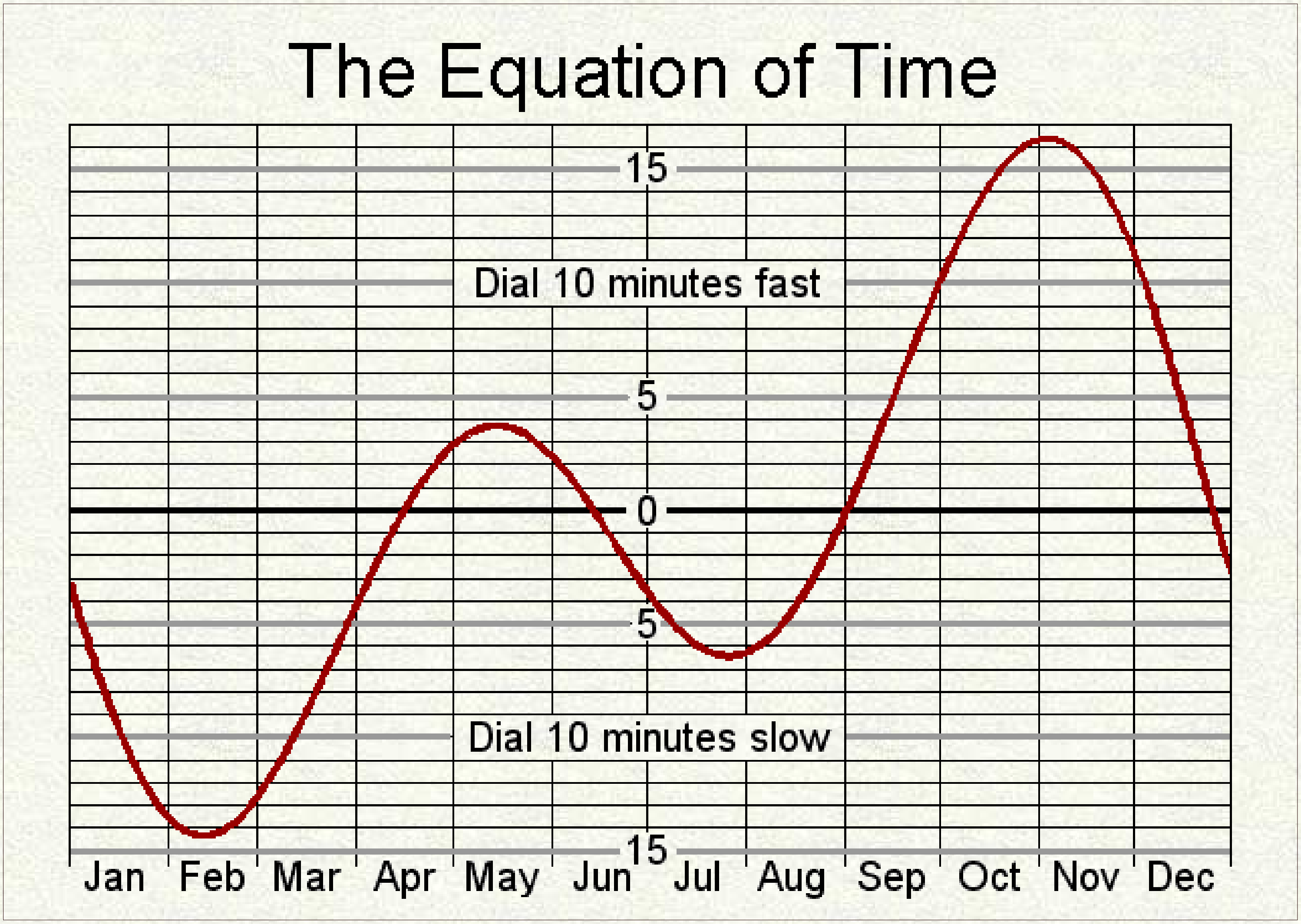
GMT-11hrs	11	165	Midway, Samoa
GMT-10hrs	10	150	Hawaii, Society Is.
NORTH AMERICA			
GMT-9hrs	9	**135**	Alaska, Pitcairn Island
US Pacific	**8**	**120**	Whitehorse, Seattle, Los Angeles
US Mountain	**7**	**105**	Yellow Knife, Denver, Phoenix, W. Mexico
US Central	**6**	**90**	Churchill, Chicago, New Orleans, E. Mexico
US Eastern	**5**	**75**	Montreal, New York, Columbia, Peru
Atlantic	4	**60**	Nova Scotia, Venezuela, (Newfoundland -30m)
GMT-3hrs	3	45	Greenland, E. Brazil, Argentina
GMT-2hrs	2	30	Georgia & S. Sandwich Islands
GMT-1hrs	1	15	Cape Verdes, Azores
Greenwich	0	0	WET, British Isles, Iceland, W. Africa
Middle Europe	-1	-15	MET, Europe, Scandinavia, C. Africa
Eastern Europe	-2	-30	EET, OEZ, Europe, Mid East, E.C. Africa
GMT+3hrs	-3	-45	Mos, Moscow, E. Africa
GMT+4hrs	-4	-60	Gorki, Oman, Mauritius
GMT+5hrs	-5	-75	Pakistan, (India +30m
GMT+6hrs	-6	-90	Bangladesh, Burma

GMT+7hrs	-7	-105	S.E. Asia, Sumatra
GMT+8hrs	-8	-120	China, Philippines, W. Australia
GMT+9hrs	-9	-135	Korea, Japan, (C. Australia +30m)
GMT+10hrs	-10	-150	P. New Guinea, Guam, E. Australia
GMT+11hrs	-11	-165	Sakhalin Peninsula, Solomon Islands
GMT+12hrs	-12	-180	New Zealand, Wake, Marshall Islands

The Equation of Time

Even if your dial includes the **longitude correction**, its timekeeping will vary throughout the year due to a phenomenon called The Equation of Time. Simply put, the **apparent** motion of the sun will cause your dial to be as much as 16 minutes fast or slow at various times of the year. The Equation is caused by the earth's elliptical orbit, and the 23.44° tilt of its axis from the plane of its orbit.

The chart below shows the amount your dial will vary from clock time through the year. Download it, print it out, and keep it close to your dial. There are dials which compensate for the Equation of Time, but they are complicated.

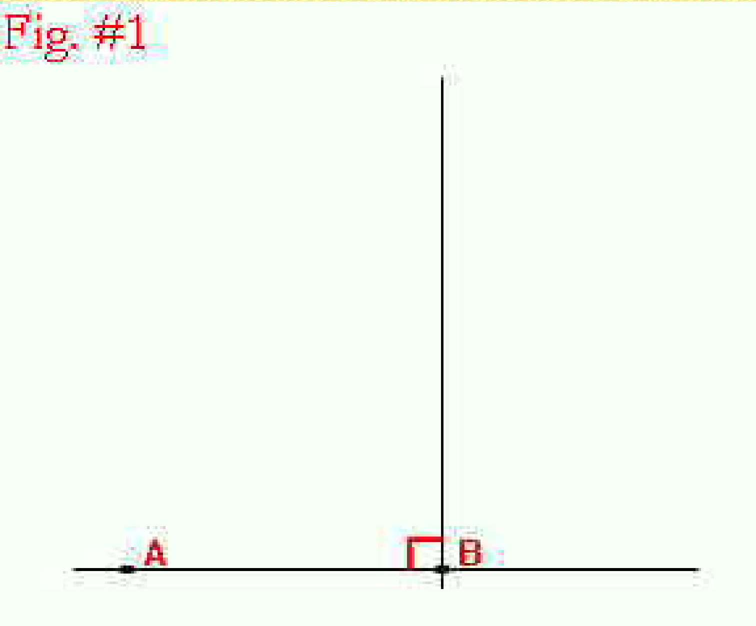


Right-click in the graph, then "Save As"

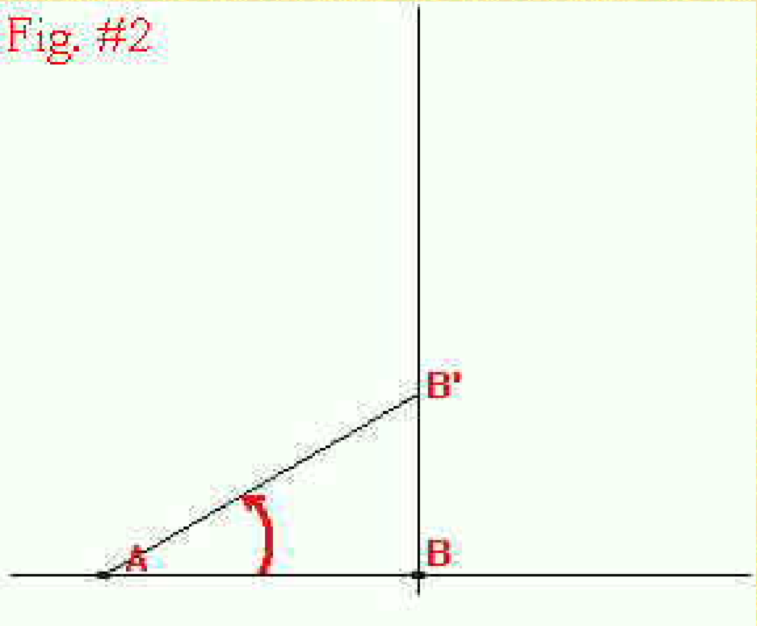
Make your own Horizontal sundial:

Materials required: A pencil, protractor, compass and a straight edge.

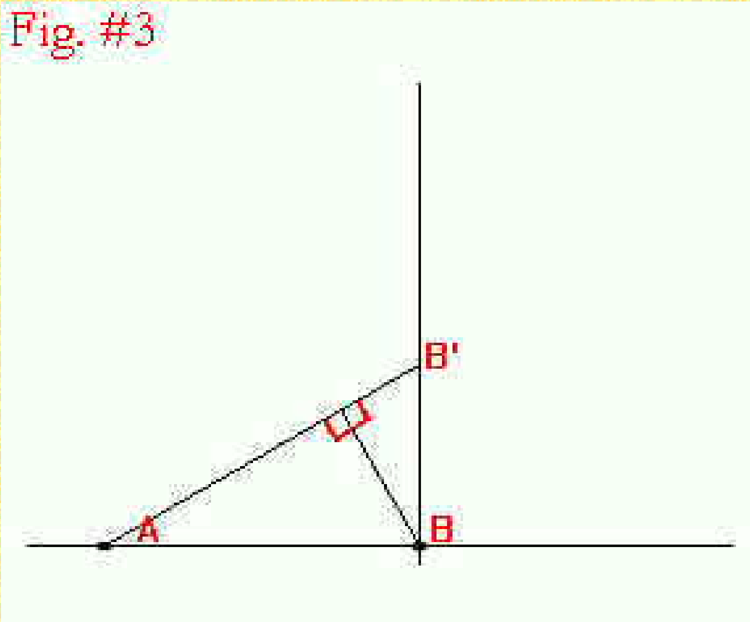
Draw a vertical line, now draw a line perpendicular (AB) to the vertical line. (Fig. #1)



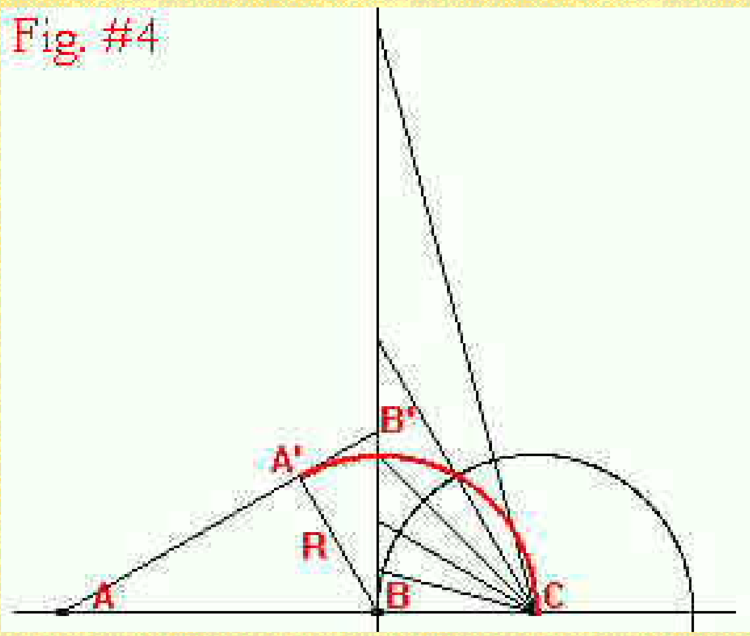
Now draw a line from A through the vertical line so that angle B'AB is equal to the latitude of the place where the dial is to be used. Remember this angle for making the gnomon. (Fig. #2)



Draw a line perpendicular to line AB' that intersects line AB at point B. (Fig. #3)

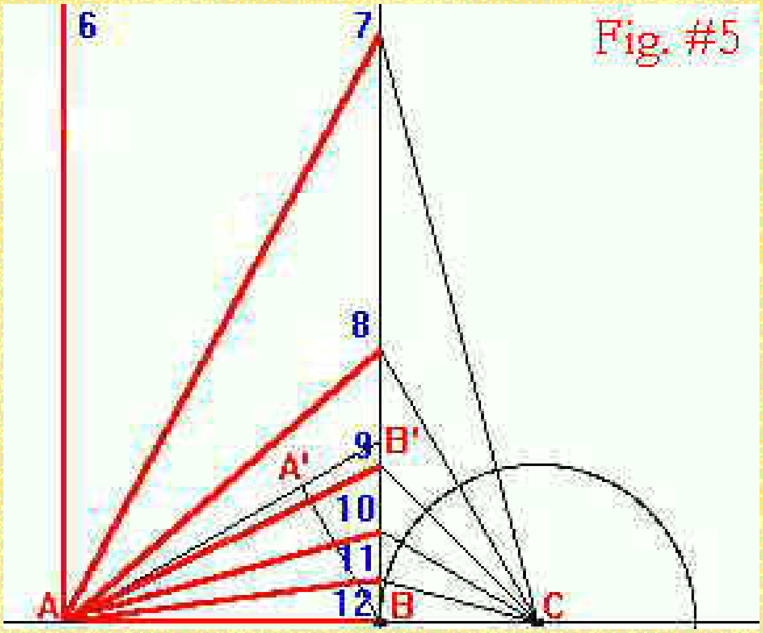


Now use the distance A'B to find C (use the compass), draw a semi-circle centered at C and divide it into 15 degree pieces (use the protractor). (Fig. #4)

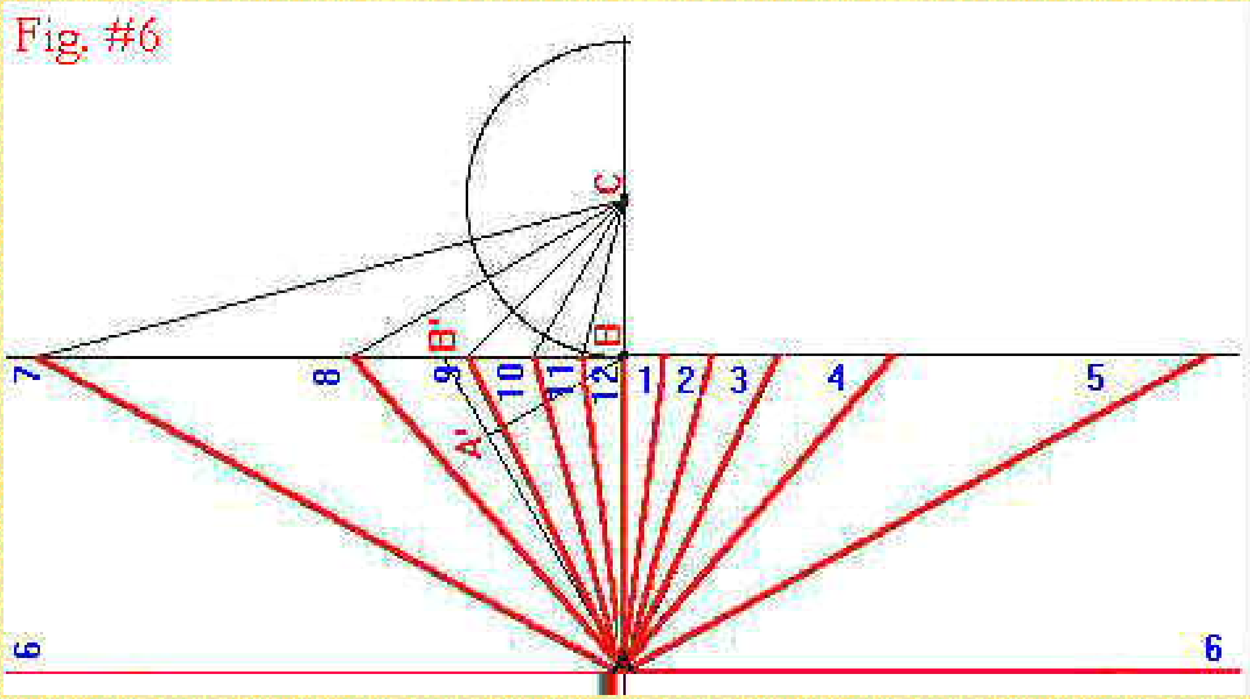


Why 15 degrees? One day is 24 hours, or the amount of time it take for "the sun to go around the earth". So in 24 hours the sun "moves" through 360 degrees (recall that there are 360 degrees in a circle). Therefore to find how many degrees are in 1 hour we divide 360 by 24. 360/24=15 degrees, this is called the hour angle of the sun.

Connect the 15 degree points along line BB' to point A. These are the hour lines for your sundial. Draw a line through A and parallel to line BB', this is the 6:00 hour line. (Fig. #5)

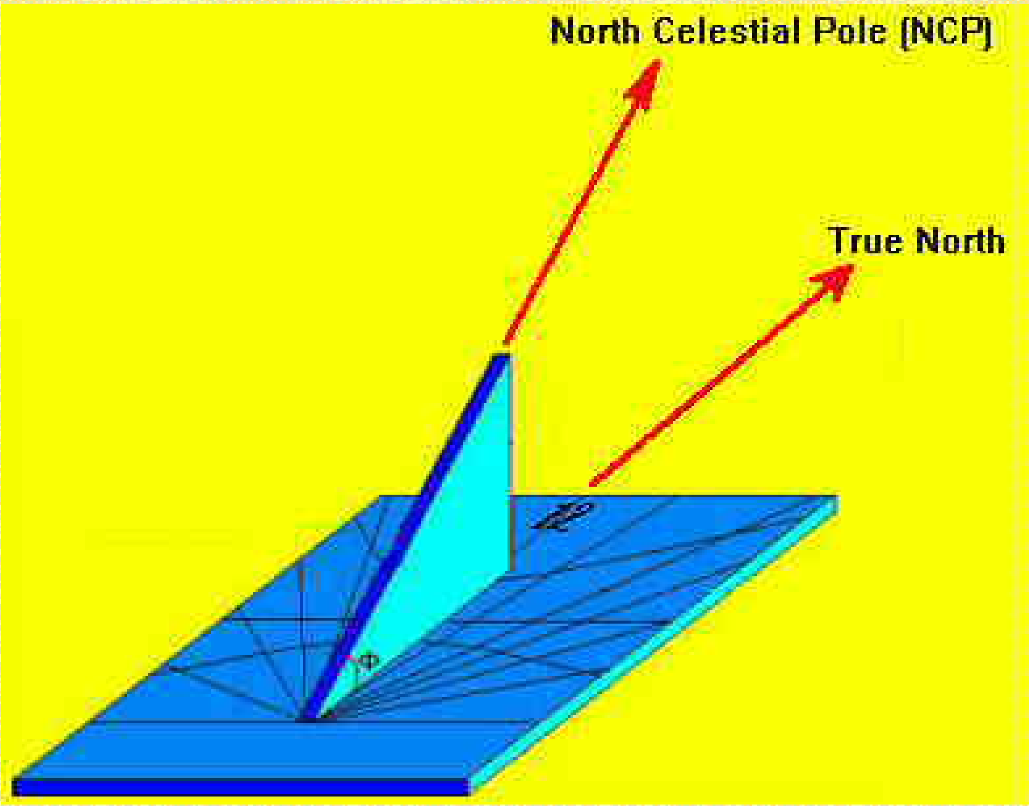


To find the morning hour line "flip" the afternoon hour lines over the 6 hour line. In other words angle B-A-11 is equal to angle B-A-1, likewise angle B-A-10 is equal to angle B-A-2 etc. (Fig. #6)

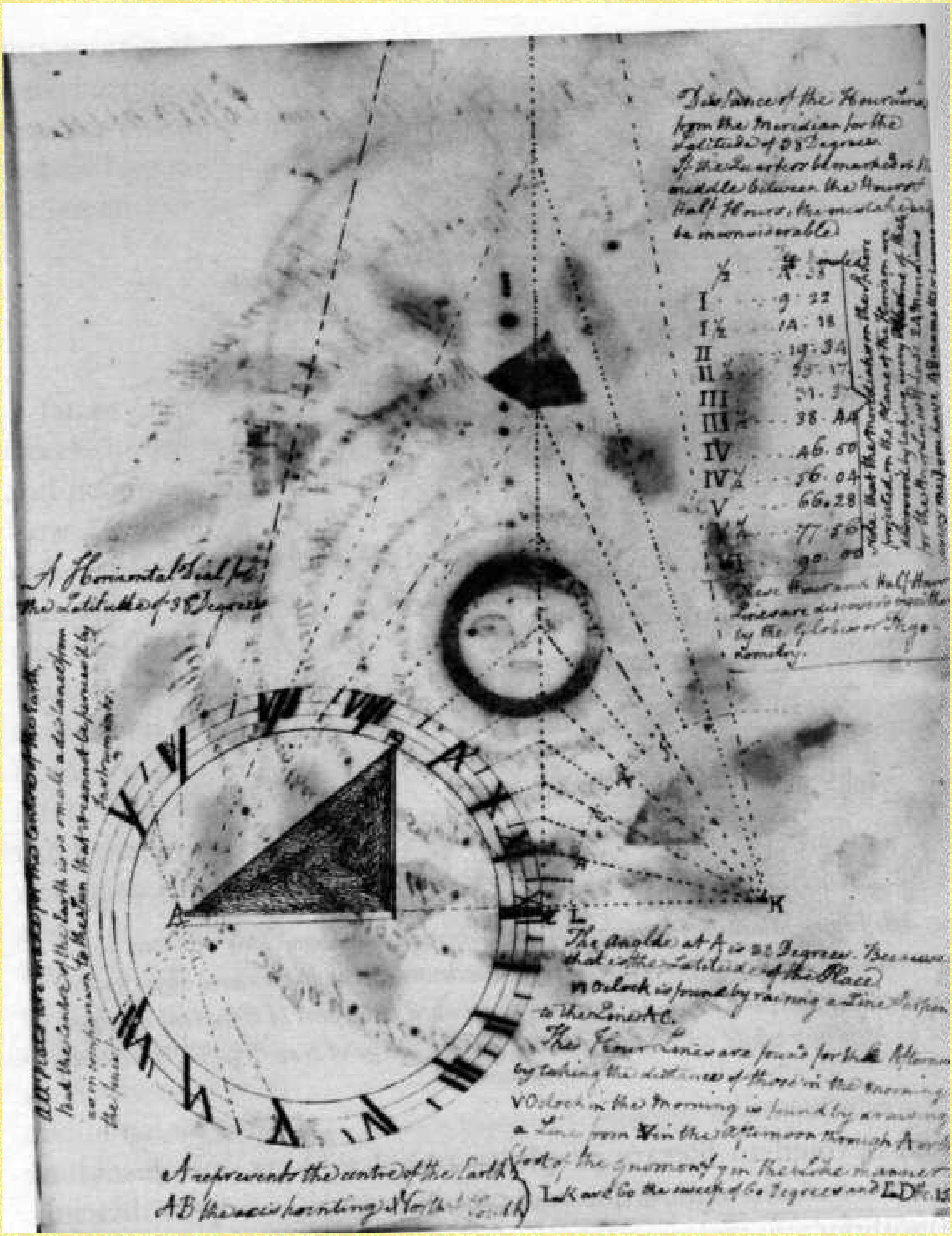


All that is left is to add the gnomon and set the dial in the sun. The gnomon is a triangular piece that has one angle equal to the latitude of the place where the dial is to be used. See the diagram below on how to afix the gnomon to the dial.

It's now time to take the dial outside and start to tell time. Orient your dial so that the 12:00 hour line and gnomon (which lies along the 12:00 line) are pointing toward TRUE NORTH.



Point of interest: The above procedure for graphically making a horizontal sundial was used by James Madison. He designed a dial using this same formula while an undergraduate at Princeton circa 1769. The image below is the actual work done by James Madison.


Distance of the Hour Lines from the Meridian for the Latitude of 38 Degrees
be inconsiderable
I ... 9 22
II
III
IV ... 46 50
IV ½ ... 56 04
V ... 66 28
... 77 50
... 90 00
by the Globe or Trigonometry
A Horizontal Dial for the Latitude of 38 Degrees
The Angle at A is 38 Degrees Because that is the Latitude of the Place
to the Line AC
The Hour Lines are found for the Afternoon by taking the distances of those in the morning
V Oclock in the Morning is found by drawing a Line from V in the Afternoon through A
LK and Go the sweep of 60 Degrees and LD
A represents the centre of the Earth
AB the axis pointing N

NOTE: The faint image of the Sun at the center of the document and the faint concentric circles are Madison's notes about the Copernican System which are on the other side of the sundial calculation page.

If you live in the Northern hemisphere finding true north is as easy as finding the North star and setting your dial to point at it, also if you measure the angle of the North star (Polaris) above the horizon you will have your latitude. DO NOT use a compass to find north, a compass shows magnetic north NOT true north.

Another way to find true north is to watch the shadow of a vertical rod, when the shadow is at its shortest length it is pointing true North/South.

Make your own Equatorial Sundial.

Make your own Vertical Sundial.

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sundials | equation of time | build a sundial | the zodiac | astronomy | longitude

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Page created by: abraxas2@ix.netcom.com
Changes last made on: *October 22, 2002*

Making a Sundial

Why make a sundial??

It is recorded that, when Louis Armstrong was once asked, "What is Jazz?", he replied, "If you've got to ask that question, there's no point in telling you?"
I guess the answer to 'why make a sundial?' could be similar.

I make them because I find them fascinating pieces of 'functional sculpture'. I enjoy seeing how another has interpreted their solution to 'telling time by the sun' and the art and craft in their finished dial. My belief in the "demystification" and free availability of 'knowledge' is also an underlying motive for this site. Anyone can make a sundial! So, if you want to make a sundial...... read on!

There is an infinite variety of interpretations and presentations of 'sundials' as viewing some of my 'Pictures of Sundials' and the even greater number in the 'Links" pages will show.
Also, there is the fact that a sundial must be specially designed for the place where it is to be viewed and must also be pointed in the right direction. There are numerous dials offered for sale for 'universal' use. While many of these are undeniably attractive 'garden ornaments', that's all they are. Many only 'resemble' a working sundial.

You can have absolute pride in your finished dial, made from materials of your choosing, and know that it is made 'for your place'. Again, there are an infinite number of designs, (see dial types) but the following procedure will enable you to make a 'good one'... in this case a 'horizontal dial'. If your enthusiasm is fired to explore this fascinating subject, read some of the references in 'links'.

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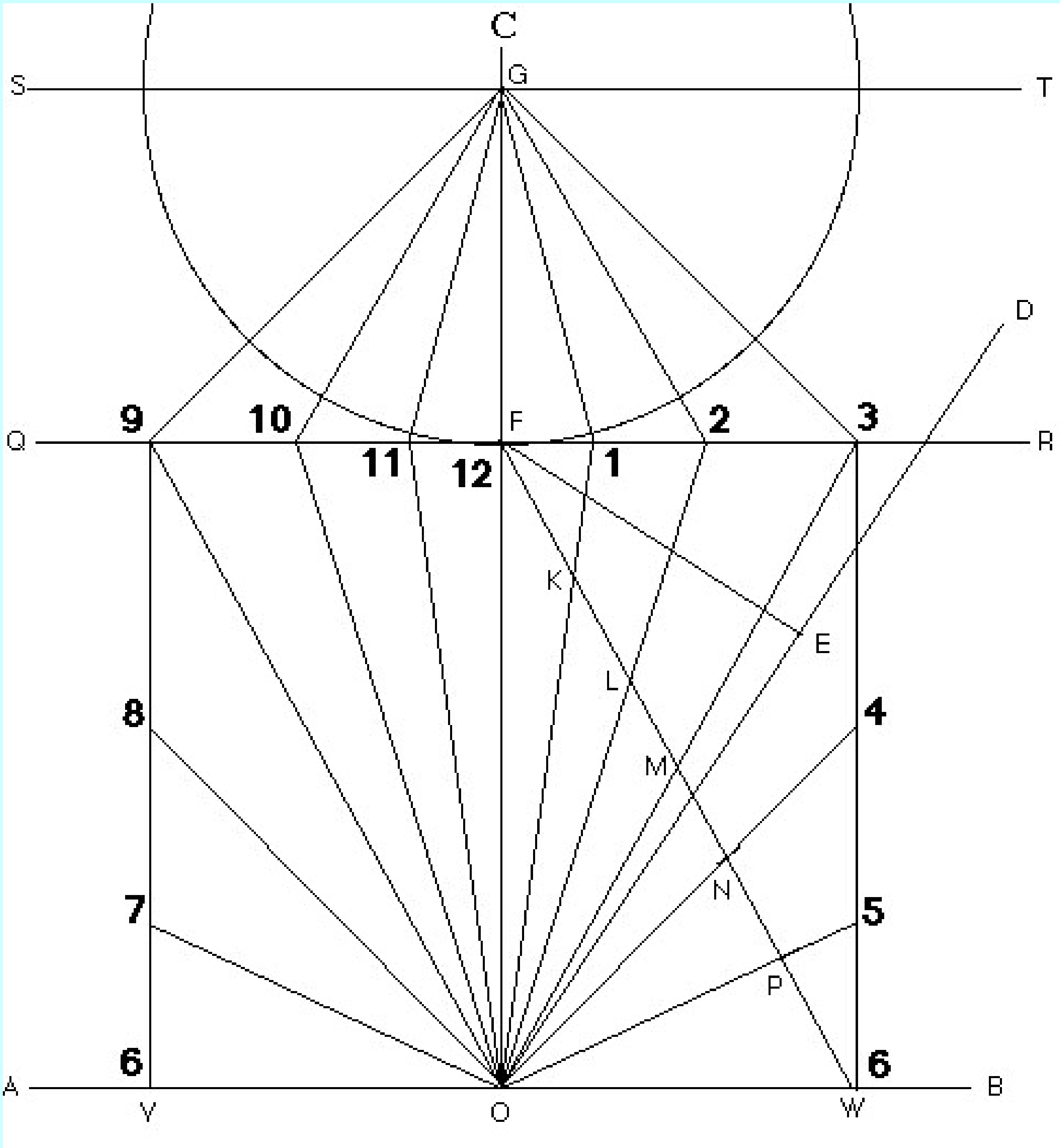
Horizontal Sundial...graphical layout.
(This procedure was worked from Albert Waugh's outstanding "Sundials" (see reference list) who based his outline on one published in Paris in 1790 by Dom Francois Bedos de Celles.)

You'll need a sheet of paper at least A4 size. The finished diagram can be traced and extended as you wish. You'll also need to know the latitude of the place where you're going to place the dial. A sharp pencil, rule, set square, protractor, and a pair of compasses are also required (if you're not using a computer-drawing facility !) ...... and a little bit of patience!! The finished product will be a template for a horizontal sundial made specifically for your place, ...that works!

Your finished pattern will be similar to this one below. It might look daunting, but, taken a 'line at a time', it is very simple.



GRAPHIC LAYOUT FOR HORIZONTAL SUNDIAL .

(FOR 33.24 DEGREES)

Procedure. (Refer to "Layout" diagram above)

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1. Draw AB and CO mutually perpendicular intersecting at O. In the final dial AB will be the 6 o'clock hour line and CO will be the 12 o'clock hour line.
2. Draw OD making angle COD equal to the latitude. In the layout example I have used 33.24 degrees since it is the latitude of my place (33.24S 151.53E). The dial layout example, however, is for the northern hemisphere. If you are in the southern hemisphere you'll have to reverse the hour numbers as the dial will be facing the sun in the opposite direction.
3. At any point on OD, as at E, draw EF perpendicular to OD and intersecting OC at F. The length taken for OE will determine the size of the final working diagram, and can be longer or shorter as one wants a larger or a smaller diagram to work with.
4. On OC lay off FG equal to EF.
5. Through G and F draw SGT and QFR parallel to AB
6. Draw a semi-circular arc centred at G and based on ST. Any radius may be used. In the example, the radius is equal to GF.
7. From GF lay off along the semi-circular arc three equal arcs of 15 degrees in each direction.... 15 , 30 and 45 degrees each way from GF.
8. From G, through the divisions of the semi-circular arc just found, draw straight lines intersecting QR at the points marked 9, 10, 1, 2, and 3.
9. From O draw straight lines to the six intersections just found on QR ..... i.e.. from O to 9, 10, 11, 1, 2, and 3. These will be the hour lines in the finished dial for 9 o'clock, 10 o'clock, 11 o'clock etc.
10. Draw FW parallel to the 9-o'clock hour line (i.e. parallel to OQ) intersecting AB at W. This line FW will intersect the hour lines of 1, 2, and 3 at K, L, and M respectively.
11. From M lay off along FW the distances MN equal to ML, and MP equal to MK. The distance MW should be equal to MF.
12. From Q and R draw QV and RW parallel to CO.
13. From O draw lines through N and P intersecting RW at 4 and 5. These are the hour lines for 4 P.M. and 5 P.M.
14. On QV make Q8 equal to R4, and Q7 equal to R5.
15. Draw straight lines from O to 7 and 8. These will be the hour lines for 7 A.M. and 8 A.M.

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So you've now got the hour lines from 6 A.M. to 6 P.M. For hours before and after these times to allow for earlier sunrises and sunsets, just extend the corresponding morning or afternoon time...i.e. extending the 5PM time line through O will give 5 A.M. time line and similarly, extending the 7 A.M. time line through O will give the 7 P.M. time line.

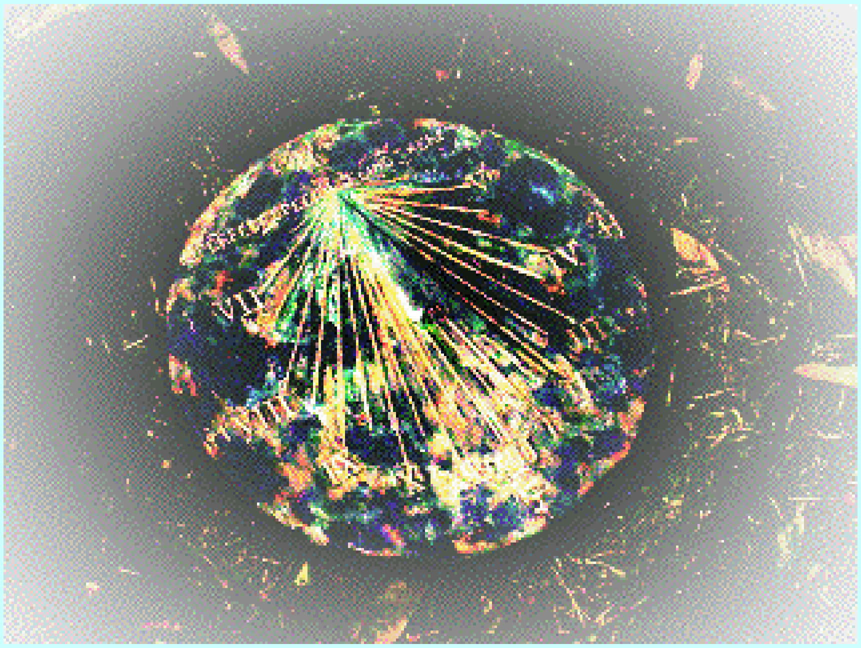
That's the dial face almost completed. You must separate the two halves of the dial-face pattern (along OF) by an amount the same thickness as your intended gnomon. If the gnomon is made of cardboard half inch thick, so the dial AM and PM sides will be divided along the 12 o'clock line by half inch and the gnomon placed between them along the O - F division. The point at O and the higher tail at F.

The gnomon will be triangular in shape, similar to FOE of the layout diagram. The angle FOE of your gnomon must equal the latitude of the place for which the dial is made....i.e... The angle that the gnomon makes with the dial face is critical. It must be equal to your latitude. The underlying, between the gnomon edge and the dial face can be crafted as you like.

Incidentally, the gnomon edge is parallel to the earth's axis and thus points upwards to the celestial pole. In the northern hemisphere, sighting to the celestial north pole, you will see the 'Pole Star' riding on the tip as you look northwards up and along the gnomon. In the southern hemisphere, sighting up and along the gnomon will point to the celestial south pole, but there is no star. However, the Southern Cross will circle around this blank point. In fact, a line extended through the ends of the Southern Cross will pass nearly through the celestial south pole. A perpendicular bisector from a line joining the 'pointers' to the Cross will also pass fairly closely through this same point...... A way of telling direction at night in the southern hemisphere!!

Having finished your dial, with the gnomon squarely fixed in position (the OE side will be the base along the dial face), it is simply a matter of placing your dial horizontally with the gnomon pointed at true north (not magnetic north)(see 'Placing a dial') and read off the times from the shadow. (see 'Reading a dial')........ Well, not quite that simple, but if you read on, we can fix that!

Here is a flat copper sheet sundial that I made using the pattern above...... Just to show you it 'works'. You can calculate the dial time-lines (I set up a template in 'Excel' which makes it easy) rather than lay them out graphically .... some of the links have facility to do this for you. But the 'graphical method' above is one that anyone can use. This dial below was laid out using the 'graphical method'....



Horizontal 'flat dial' in copper sheet. (300mm across)

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Placing the Dial

The sundial must be aligned along your meridian, i.e. along the true north south line. The accuracy of your completed dial will depend on this!

Alignment....

- If you know the current magnetic variation at your place you can use a compass.
- Knowing the meridian from which your standard time is taken, you can work out the time of your local apparent noon time and the shadow cast from a vertical stick will lie along the meridian line. e.g. if your standard time is based on 151E and your place is located at 159E, then, since the sun moves through 1 degree in 4 minutes, your local noon time will be 8 minutes ahead of your standard time. So, assuming your watch is accurately set, at precisely 8 minutes to 12 a shadow from a vertical stick will lie along the meridian. (but you must allow for the 'equation of time'...see below in 'Reading a Dial')
- Place a long nail vertically in a secured horizontal board. Note the shadow length as the sun moves across the sky from morning to afternoon. Draw a line from the shortest shadow point to the nail. This line will be your meridian line.
- Fix a vertical rod into a secured horizontal board. (Be accurate with the 'vertical' and 'horizontal'!)
  Sometime during the morning, mark where the tip of the rod's shadow falls. Using this distance as the radius, trace out a semi-circle from the base of the vertical rod as center. As the morning progresses, passes through midday and into the afternoon, the shadow will shorten and then lengthen again. At the precise time that the shadow of the tip of the vertical rod touches your semi-circle again, again mark the semi-circle. Join the chord between these two points you have marked.
  The perpendicular bisector of this chord passing through the base point of your vertical rod will be the true north-south line.... the line along your meridian of longitude.
- Use all four methods to be sure. There are several other ways, but the ones above will enable you to accurately find your meridian line.

Place your dial horizontally (most important!... use a level in several directions to be sure of this) with the gnomon precisely along your meridian line , i.e. to the true south pole in the northern hemisphere and the true north pole in the southern hemisphere. (You can now see why the numbers will be reversed from northern to southern hemispheres , as I mentioned in step '2' in 'procedure'.)

That's almost 'it'. Your dial is placed accurately and will keep accurate time while in that position for the rest of your life...and then some! It will never wear out or require maintenance!! And, if you've chosen some pleasing materials (after your cardboard protoype!!) such as brass, copper, or attractive stone, you will have pride in a 'functional sculpture' that you made, to be admired by all. So easy, eh!!??

Not quite!....... While your sundial will keep accurate "sun time", that is not the time we use, and, even more, the sun time varies thoughout the year! So , if you're going to 'set your watch', you have to be aware of just a few more little things.

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Reading the Dial

For the moment we'll assume your place is 'on' the meridian from which your 'standard time' is taken.. i.e. when the sun is at it's zenith, it is both 12 noon in your 'standard' time zone and 12 noon local (sun) time. Your sundial will have the gnomon shadow right on the 12 noon........ But only four times a year!!!! (April 16, June 15, Sept 1 and Dec 25.)

Why is this so? Does this make a sundial less than a timepiece?

The 'Equation of Time'.

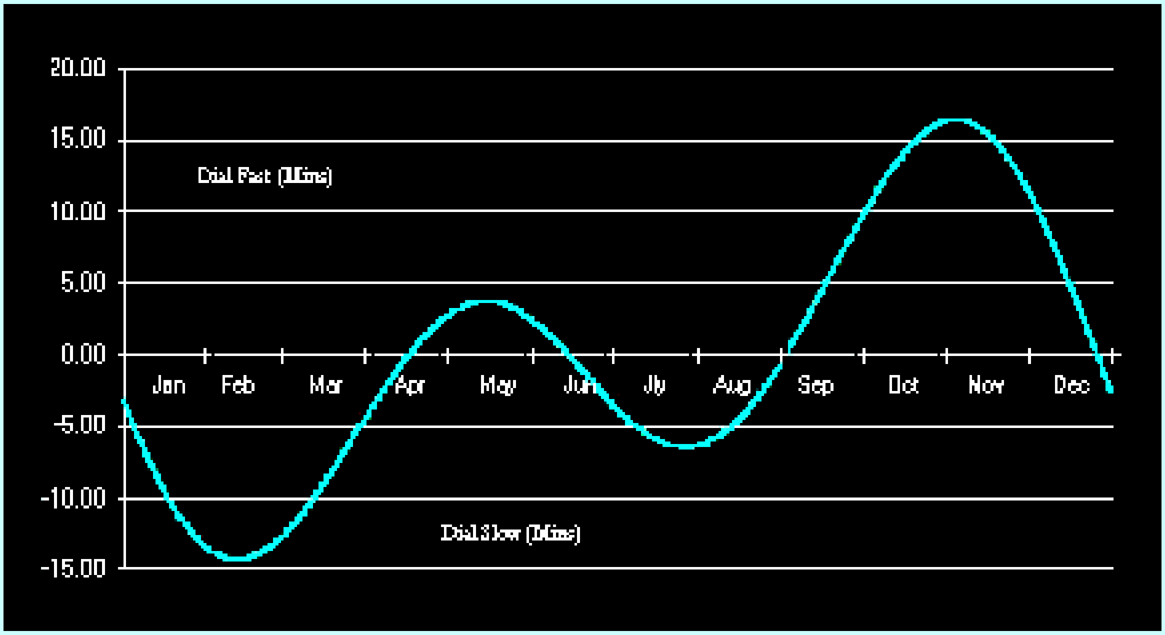
Modern measurement of time uses mechanical and electronic devices to measure time at a uniform rate and so 'averages out' the 'sun time' ..... Hence Greenwich 'Mean' Time from which we derive our 'time zones'..

A sundial shows 'sun time' which varies up to around sixteen minutes faster and slower than 'clock time'. This difference between 'clock time' and apparent 'sun time' is referred to as the "Equation of Time". The graph below shows the variation over a year.

In simple terms, this Equation of Time results from the sum of two causes:-

- The inclination of the earth's axis to its orbital plane which means that the plane of the earth's equator is inclined to the plane of the earth's orbit around the sun. The effect of this is that the sun is only 'on the meridian' of a place at noon on the solstices and equinoxes. Between these times the sun will be either fast or slow.
- The earth's orbit around the sun is elliptical, not circular. Only at the perigee (Dec 31) and apogee (July 1) will the sun appear over the meridian at noon. Between these times the sun will be either faster or slower relative to 'clock time'.

So, other things being equal, to read our sundial the Equation of Time must be used to correct the 'sun time' . The graph below serves this purpose.



Graph showing the Equation of Time

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Allowing for your Longitude.

The earth makes its rotation in 24 hours. 360 degrees over this period means that 15 degrees longitude is covered in 1 hour i.e. each degree longitude accounts for 4 minutes of 'sun time'. Clearly, to keep such times would make our 'interchanges' of business, transport and communications almost impossible. So , by international agreement, by taking 0 degrees through Greenwich in England as the base, every 15 degrees for 180 degrees east and west of this 'Greenwich Meridian' is assigned a 'standard time zone'. There are national variations within this, but each zone has a meridian from which the 'standard time' is taken to be common. I live in Australian 'Eastern Standard Time'.

Now if your place happens to be 'on' the meridian from which your standard time is taken, then 'noon' clock time will coincide with the sun's zenith....i.e. considering the Equation of Time, the sun will be 'over the top of your gnomon' as the clock strikes twelve noon.

So, it follows that for every degree that your place is longitudinally either side of the 'standard meridian' for your time zone, so your sun dial will be either ahead or behind the clock time by 4 minutes for each degree.

Now you can allow for this by building the variation into your sundial.... the 12 noon line will now not be directly along your gnomon line... i.e. if your sun time noon is 4 minutes behind 'standard time' noon, you will mark your dial as 12 noon at 4 minutes before the central line on which your gnomon is placed on your dial.

Or you can just note, along with your equation of time, that such an adjustment is necessary when reading your sundial.

With the above considerations, you can rely on your sundial to keep accurate time for much longer than you'll be around to read it!

Back to Horizontal Sundial layout
Back to graphic layout of horizontal sundial.
Back to procedure for horizontal sundial
Back to placing the dial
Back to reading the dial
Back to equation of time graph
Return to Home Page
Go to 'Links 'n' Stuff'f
Go to "Types of Sundials" page
Go to "Pictures of Sundials" page

Basic Trigonometry

The formula for calculating the hourlines on a horizontal sundial is:

tan X = (tan h)(sin lat)

Where:

X = the result, the angle the hour line makes with the 12 o'clock line.

h = the time (hour angle) measured from noon in degrees. The earth rotates 360 degrees in 24 hours, or 15 degrees in 1 hour

lat = the latitude of the dial.

Here is the framework for a BASIC program for computing the angles for the hourlines from 6 AM to 6 PM on a horizontal dial located at 35º . The program will not work as-is because most BASICs require angles to be computed in radians.

Use the format to build your own programs; or for a calculator or spreadsheet.

```
1 CLS
2 lat = 35
3 FOR h = -90 to 90 STEP 15
4 X = ATN((TAN(h)*SIN(lat))
5 PRINT X
6 NEXT
7 END
```

You can apply the longitude correction (time zone offset) by changing line 3. For instance, if your longitude is 4.56 degrees **east** of your central meridian, you would **add** 4.56 to the value for h, and line 3 would be:

```
3 FOR h = -90 + 4.56 to 90 + 4.56 STEP 15
```

But let's do the arithmetic, and while we're at it, let's change the STEP value to produce half-hours.

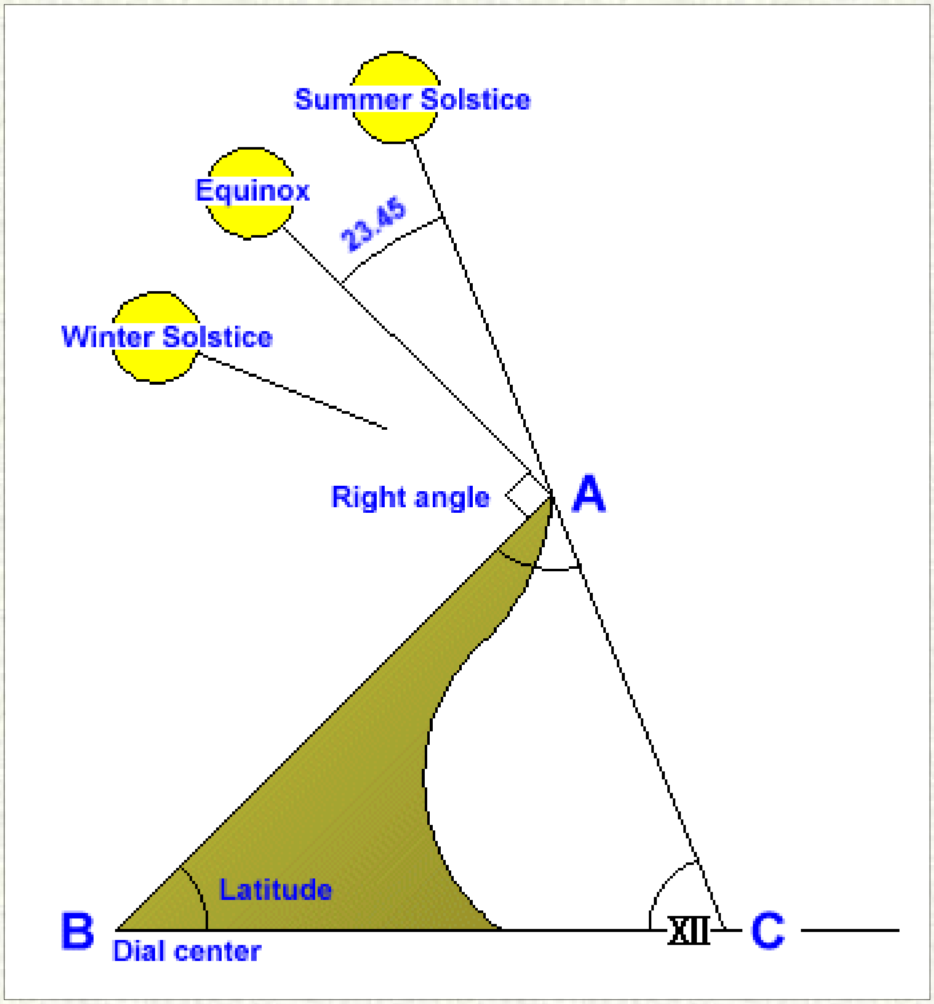
```
3 FOR h = -85.44 to 94.56 STEP 7.5
```

How long should my gnomon be?

The shortest shadow your gnomon will cast will be at solar noon on the summer solstice. The length of your gnomon is dependent on your latitude and the distance between the center of your dial and the numeral or indication that you require to be in shadow at solar noon.

No doubt you will wish all indications to lie in the shadow of the gnomon on every day of the year. The minimum length of the gnomon to meet this condition is shown by the relationship of the dial center at **B** to the symbol **XII** in the sketch below. Note that **XII** is closer to the dial center than the projection of the shadow on the summer solstice. i.e. The value for **BC** must be long enough to completely shade the numeral or indication.

A horizontal dial in the northern hemisphere



The required gnomon length **BA** can be found by experimenting with the angles in the sketch, or by a formula which solves the triangle **ABC**.

The angle at A is: 90 - 23.45 = **66.55**
The angle at C is: **180 - B - 66.55**

Then by the law of sines:
Side **BA / sin C = BC / sin 66.55**

Sin 66.5 = .91706

$$BA = \frac{BC \times \sin(180 - B - 66.55)}{.91706}$$

In some cases the minimum condition may seem somewhat extreme, and your aesthetic sense may suggest that the gnomon should be longer for appearance sake. Don't be concerned, shadows are never wasted.

By Bob Terwilliger and Fer deVries

Creating Sundials with DeltaCad

DeltaCad is a reasonably priced and easy-to-use CAD program. It features a built in programming or 'macro' language based on the familiar BASIC language.

DeltaCad is emerging as the program of choice for sundial designers. It is available from Midnight Software. The price is $39.95, and there is a 45 day demo available.

NASS members and others will be providing programs here for producing various types of sundials with DeltaCad macros.

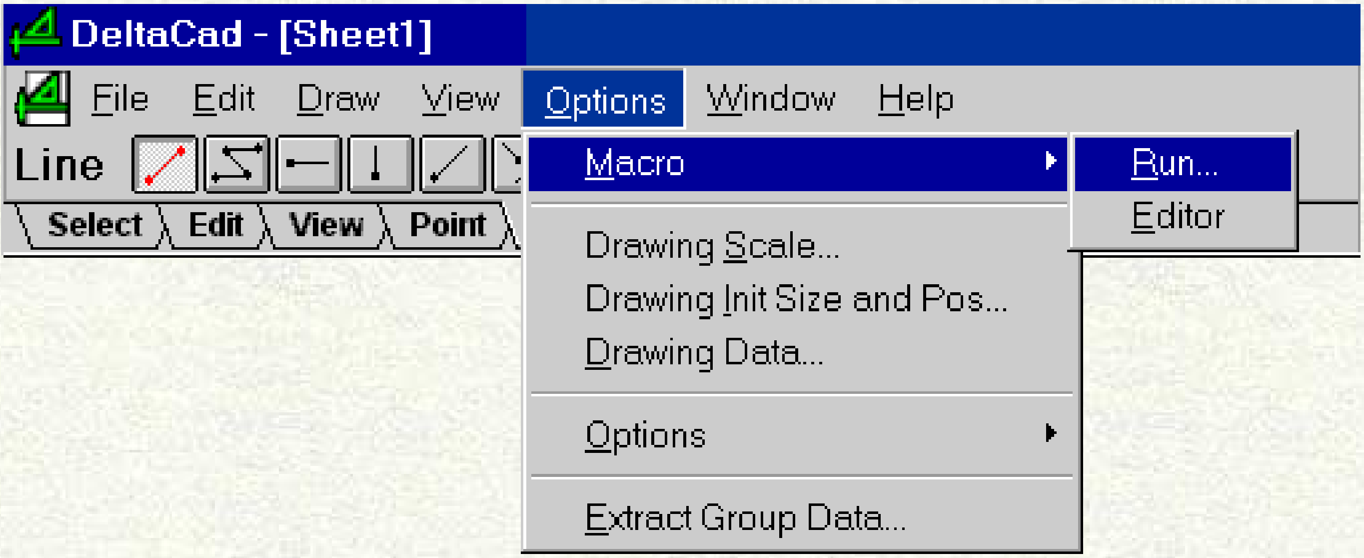
These programs are intended for those who want to make their own sundials as well as for those who wish to explore the possibilities of writing their own programs. With this in mind, all the program source code includes extensive remarks as well as various procedures and functions which form a library which can be copied and used in your own programs.

All the programs below can be downloaded in a single zip file: programs.zip.

The pages you are now reading which describe the NASS programs in the above zip can be downloaded in another zip: document.zip. The document is in HTML format. It is recommended that you unzip each of the files into separate folders under your main DeltaCad folder.

To run the programs, open DeltaCad and click:

| Options | Macro | Run |



New to sundials design? Here are some tips before you start.

Please, the programs are the intellectual property of the respective authors. You may modify them for your own use, but do not alter the original header.

Some Basic Dials

Horizontal "Garden Variety" sundials by Ron Anthony

In this series of dials, each program adds a feature to the previous one. Those wishing to learn to program sundials in DeltaCad should start with Horizontal #1 and continue with each program in sequence. Each program includes remarks explaining the code and it's new features.

- Horizontal #1
  A simple horizontal dial indicating local solar time. No input. The basic code for a horizontal dial.

- Horizontal #2
  Extends #1 by having a dialog with the user to get the latitude of the dial.

- Horizontal #3
  Extends #2 by asking the user for the longitude and timezone of the dial. The new information is used to factor in the "correction for longitude". In addition, user data is validated for correctness, and a help page is added.

- Horizontal #4

Extends #3 by drawing a rectangular border around the dial. This addresses several problems in drawing and placement of lines. Also introduced but not visible is the concept of making factors related to size based on each other. For example, the size and shape of the rectangle can be set and the length of the hour lines must change automatically.

- Horizontal #5
  Extends #4 by adding the lines and curves of declination. Changes the formula for hour lines to that provided by Fer de Vries. Accommodates dials in the southern hemisphere.

- Horizontal #6
  Extends #5 by adding provision for gnomon width.

- Horizontal #7
  Extends #6 to make all variable settings controllable by the user; consolidate validation routines; consolidate help routines; allow for half and quarter hours.

Analemmatic "Walk in" sundials by Fer de Vries

Use your body as the gnomon. This dial is popular with children. The output includes a text file of X,Y coordinates for layout.

- Analemmatic #1
  A simple analemmatic dial indicating solar time.

- Analemmatic #2
  Extends #1 with a provision for the time zone correction.

- Analemmatic #3
  Extends #2 to include day-circles in a separate layer.

A Bit More Advanced

These dials includes a correction for The Equation of time

- Madjet by Fred Sawyer.
  A universal analemmatic sundial, using a vertical gnomon placed on the central date scale, with time read by the intersection of the shadow with the appropriate latitude ellipse. "I chose the name because the design reminds me of the papyrus boat that the Egyptian god Ra uses to ferry the sun disk across the sky each day; his boat is called a Madjet".

- **SCADD** by Steve Lelievre is a program for calculating a category of Standard Time horizontal sundials, either azimuth or polar style, using 15 minute intervals. Finite thickness gnomons are catered for. The plots are drawn in several layers, to aid later manual editing and additions. The EoT calculations are fixed to the year 2002. [Link to SCADD]

Miscellaneous

- Duration
  An application that computes the duration of sunlight on any flat surface, anywhere on earth, at any orientation of inclination and declination. The output is a colorful graph.
  Options for time systems: Standard time, Local apparent time, Local mean time and Time zonal, apparent.

- Eot Graph
  Generate an Equation chart for any year from -3000 to 4000 using the Gregorian Calendar.

- The NASS Logo

We would like to expand this selection of programs. If you have written programs or procedures that you think would add to those presented here, please email them to Fer de Vries.

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homepage van fer j. de vries

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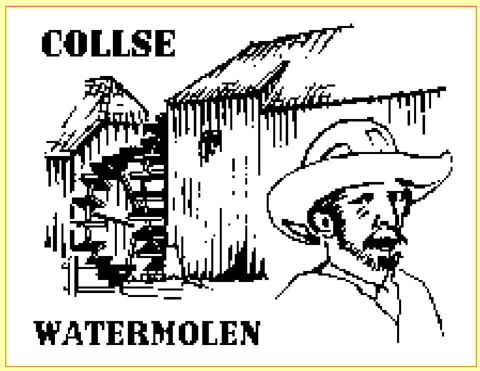
naar oficiële site van De Zonnewijzerkring

to official site of De Zonnewijzerkring



Bezoek ook de Collse Watermolen (Wassermühle, Watermill, Moulin á 'eau)

Download Windows Computerprogram

Zw2000

Links naar andere pagina's

Tijdsystemen
Types zonnewijzers
De wettelijke tijdregeling in Nederland door Robert van Gent

Pages in English
Method to compute flat sundials
Construction of hemispherium

Pictures of Sundials in the Netherlands
Projection dials
Sunpointer at Railwaystation in Amersfoort
Download Software

Other links on the internet

Summaries of the Journals of De Zonnewijzerkring since issue 98.1.
List of links to other sites
International Sundial Society on the Internet SOTI
British Sundial Society BSS
Sundial page Frans Maes : Dutch + English
Sundial page Austria / Österreich : Deutsch + English
Sundials in France
Sundials in Czech Republic : Cataloque.
North American Sundial Society NASS
Charles Gann
Robert Terwilliger
Gordon Uber
Organizations (see item 4.6, sundials)

Yvon Massé, pages in French and some in English about very special sundials.
Mario Arnaldi, pages in Italian
Zonnewijzerkring Vlaanderen, pages in Dutch

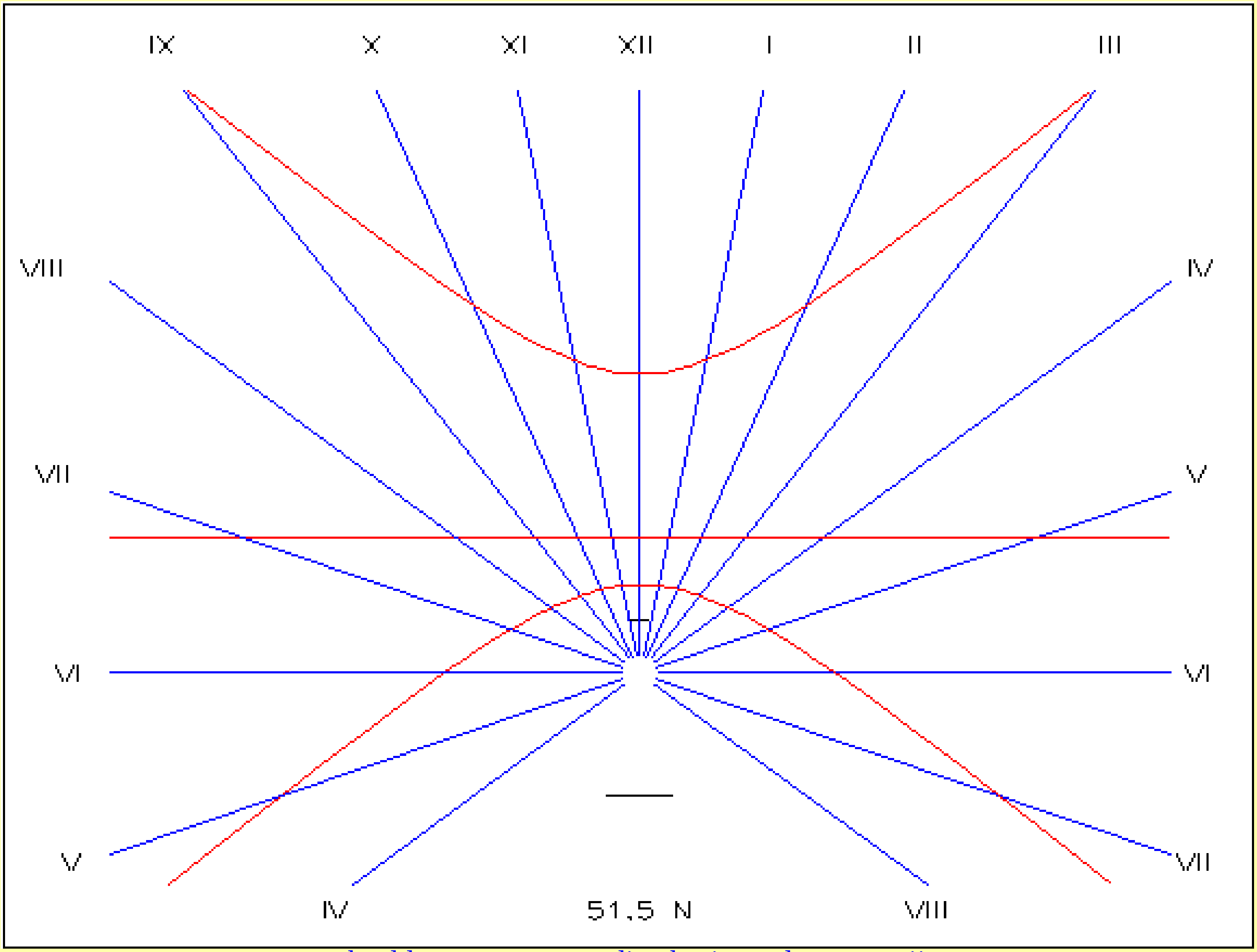
Copy of articles in Compendium, bulletin of NASS

1 - Regiomontanus, Apian and Capuchin dials.
2 - Hâfir and Halazûn.
3 - Shadow Plane Sundials.
4 - Cord & Spar Sundials.

***Do you like these articles?* Join NASS.**

To top of page

Aantal bezoekers 46498



voorbeeld van een eenvoudige horizontale zonnewijzer

Pagina's voor het laatst bijgewerkt: november 2002

Download Software

ZW2000v1_3.zip (410 kB) The program Zw2000 for Windows. Minimum screen resolution 800 x 600.

MANUALv1_1.zip (520 kB) The manual for the program Zw2000 as HTM document, thus you need a browser.
Main document zw2000.htm. Only in English. Translated by Bob Terwilliger, USA.

You also may read the MANUAL on line.

SITE-PDF.zip (65 kB) The text of the site *"Method to compute flat sundials"* in PDF format by Anselmo Pérez Serrada, Spain.
Here you may find the basic mathematics used in the program ZW2000.

PRINTGL Page to download PRINTGL to print a drawing to paper.

All the programs are free to download for members of any Sundial Society.
If you aren't a member of any Sundial Society you are encouraged to join.

PRINTGL is an american shareware program to print a drawing. To register this program contact the authors of Printgl.

To top of page
To pages in English

Les anciennes pages de ce site ont changé de place.
Veuillez noter le nouvel emplacement du site et modifier vos signets : www.shadowspro.com

Un logiciel simple et convivial

Shadows est un logiciel de conception de cadrans solaires. Il est utilisable par tous sans connaissances préalables et permet de calculer et imprimer tous les tracés nécessaires à la réalisation d'un cadran solaire personnalisé.

Un logiciel pédagogique et utile

Les différentes fonctionnalités du logiciel permettent de comprendre comment l'ombre du style fournit l'heure solaire et par le biais de corrections expliquées en détail, obtenir l'heure de la montre quelque soit l'endroit où l'on se trouve.

L'aide en ligne très complète, au format HTML, propose de découvrir la gnomonique et d'apprendre les secrets des cadrans solaires. De nombreuses rubriques prodiguent des conseils utiles pour la fabrication de son cadran à partir des informations fournies par le logiciel.

Un logiciel pour tous

Shadows se distingue des autres logiciels depuis plusieurs années par sa convivialité, le rendant accessible à tous les curieux, même ceux qui n'ont aucune connaissance en astronomie ou en mécanique céleste. Ici, aucune équation compliquée ; juste quelques clics de souris dans des boîtes de dialogues simples et le logiciel fournit directement un tracé utilisable tel quel ou modifiable par le biais d'options pilotées par des icônes.

Shadows est l'outil qu'il faut pour les bricoleurs, les passionnés de sculpture, de gravure, de fresque, de peinture, bref, toutes les personnes qui à leurs moments libres, sont capables de créer des oeuvres dignes des meilleurs artisans. ***Shadows*** leur fournit les compétences complémentaires qui leur manquaient pour leur permettre de réaliser un vrai cadran solaire.

Pour autant, les passionnés de cadrans solaires, les gnomonistes amateurs et même les cadraniers professionnels apprécieront également de trouver dans ***Shadows*** un outil puissant, capable de créer des cadrans complexes et offrant des options évoluées.

Ces pages sont complémentaires du site www.cadrans-solaires.org qui depuis plusieurs années vulgarise la science des cadrans solaires auprès du plus grand nombre. N'hésitez pas à visiter le site .

Spécifications

Ce logiciel est conçu pour fonctionner sous Windows (95, 98, ME, NT4, 2000, XP) sur n'importe quel PC. Il peut être utilisé sur Macintosh et Linux à condition d'avoir un émulateur Windows. Il faut simplement disposer d'un navigateur Internet compatible Javascript et acceptant les feuilles de style (n'importe quel navigateur récent convient)

Shadows est disponible en plusieurs langues et est fourni avec une aide en ligne complète.

Pour tout connaître de ses fonctionnalités, cliquez sur le lien **Fonctionnalités** sur la barre de lien ci-dessous.

Des milliers de personnes utilisent déjà le logiciel Shadows dans le monde. Lisez leur témoignages et découvrez les cadrans solaires qu'ils ont réalisé avec.

Check your dial, and align it to True North

If you are setting up a commercial dial, you can check it to see if it has been constructed to be a timekeeper and not just a garden ornament. .

If you have an armillary or bowstring equatorial dial, the dial must be positioned so it is level east to west, and the gnomon (usually an arrow), is vertically directly above 12:00. Skip to finding north

If you have a horizontal dial proceed to **1.**

For the terms used below, you may wish to refer to the glossary.

- **1.** The high end of the gnomon should point directly to 12:00 on the dial face. If it doesn't, your commercial dial is incorrect.

  If you have a custom made dial, it may include a longitude correction, in which case the gnomon will not point precisely to 12:00. Unless it is designed for your location, setting it up is beyond the scope of this FAQ.

- **2.** If the dial includes 6:00 AM and 6:00 PM, they should be at the ends of a single straight line, which is at a right angle to the sub-style - the line where the gnomon meets the dial face.

- **3.** Since the gnomon must have a finite width, the indication for 12:00 must have an equivalent width.

A sketch of a dial that meets conditions **1** through **3**

- **4.** If you want to test further **. . .**

  Measure the style height - the vertical angle the gnomon makes with the dial face.

Measure the angle on the dial face between the sub-style and the 3:00 or 9:00 hourline. (These two angles should be the same.)

The sine of the style height should equal the tangent of the 3:00 hourline.

This trick can also be used to determine the style height, and hence the original latitude, for a dial that is missing its gnomon.

Although there are exceptions, most common dials must be oriented with regards to north.

The high end of the gnomon on an ordinary flat dial must be aligned to **True North**. (In the southern hemisphere to **True South**.) i.e. The style, or shadow casting edge of the gnomon must be parallel to the earth's axis.

Using the Shadow of a Vertical Object at Solar Noon

Perhaps the most accurate method. The shadow of a vertical object at Solar Noon will point to True North. A string with a weight on the end suspended from a tripod will make a true vertical object.

You can find the time of Solar Noon at your location on the page below. To use this page, do not use the pull-down list of cities. To get the precise time you should use your exact latitude and longitude.

If you need to convert from decimal degrees to deg/min/sec or vise-versa, go here.

You will also need to enter your offset to UTC (EST = 5, PST = 8) and indicate if it is currently Daylight Saving Time.

- NOAA Sunrise/Sunset and Solar Noon Calculator

Another method of finding Solar Noon, and much, much, more about your dial and how it operates is to download ***The Dialist's Companion***. It is a DOS program, published by NASS, which calculates a wide range of data elements of interest to dialists and others who are concerned with phenomena associated with solar time.

- ***The Dialist's Companion***

Using a Compass

Using a compass is not recommended as a compass needle points to **Magnetic North**, and it is also difficult to get accurate readings with a compass. If you do use a compass, be sure to compensate for the **magnetic declination** of your location.

To find the magnetic declination for your location, go to the link below and enter your latitude, longitude, and altitude (approximate). If you fill in only your Zip code and click [Get Location], your latitude and longitude will be filled in automatically, and accurately enough - then scroll down the page and click [Compute!]. Your **magnetic declination** will be D the value in the first field of the table:

D (+ East) (deg)
-5d 26m

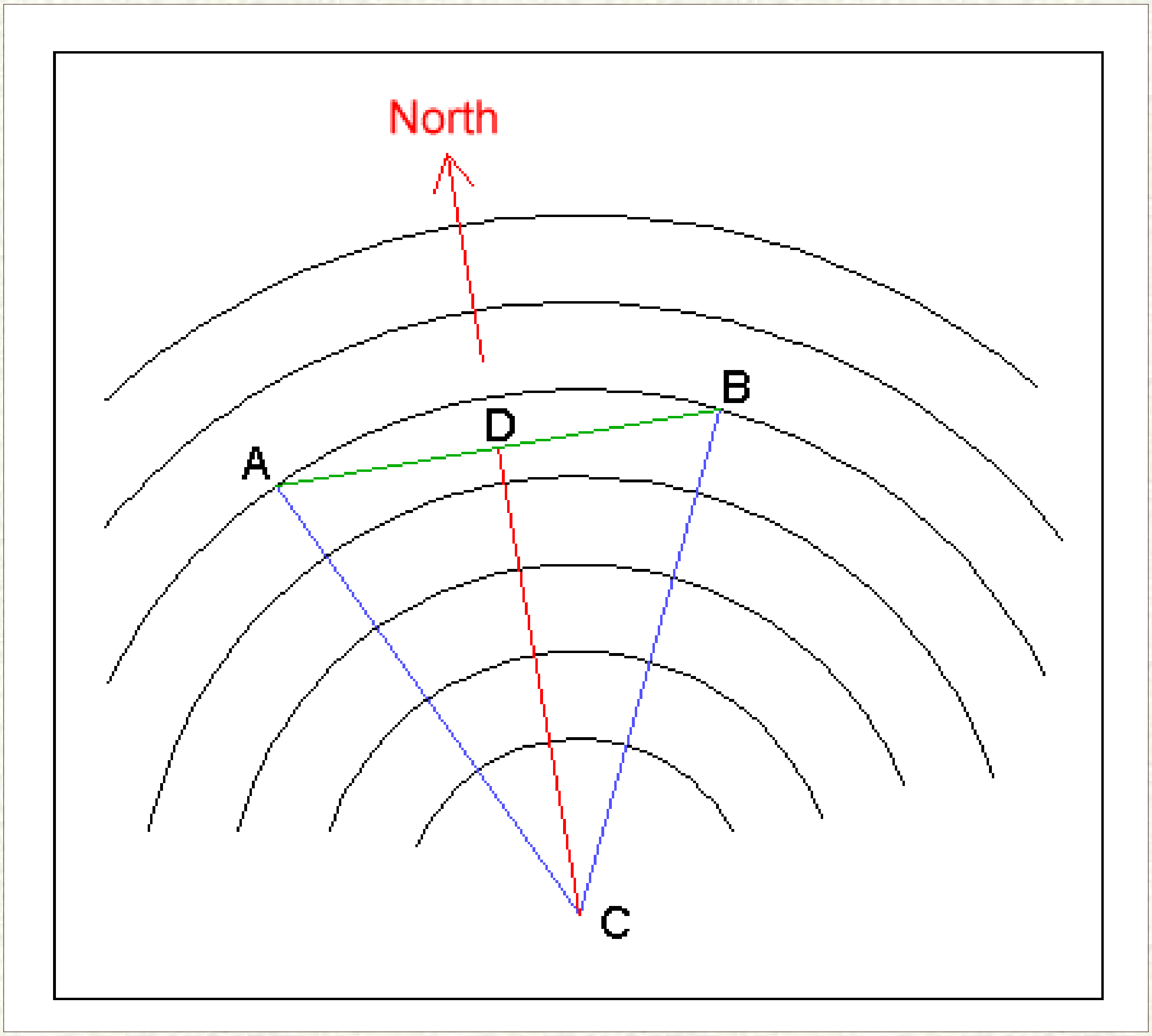
The negative value in the example above indicates that **True North** lies 5 degrees 26 minutes **clockwise** from the compass needle.

- Compute Values of Earth's Magnetic Field

A Graphical Method Using Shadows

Draw a diagram with concentric circles as shown below. Place a vertical object (a nail?) at **C**, and place the diagram on a level surface where it will receive sunlight all day.

Note where the shadow of the object touches one of the circles in the morning, and again in the afternoon as at **A** and **B**. Draw a line from **A** to **B** and bisect it at **D**. A line connecting **C** to **D** will point to True North.



Using Polaris, the North Star

If you can get a good view of Polaris, it is always within a degree of True North.

When you have determined True North, proceed to:
Correcting a commercial dial to your latitude

Correcting a commercial dial to your latitude

Assuming a mass produced dial

or a dial that was constructed for a different latitude

If your dial has been custom made for your location, no latitude correction is necessary. If you have a mass produced dial, it is unlikely that it will tell time unless you correct it for your latitude - which you will need to know. See Find Latitude and Longitude from Internet Sources. A mass produced dial will not have a longitude (time zone) correction.

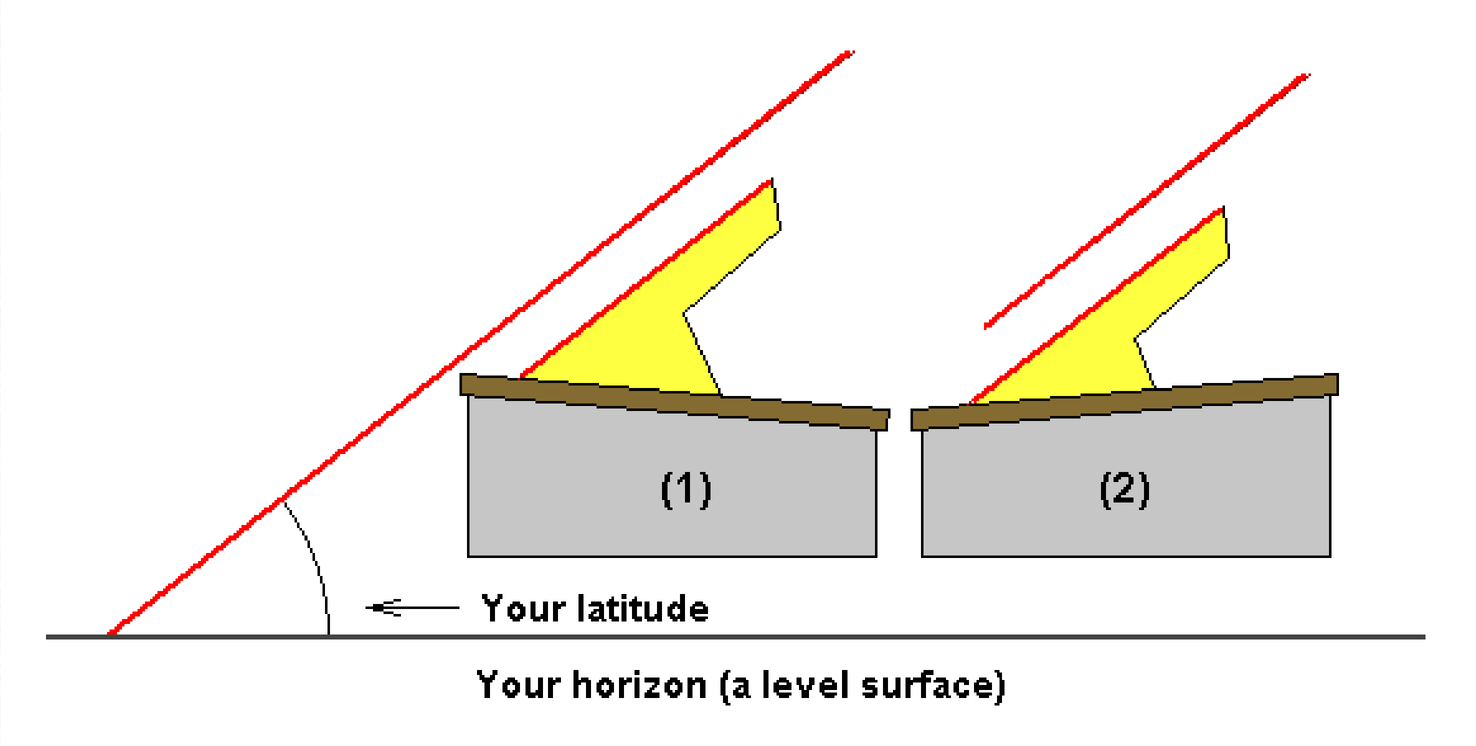
First, measure the angle the gnomon makes with the dial face. This is the latitude for which the dial was designed. Most commercial dials sold in the U.S. are manufactured for 45º North, as that is roughly the midline of the U.S.

Determine the difference between the dial's latitude and your latitude. If there is no difference, mount the dial level in all directions. Assuming the dial is properly oriented to **True North** you are finished.

If there is a difference, you will have to tilt your entire dial by this difference so the angle the style (the shadow casting edge of the gnomon) makes with the horizontal (a level surface) is equal to your latitude. If your latitude is less than that of the dial, the north end of the dial will have to be tilted down as shown in (1) below. If your latitude is greater, the north end must be tilted up as in (2).

If you have an armillary or bowstring equatorial dial the arrow is the gnomon and the entire dial must be tilted.

Be sure to keep the dial level east to west.

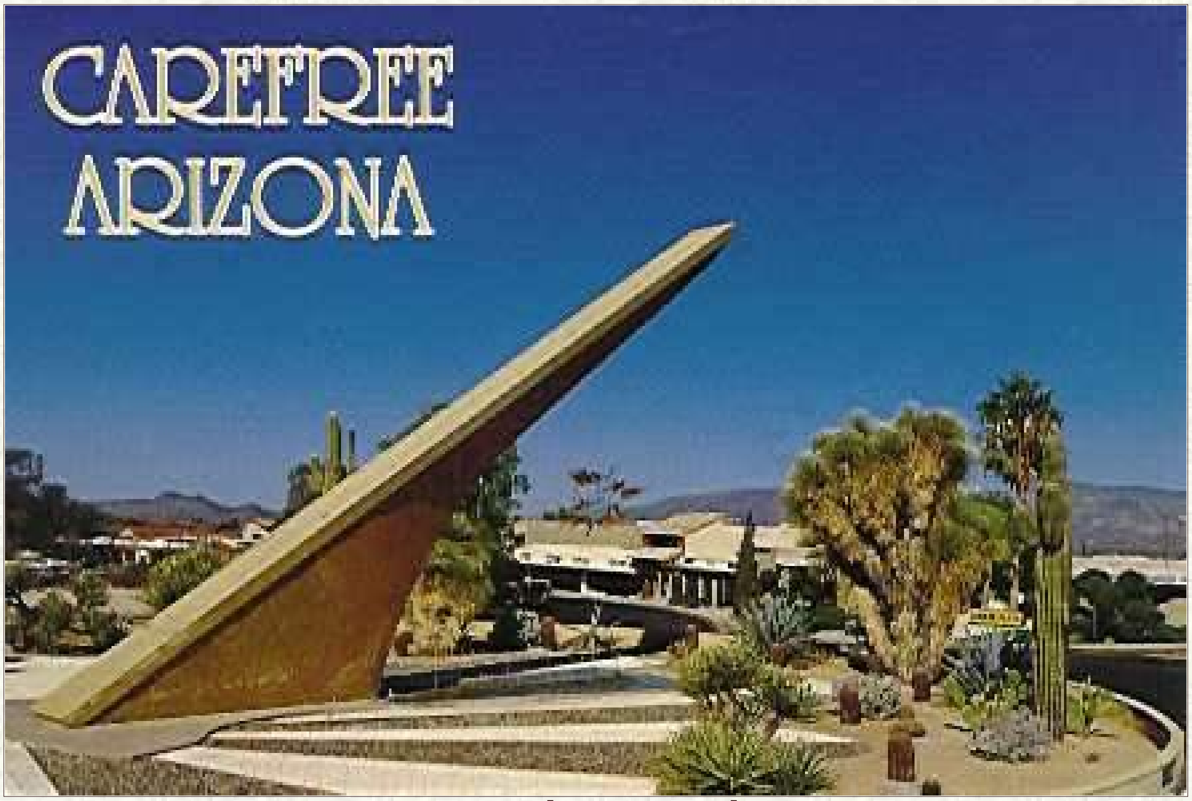


View from the east

Horizontal Dials

The plane of the shadow-receiving surface is horizontal.

A typical, but very nice garden-variety horizontal dial



A very large example

Equatorial

The plane of the shadow-receiving surface is parallel to the equator.

During the fall and winter, the time is read from the face towards the camera. During the spring and summer, the time is read on a similar face on the back of the dial. On the equinoxes, the gnomon will not cast a shadow on either face because the sun will be on the celestial equator.

Another form of the equatorial dial, often called a "bowstring" equatorial

Yet another form, a variation of the "Thew patent"

Armillary Dials

Armillary dials are equatorial dials with extra circles emulating those found on armillary spheres. A true armillary sphere is not a sundial but a model of the heavens. The extra circles on an armillary dial actually hinder timkeeping by blocking the sun at various times.

INTRODUCTION

There are two other important Internet sources for information on Sundials. The first is Sundials on the Internet. Links to pages on SotI are included in the list below, and are suffixed with [SotI].

Second is The Sundial Mailing List maintained by Daniel Roth. The Internet dialing community is indebted to Daniel for the mailing list, as well as his list of links from which those below were originally derived.

Here is a link to the AltaVista translation utility which may help you with pages that are not in your native language.

Please report new or dead links to the Webmaster.

NEW!! - a category for New Links

SEE WHO IS LINKING TO US!

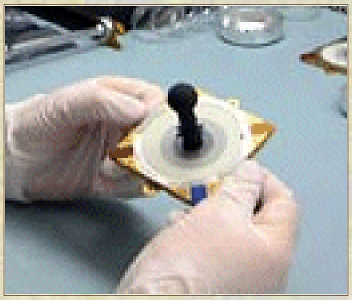
FEATURED SITE

THE MARS SUNDIAL

One Sun

Two Worlds

- **The Mars Sundial**
- **Spirit Updates**
- **What time is it on Mars?**
- **I mean really... What time is it on Mars?**
- **Sundial to calibrate Pancam, the camera on the rovers**



- Bill Nye, the science guy on **The first interplanetary sundial**
- **The overhead view of the rover indicating the sundial**
  (At work?) - large image - 1694x1690x200k
- **Mars Sundial to Help Teach Kids About Time, Sun**
- **NASA Flash presentation: M2K4** (**Noisy** but nice)
- **The EarthDial Project**

MORE FEATURED SITES

- The Sundial Site of Frans Maes (English) & (Dutch)
- Sotheby's auction of sundials from the Time Museum (Rockford, IL)
- Epact - Scientific Instruments of Medieval and Renaissance Europe
- A starting point for the many sundial pages at the Bremen Planetarium (German)
- Stained Glass Sundials From Around The World

NEW LINKS

New links will be kept here for a few weeks before they are categorized.

- The Jaipur Observatory Sundial (Follow the Links)
- Piet Hein's helical sundial (Click #25)
- The U.K.'s £1.2-million Stainless Steel Sundial (Proposed)

Images of the Analemma

- Some beautiful images of the analemma by Anthony Ayiomamitis
- The Analemma Project
- Analemma

- Astronomy Picture of the Day - July 9 2002

The Sun Dagger in Chaco Canyon

- Archaeoastronomy in the American Southwest
- The Sun Dagger
- A Unique Solar Marking Construct

GENERAL

- Daniel Roth's comprehensive Sundial Links
- Search previous postings to the sundial mailing list
- A Glossary of Sundial terms by John Davis

- Solursida (Norwegian)
- Sundials in the Lycée Louis-le-Grand
- Santiago Calatrava's Turtle Bay Sundial Bridge and The Official Web Page
- Design Options for Horizontal Monumental Dials (PDF) - John Carmichael
- The Gregorian Calendar and the vernal equinox also the autumnal equinox
- The fantastic sundial made for Charles II in 1669
- A sundial on the Greenwich Meridian
- Sundials At New College, Oxford
- Sundials at Wadham College, Oxford
- The John Garrey Tippit Memorial Sundial
- Bob's Sundial Page
- University of Sydney Museum Sundials and Other Time Pieces
- A Quest for a Civil Time Polar Sundial
- Iowa State University's Polaris Project Unit Six - Sundials
- L'arte della Gnomonica - site has more links
- Nonvedolora Gnomonics and Fabio Savian
- Sundials - The New Zealand Garden Journal
- Sundial at the ancestral home of George Washington [More]
- The Sundial
- Find Latitude and Longitude From Internet sources
- Convert from deg/min/sec to decimal degrees and vise-versa
- Carpe Diem El mundo de los Relojes de Sol en una página (Spanish)
- Make a Quadrant Sundial - Valentin Hristov

- The Pilkington Gibbs Heliochronometer and how it works (Mike Shaw)
- Me and My Shadow Making the Sun-Earth Connection
- Relojes de Sol (Spanish)
- Cadrans Solaires 3D (Macromedia required)
- Introduction to sundials (German)
- Three exceptional sundials at the Adler Planetarium
- Metal has proven itself indispensible in telling time.
- Sundial Page - David M.F. Chapman
- Sundials- Brooke Clarke - many links
- Geometric sundial construction - T. Gebhardt (German)
- Mike Shaw's sundial page
- Quadranti Solari - Franco Martinelli (Italian)
- Sonnenuhren (German)
- The Homepage of Mario Arnaldi
- A series of sundial pages by K.P. Cheung (Hong Kong)
- Convert geographical co-ordinates: - decimal to d,m,s; and vise-versa
- NOAA Solar Calculator Glossary
- Sundials National Institute of Standards and Technology
- Make your own horizontal sundial
- Sundials Royal Observatory, Greenwich
- Sundials 'n Stuff
- What is Local Noon?
- Sundial - Brittannica.com
- Clockworks - Britannica.com
- Les cadrans solaires (French)
- Sundial Information
- ***Sundials*** by F. J. Britten (Clocks and Time)
- What is a sundial
- Sundials of the World
- Exploration - Sundials (NASA)
- Sundial Mottos in Latin and French
- World Time Zone Map
- Time Zone Abbreviations
- About the measure of time

- Meridiane in Canavese Mauro Basiglio (Italian)
- Gnomonics Riccardo Anselmi (Italian, English)
- Solis et Artis Opus Mario Arnaldi (Italian)
- Gnomonica Rosa Casanova (Italian)
- Quadrandi Solari Diego Bonata (Italian)
- Meridi@ne Gianni Ferrari (Italian)
- Earth's Equinoxes, Solstices, Perihelion, and Aphelion 1992-2005
- Page personnelle de Gérard Baillet (French)
- Shadow Plane Sundials
- Find your latitude and longitude - from your street address
- An Essay on Hours and Unequal Hours
- Mario Arnaldi (Italian)
- Sundial Books [SotI]
- Sundial Computations - Slawomir K. Grzechnik
- Method to compute flat sundials - Fer J. de Vries
- Zonnewijzer - H. van Winkel (Dutch)
- A sundial page - Patrick Powers
- Jack Aubert's Sundial Page
- Gnomonique par Yvon Massé (French)
- Gruppo Astrofili Piceni: Orologi Solari (Italian)

HISTORY

- Scientists identify a sundial at Qumran
- Lo strumento astronomico di QUMRAN - Nuove interpretazioni (PDF - Italian)
- Astronomisches Meßgerät aus Qumran / „Sonnenuhr" (German)
- A polyhedral dial attributed to Nicholas Kratzer
- Athens: The Tower of the Winds
- Gaffarel's Description of The Dial of Achaz
- Equinox - The Mayan Astronomers
- A Pompeian sundial inscription
- Histoire de la mesure du temps (French)
- Queens' College Dial
- A Brief History of Time - From Thales to Callippus
- The MacTutor History Archive

- History of Astronomy - University of Bonn
- Article about Jaipur - Jantar Mantar (English) or (German)
- Augustus' sundial
- Le Champ de Mars: l'Horologium Augusti

PUBLIC DIALS

- Richard Schmoyer's Lyre/Tuning Fork Dial
- The Schmoyer "Sunquest" - an elegant dial that reads Standard Time
- The Schmoyer "Sunquest" revisited
- The Solar Pyramid
- Sun Cannon - Åtvidaberg Sweden
- Keppel Henge
- Tavel Sun Nave
- La Nef Solaire de Tavel (French)
- Sundial by Christian Renonciat in Reims
- The Portland Oregon Union Station (not really a) sundial
- An analemmatic dial near Lichfield, England
- Perranzabuloe Millenium Sundial - Cornwall
- Sundial at the Griffith Observatory
- Precision sundial in Tholey (German)
- The Lyman Briggs Standard Time Sundial
- Equatorial dial at New Mexico State University
- The Amble Dial - (England)
- Sundial at the University of Hawaii
- Digital Sundial Patent
- A giant sundial in Cornwall (Proposed)
- The Heidenheim sundial (Proposed)
- The beautiful dolphin dial at the Greenwich Maritime Museum
- Lumbutts Sundial - West Yorkshire
- A bifilar dial in Barcelona (Spanish)
- Sundial at the public observatory in Mainz, Germany
- Sundial on the Atelier Acacia in Mont-Dauphin (Haute Alpes, France)
- Large horizontal dial at Binghamton University, New York
- Armillary sphere at Penn State

- Horizontal dial at the University of Kentucky
- "The Cycle of Life" an armillary sphere by Paul Manship
- Armillary dial at Heritage Plantation, Sandwich MA
- Equatorial dial at the University of Nevada, Reno - another view
- Sundial at the former Québec Astronomical Observatory (2 Photos)
- Sundial at the Dows Planetarium in Montreal
- Sundial on Terrasse of the Québec Parliament
- Vertical dial at the Séminaire de Québec
- Sundial in the Forbidden City, Beijing
- Dial by Thomas Tompion, at Hampton Court Palace in London
- Polyhedral dial - Stropshire England
- Equatorial dial at New Mexico State University
- Armillary dial at the University of Virginia
- Horizontal dial at the University of Virginia
- Polyhedral dial on the Isle of Man
- Vertical Declining Dial, Paris
- Eastern Michigan University A Dial Rededication
- The Pinawa Heritage Sundial
- "Child Sundial" at the Missouri Botanical Garden
- An original Russell Porter SunClock
- The Richard D. Swensen sundial at the University of Wisconsin
  Web Cam
- The Physics-Astronomy Sundial at the University of Washington
- Sundial at the public observatory in Mainz (German)
- Church sundial, Jausiers
- Vertical dials at Palladio's Villa Barbaro at Maser, Italy
- Sundial at the Justice Center, Hunterdon County NJ
- Vertical dial on a church in Cornwall
- St. Peter's Cathedral, Geneva
- Queens' College Dial
- Sundial in front of the planetarium in Berlin (German)
- Sundial at Fort Oranje, St. Eustatius, Dutch Caribbean
- Sundial at the University of Limerick
- A sundial at Kochi Castle, Japan

Mass Dials

- The Aldbrough Sundial, a Mass Dial in East Yorkshire
- The Kirkdale Sundial, a Mass Dial in North Yorkshire
- The Kirkdale Sundial - the inscription

MONUMENTAL DIALS

- Word's biggest sundial is in Pajala
- Te Ra Tu - The Standing Sundial (Proposed)
- Large Sundial in grass. Pekin Illinois
- Mount Laguna Observatory sundial
- Sundial at Hong Kong University
- SunPath Designs
- Haym Kruglak Sundial at Western Michigan University
- The sundial for Reutte

ANALEMMATIC DIALS

- A new analemmatic sundial in Torreón, Mexico
- A Table Top Analemmatic by John Carmichael
- A Jubilee Sundial for West Somerset
- Sundial Garden at Michigan State University
- Make your own Sundial
- Two mean-time analemmatic sundials - Yvon Massé
- Central projection analemmatic sundials - Yvon Massé
- Analemmatic Sundials How to build one and why they work
- The Sundial of Human Involvement
- M. Vitruvius Pollio and the Analemma
- Thunder Bay, Ontario
- Dial at The Flandrau Planetarium and Science Center, University of Arizona
- Analemmatic sundial, Riverwalk, Augusta, Georgia
- Of Analemmas, Mean Time, and the Analemmatic Sundial - Frederick W. Sawyer III
- Sunclocks - human sundials

PORTABLE DIALS

- Three sundials in the collection of the Adler Planetarium

- The Ansonia Sunwatch
- A German string-gnomon dial circa 1680
- 15th century navicula, or "little ship of Venice" sundial
- Shepherd's Dial
- A cube sundial with Italian hours
- Old quadrant in the Museum of the History of Science, Oxford
- St. Peter's Cathedral, Geneva; German diptych dial
- Portable sundials at the Manor House Museum, Bury St Edmunds

BY LOCALE

- Cadrans Solaires en Alsace
- Sonnenuhr in Bad Bevensen
- Sundials in Manchester
- More on the Manchester sundials
- Meridiane in Piemonte
- A new sundial in Bremen (German)
- Sundials in Italian Schools (Italian)
- Sundials in the Czech Republic
- Sundial Gallery (Czech)
- Sundial in Isan, Thailand
- Orologio Solare Equatoriale - Pisa (Italian) (English)
- Cadrans solaires en Queyras - France (French)
- Murcia - Spain (Spanish)
- Die Sonnenuhr in Bad Bevensen
- Sundials in Nürnburg
- Germany sundials & other astronomical clocks - Peter Lindner
- Various locations - mostly Europe (German)
- Bremen - (German)
- Paris
- Ancient Sundials of Ireland
- Barcelona (Spanish)
- Andalucia - includes Islamic dials (Spanish)
- Alsace, France
- Québec

- Leeds, England
- Sundial Trails [SotI]
- Nova Scotia
- China
- France
- Brittany (French)
- The Netherlands
- Germany (German/English)
- Berlin, Germany
- Austria

COLLECTIONS

Here you will find anything from Museum exhibits to personal collections of photographs.

- Deutsches Museum Der Sonnenuhrengarten
- Sundials at the Franklin Institute
- The Homepage of Frans Maes (English) & (Dutch) Excellent illustrations of dial types

  Antique Dealers who may have sundials for sale

  - Galai Collectibles
  - Tesseract
  - The Gemmary
  - Artifice
- Pictures of sundials & astronomical clocks - Peter Lindner (German/English)
- Sundials at the Deutsches Museum, Munich (German)
- Sundials at the AstroGallery (China, India, South Tyrol)
- Sonnenuhren - Daniel Roth (German)

ARTISANS

This category includes anyone who makes sundials, either as a hobby or a commercial venture.

- Custom Consulting Work - Bill Gottesman
- GNOMÒNICA Rellotges d'Autor - Joan Olivares Alfonso
- Villalcor Una compañía dedicada a la recuperación y fabricación de instrumentos antiguos.
- The sundial site of Angelo Brazzi (English) (Italian)

- The Universal Pocket Sundial
  If you indicate on the order form that you are a NASS member, the price is $40 + shipping
- HinesLab Digital Sundial
- The sundial page of Giuseppe Ferlenga (Italian)
- John David Cooney Art in Platinum and Gold
- Westwood Dials
- Sundial Sculptures by John L. Carmichael Jr. (Site re-written)
- David Brown
- Sally Hersh
- David Harber Sundials)
- Accurate Sundials
- Artisan Industrials - The Spectra Sundial
- Meridia Net - Sundial plans
- Helios Astronomical Timepiece
- Sol Invictus GmbH (German)
- Sonnenuhrengestaltung - Arno Ruckes (German)
- Wearable sundials
- Helios - high precision sundials by Carlo Heller (German)
- Analemmic-Equatorial Sundials - Peter Swanstrom
- Solaria - L.M. Morra e Fabio Garnero (Italian)
- Carlo Heller high precision sundials (German)
- Orologi Solari & Meridiane - Enio Vanzin (Italian)
- Meridiane ed Orologi Solari - Giovanni Paltrinieri (Italian)
- Orologi Solari - Ugo Beccheroni (Italian)
- Sundials and Moondisks - Daniel Oberti
- Forging Ahead - Paul Margetts
- The Universal Ring Dial - Saunders and Cooke
- Sundials for the Connoisseur - Silas Higgon
- The Wenger Sundial
- David L. Aho - Metalworking
- Sunclock (Human Sundial)
- Kate Pond
- Accurate Standard-Time Sundials
- Flowton Dials - John Davis

- Harris Morrison's web site for Shepherdswatch portable sundials
- Precision Sundials LLC - Bill Gottesman
- Great Circle Studio - Luke Coletti
- Michael Malleson
- David Harber Sundials
- Harriet James
- “The Accurate Sundial”
- Astromedia - Scientific stuff, including cardboard sundials (German)
- Stephen Luecking
- Interior Sundials - Reflected Ceiling Dials
- Carlo G. Croce
- Timeless Instruments - Norman Greene
- Orologi Solari - Ugo Beccheroni (Italian/English)
- Tony Moss, Lindisfarne Sundials
- Giuseppe Viara
- Saunders and Cooke, Antique re-creations
- About Time - Mike Manning
- Sundial designers and makers [SotI]
- Heliochronometers by Gunning Sundials
- Merlin Design - Etchers in Brass
- Some sundials by Piers Nicholson
- Welcome in the world of the sundials - Philippe Langlet
- Suntiles
- Jack Aubert's Sundial Page
- The Astrolabe - James E. Morrison
- Universal Ring Dial by Ames Instrument Company
- Colonial Brass - sundials
- About Time - engravings from computer-generated files for sundials etc.
- Blades of Tara
- Sundials at Radnor Forge
- Kenneth Lynch & Sons
- Armillary sundials by New England Garden Ornaments
- Robert Terwilliger's Homepage
- SunPath Designs: outdoor sundials as functional works of art

- Sundial cannon - The Arsenal Store
- Travelsundial for Europe: for hiking and beach

EDUCATION (Elementary)

- An Educator's Guide to Equatorial Sundials
- Sunshine in your pocket! Making a sundial for the northern hemisphere.
- What is a sundial?
- Fabriquer un cadran solaire (French)
- What is a sundial?
- Sundials - NASA Kids
- Making a Sun Clock
- Sundial Planning
- Building a Simple Sundial
- Cosmic Gnomon
- Sun tower at Gullett Elementary School, Austin, TX
- Urbana IL high school "Merging Science and Art" sundial project
- The Event Inventor, including Sun Fun
  Time on your hands

TRIGONOMETRY

- Dave's Short Trig Course
- Frequently Asked Questions About Trigonometry
- The Trigonometry Forum
- Math Archives - Trigonometry - Links
- An introduction to Trigonometry
- Spherical Trigonometry - a new approach (Advanced)

THE EQUATION OF TIME

- The fabulous photograph of the analemma by Dennis di Cicco
- Another Sunrise Analemma
- The Equation of Time - The Royal Observatory, Greenwich
- Analemma - an extensive explanation - Bob Urschel
- The Analemma (C program)
- A digression on the equation of time
- The equation of time (scientific approach) - Art Carlson

SUNDIAL GENERATORS & CALCULATORS

- AstroCalculator - includes sundial calculations
- SUNDI Sharweware sundial generation program
- Calculate and Chart the Analemma
- An online solar calculator
- Sun Positions, Formulas, & Sundials
- Generate sundials - PDF output
- Sustainable By Design - various solar calculations
- Computing Local Noon
- Almanac of Solstices, Equinoxes and Cross Quarters -2003
- Azimut und Elevation der Sonne
- U.S. Naval Observatory Data Services
- NOAA Sunrise/Sunset/Solar Noon/Position Calculator
- Generate a Virtual Sundial based on the Queens' College dial, Cambridge, UK.
- Sun Position Calculator
- MrCalculator's Sundial Calculator - Vertical south dials - with optional declination
- Animated java design for a dial in Damongo, Ghana
- Jürgen Giesen's GeoAstro Java Applets
- Solar data JavaScript calculator
- Sun's Information and Sight Reduction
- View the earth from the sun
- USNO Sun or Moon Rise/Set Table for One Year
- Astronomical Time Calculations
- You can make a sundial! (PostScript files)
- Bob's Sundial Generator (PostScript file)
- Great Circle Studio - Many options
- Collection of Sun Maps / Sun Clocks (Java applets)

MOON DIALS

- The Moondial
- Moon Calendar
- Celestial Products: Moon Posters

MERIDIANS

- Merdienne in Serres (Hautes Alpes, France)
- Images of the solar eclipse of August 11, 1999 seen as pin-hole projections on various meridian lines in Italy.

MISCELLANY

These are links that don't fit anyplace else. You will find some strange and wonderful things here.

- A Martian Analemma
- The Kellogg's Raisin Bran Sundial
- GEOCACHING - Sundials (Interesting!)
- Some pages on solar alignments with the Arc de Triomphe
  Link 1 Link 2 Link 3
  A gnomonic experiment
- The Pilkington Gibbs Sol Horometer
- FAQ: Roman IIII vs. IV on Clock Dials
- Make a sundial and compass from your fingers
- Coffee Can Time Machines
- Sunrise on the Equinox + 1
- The first US coin had a sundial on it! (Click any picture and scroll down.)
- Stolen Sundial - From Kent, England
- Tridux 2000 - a device for laying out mirror sundials
- Sundial memorial to cyclist Fabio Casartelli
- There used to be a sundial here **...**
- Compendium Article (PDF) A "Digital" Dial – Time At Your Fingertips by Karen Robinson
- The Solar Telescope at Kitt Peak is becoming a sundial!
- Il Notturnale (The Nocturnal) (Italian)
- A discussion of the polyhedral and cylindrical sundials in Holbein's *Ambassadors*
- Earth Viewer
- Mike Shaw's Remote Reading Sundial - using fiber optics
- The fabulous photograph of the analemma by Dennis di Cicco
- References to sundials in the works of Shakespeare
- Web Cam of the Swensen sundial at the University of Wisconsin (if available)

- A Mirror Sundial in Bremen
- A Mechanical Sundial, or Sunpointer in Amersfoort, The Netherlands
- A sundial made of Legos
- Reviews of Universal Ring Dials being offered for sale
- A Sundial Park in Genk, Belgium featuring a dozen different sundials (English) & (Dutch)
- The Abbey of Mont Saint-Michel as a sundial? (French)
- The Washington Monument as a sundial?
- Play Sundial Games!
- To IV, or not to IV? That is the question.
- A Stonehenge watch
- Article on "Horologium"
- 103 commercial sundial images - that you can send as an E-card
- Sundial Patents - Search on "sundial".
- The Analemma Society A proposed astronomy park.
- Calendrical and Astronomical Links
- Use the wisdom of the sun to aim a satellite dish.
- An Anglo-Indian sundial project
- 7 Sundials +1 at the Robert Doisneau lycée in Vaulx-en-Velin
- Construction of a hemispherium - Fer J. de Vries
- The Measurers: a Flemish Image of Mathematics in the Sixteenth Century
- Sundial trails [SotI]
- Sundial on a computer chip
- Live Webcam on the sundial at Pembroke College, UK
- Startime Sundial
- Digital Sundials International
- Théorie sur le cadran solaire bifilaire vertical déclinant - D. Collin (French)

SOCIETIES

- Asociación de Amigos de los Relojes de Sol
- How to join your national sundial society [SotI]
- Sundial Organizations (Clocks and Time)
- Austrian Astronomical Society - Working Group for Sundials
- De Zonnewijzerkring (The Dutch Sundial Society)
- English summaries of the journal of the Dutch Sundial Society

- The British Sundial Society
- Arbeitskreis Sonnenuhren (German)
- The National Association of Watch and Clock Collectors
- La Commission des Cadrans solaires du Québec
- Societat Catalana de Gnomònica (Catalan)

SOFTWARE

- DeltaCad Macros for drawing sundials and other applications
- Precision Sundials LLC Software and Other Downloads
- The Sun API- solar values for programmers & Excel spreadsheets
- An Excel spreadsheet for analemmatic dials by Gianni Ferrari
  The file is Zipped and can be downloaded directly.
- zw2000 - very popular and easy to use
- The Dialist's Companion
- Sonne Software (English) (German) - Including an Excel spreadsheet for analemmatic dials
- The USNO MICA - The Multiyear Interactive Computer Almanac
- Cadrans Solaires Shadows Software
- Welcome to the Sundial Calculator.

INTERNET HOROLOGICAL SITES

- Clocks and Time
- Horology - The Index
- Time Measurement
- WorldTempus.com (French)
- Antiques Guide

Analemma

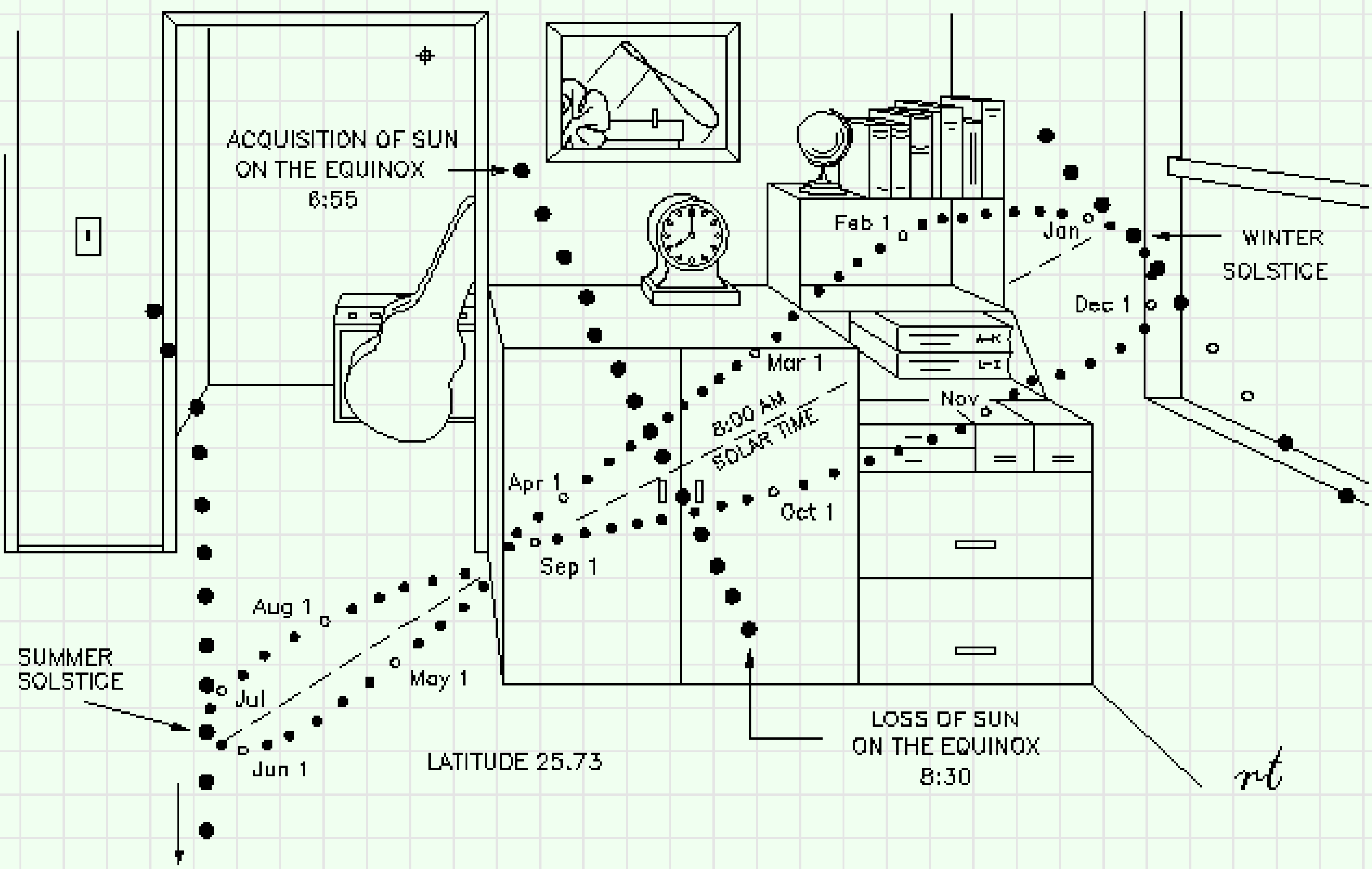
Pages From a Dialist's Notebook
An Indoor Analemma

In the fall of 1995 I moved to a new home where I placed my office in a room high in the north east corner of the building. The room has a large east-facing window through which the sun came - suddenly and brightly - each morning at about 7:30. At first I found this annoying, but then I realized I could take advantage of the situation and project an 8:00am analemma which would demonstrate the **Equation of Time**. Preliminary observations indicated that the analemma would wind its path across the walls, furniture and floor on the west side of the room.

I mounted a cardboard arrow high on the east window for a gnomon, and each morning at 8:00 I placed a small Avery dot where its shadow fell at **Standard Time**. My first dot was placed on the 1995 winter solstice. During the winter the analemma snaked its way across the north wall, through a bookcase, and onto a filing cabinet on the west wall.

A GNOMON'S EYE VIEW of its own ANALEMMA

It made it! - this depiction 12-21-1996, the winter solstice



Click in the drawing to see a color version.

The morning of the vernal equinox was clear and sunny. I placed dots at 5 minute intervals following the path of the shadow as long as the sun entered the room.

I realized from the Loss Of Sun on the equinox that I was in for some damage control. An eave overhanging the window was going to block the sun during high summer. Also, the point where the loops of the analemma crossed was going to come right where the shadow dropped off the filing cabinet and into the closet.

I decided to plot the smaller, summer loop with a second gnomon 10 inches below the first. This had the effect of moving the loop out into the room where it makes an interesting conversation piece. The effect of lowering the gnomon is not obvious in the drawing.

On the morning of the summer solstice, I again traced the path of the shadow, this time into and out of the closet, then across the floor. Here is a photograph of the small loop taken a few days after the summer solstice. The photo also shows a portion of the path of the summer solstice shadow as it moved across the floor.

The journey through the autumnal equinox and back across the filing cabinets was uneventful, and eventually the shadow crept up onto the north wall.

Although the morning of the winter solstice was cloudy I had already placed enough dots to indicate that analemma had found its home, and the year-long project was successfully completed.

The timing for the placement of the dots was provided by ***The Dialist's Companion***, a program written by Fred Sawyer and myself recently published by **The North American Sundial Society**.

Analemma started 12-21-1995. Drawing started and put on line 6-22-1996. Updated 7-6, 8-21, 9-24, 10-16, 10-30, 11-10, 11-23, 11-30, 12-9, 12-21 of 1996

Return to The  Dialist's Notebook

The NASS Message Board

[Post Message] [Read Me] [Message Board Home]

- sundial accuracy - **Josh** *1/9/2004* (2)
  - Re: sundial accuracy - **Bill Gottesman** *1/10/2004* (1)
    - URLs for the message above - **Bill Gottesman** *1/11/2004* (0)
- Small Sundials - **Bree** *1/9/2004* (1)
  - Re: Small Sundials - **Webmaster** *1/10/2004* (0)
- Advice re: Designing a Sundial - **Walter Sanford** *1/2/2004* (0)
- Sundials and ratios - **Rachel** *12/30/2003* (1)
  - Re: Sundials and ratios - **Uno Kurvet** *12/31/2003* (0)
- Registry entries #75 and #10 - **John Decker** *12/29/2003* (1)
  - Thank you! - A dial is found. - **Webmaster** *12/30/2003* (0)
- The EarthDial Project - A Golden Opportunity for NASS - **Walter Sanford** *12/7/2003* (0)
- sundial time... - **lindsey besthorn** *12/5/2003* (1)
  - Re: sundial time... - **Bill Gottesman** *12/7/2003* (0)
- Memento Mori - **Frank Mand** *11/29/2003* (4)
  - Re: Memento Mori - **Frans Maes** *1/6/2004* (0)
  - Re: Memento Mori - **Uno Kurvet** *12/1/2003* (2)
    - Re: Memento Mori - **Frank Mand** *12/1/2003* (1)
      - Re: Memento Mori - **Uno Kurvet** *12/2/2003* (0)
- Armillary Sphere Instructions - **Eric** *11/23/2003* (1)
  - Re: Armillary Sphere Instructions - **Roger Bailey** *12/5/2003* (0)
- Construction of a sundial - **Richard Westfield** *11/22/2003* (0)
- Portable Sundial - **F F** *11/19/2003* (4)
  - Re: Portable Sundial - **F F** *11/19/2003* (3)
    - Re: Portable Sundial - **John Davis** *11/20/2003* (2)
      - Re: Portable Sundial - **John Davis** *11/20/2003* (1)
        - Re: Portable Sundial - **F F** *11/22/2003* (0)

- vertical direct dial in the tropics - **Carla** *11/17/2003* (2)
    - Re: vertical direct dial in the tropics - **Bill Gottesman** *11/18/2003* (1)
        - Re: Thank you Bill Gottesman - **Carla** *11/19/2003* (0)
- Help with a science fair question - **Marlon** *11/9/2003* (1)
    - Re: Help with a science fair question - **Uno Kurvet** *11/12/2003* (0)
- How best to adjust a horizontal sundial for a new latitude? - **Albert Franco** *11/3/2003* (4)
    - Re: How best to adjust a horizontal sundial for a new latitude? - **Roger Bailey** *12/5/2003* (0)
    - Re: How best to adjust a horizontal sundial for a new latitude? - **Walter Sanford** *11/6/2003* (0)
    - Re: How best to adjust a horizontal sundial for a new latitude? - **Webmaster** *11/4/2003* (1)
        - Re: How best to adjust a horizontal sundial for a new latitude? - **Albert Franco** *11/28/2003* (0)
- The Sundial Group at Yahoo Groups - **Albert Franco** *11/1/2003* (0)
- Arkansas' Sesquicentennial Sundial - **Albert Franco** *10/31/2003* (0)
- sundials - **kw** *10/29/2003* (1)
    - Re: sundials - **Uno Kurvet** *10/30/2003* (0)
- sundial question - **rayna denneler** *10/14/2003* (1)
    - Re: sundial question - **Mac Oglesby** *10/15/2003* (0)
- Length of Gnomon - **Edwin C Goodrich** *10/10/2003* (1)
    - How long should my gnomon be? - **Bob Terwilliger and Fer deVries** *10/15/2003* (0)
- Sundial location - **Glen** *10/5/2003* (1)
    - Re: Sundial location - **Webmaster** *10/10/2003* (0)

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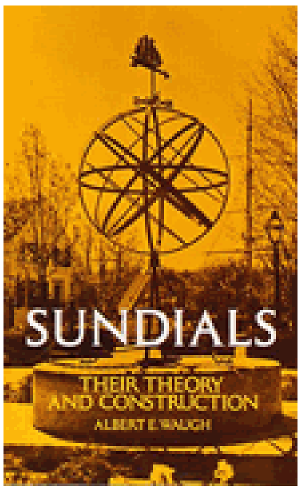
By Subject > Crafts > General



Zoom

Sundials, Their Theory and Construction

Albert Waugh

Ou

Avail

(Usually ships in 24 to 48 hours)

Pa

Di

Fascinating approach to sundials. On one hand, it is a rigorous appraisal of the science of sundials including mathematical treatment and pertinent astronomical background. On the other hand, it provides a nontechnical treatment simple enough so that several of the dials can be built by children. 106 illustrations.

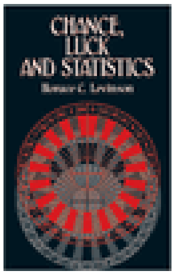
Here's a sample of other books in this Dover category

Relativity Simply Explained

by Martin Gardner

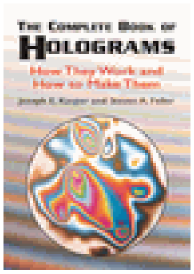
Lucid explanations of special and general theories of relativity, gravity and spacetime, models of the universe and other topics. 100 two-color illus.

all books in General Science



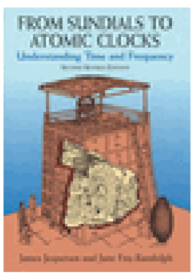
[Chance, Luck, and Statistics](#)
by Horace C. Levinson
In simple, nontechnical language, this volume explores the fundamentals governing chance and applies them to sports, government, business, and other fields. Part I concerns the theory of probability in relation to superstitions, fallacies, and betting odds. Part II ap...

all books in General Science



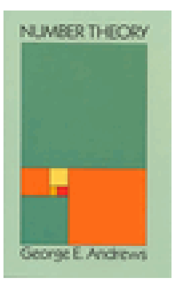
The Complete Book of Holograms: How They Work and How to Make Them
by Joseph E. Kasper, Steven A. Feller
Clear, thorough account, without complicated mathematics, explains the two models of holography-the geometric and the zone plate-and different types of holograms, including transmission, reflection, phase, projection, rainbow, and multiplex. They also show basic setup...

all books in General Science



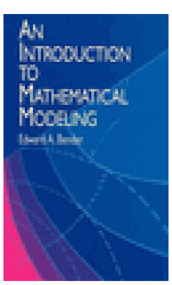
From Sundials to Atomic Clocks: Understanding Time and Frequency, Second Revised Edition
by James Jespersen, Jane Fitz-Randolph
Newly revised and updated introduction to time-its measurement, historic methods of timekeeping, uses of time information, and role of time in science and technology. Over 300 illus.

all books in General Science



Number Theory
by George E. Andrews
Undergraduate text uses combinatorial approach to accommodate both math majors and liberal arts students. Multiplicativity-divisibility, quadratic congruences, additivity, more.

all books in Number Theory

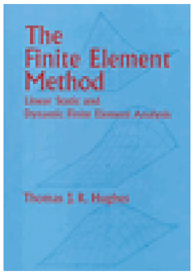


An Introduction to Mathematical Modeling
by Edward A. Bender
Accessible text features over 100 reality-based examples (from science, engineering, operations research). Prerequisites: ordinary differential equations, continuous probability. Numerous references. 1978 ed. 27 b/w figures.

all books in Operations Research

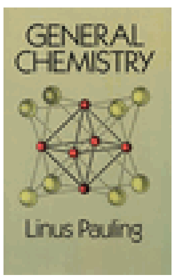
[The Works of Archimedes](#)
by Archimedes, Sir Thomas Heath
The complete works of antiquity's great geometer appear here in a highly accessible English translation by a distinguished scholar. Remarkable for his range of thought and his mastery of treatment, Archimedes addressed such topics as the famous problems of the ratio o...

all books in History of Mathematics



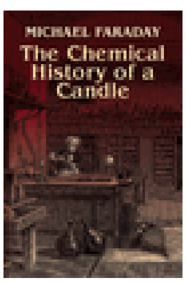
The Finite Element Method: Linear Static and Dynamic Finite Element Analysis
by Thomas J. R. Hughes
Directed towards students without in-depth mathematical training, this text includes a comprehensive presentation and analysis of algorithms of time-dependent phenomena plus beam, plate, and shell theories derived directly from three-dimensional elasticity theory.

all books in Civil, Mechanical and Other



General Chemistry
by Linus Pauling
Revised 3rd edition of classic first-year text by Nobel laureate. Atomic and molecular structure, quantum mechanics, statistical mechanics, thermodynamics correlated with descriptive chemistry. Problems.

all books in Chemistry



The Chemical History of a Candle
by Michael Faraday
One of the greatest experimental scientists of all time, Michael Faraday (1791-1867) developed the first electric motor, electric generator, and dynamo--essentially creating the science of electrochemistry. This book, the result of six lectures he delivered at London'...

all books in General Science

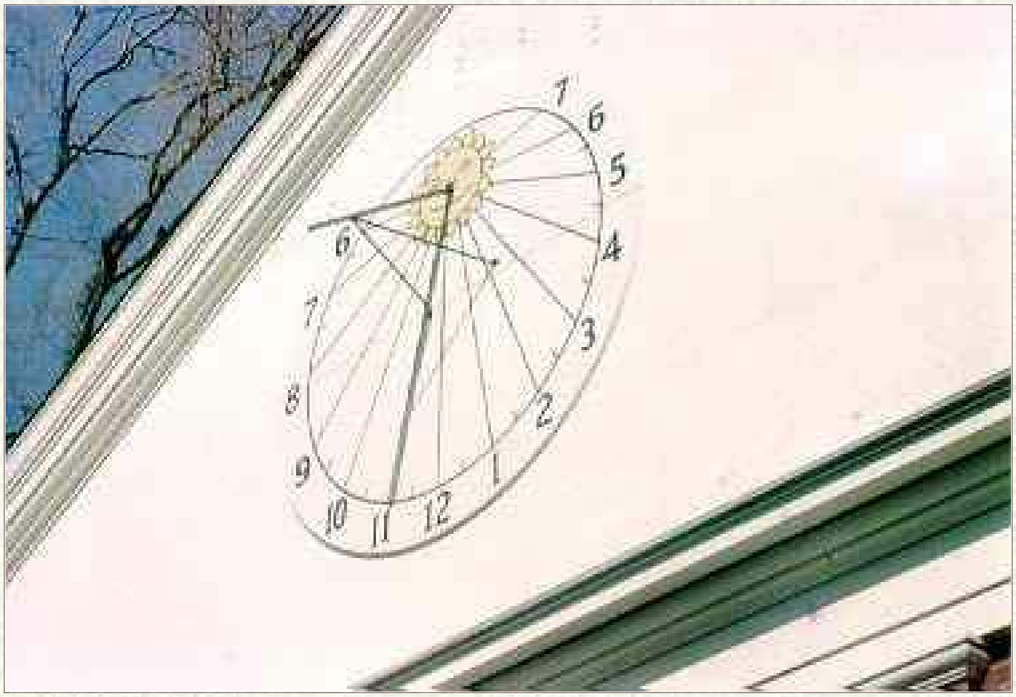
Vertical Dials
and Reclining Dials

On a **vertical** dial the plane of the shadow-receiving surface is vertical.

When a vertical dial is oriented to a cardinal point it is referred to as **direct** (east, west etc).

A **vertical declining** dial may face any direction between the cardinal points.

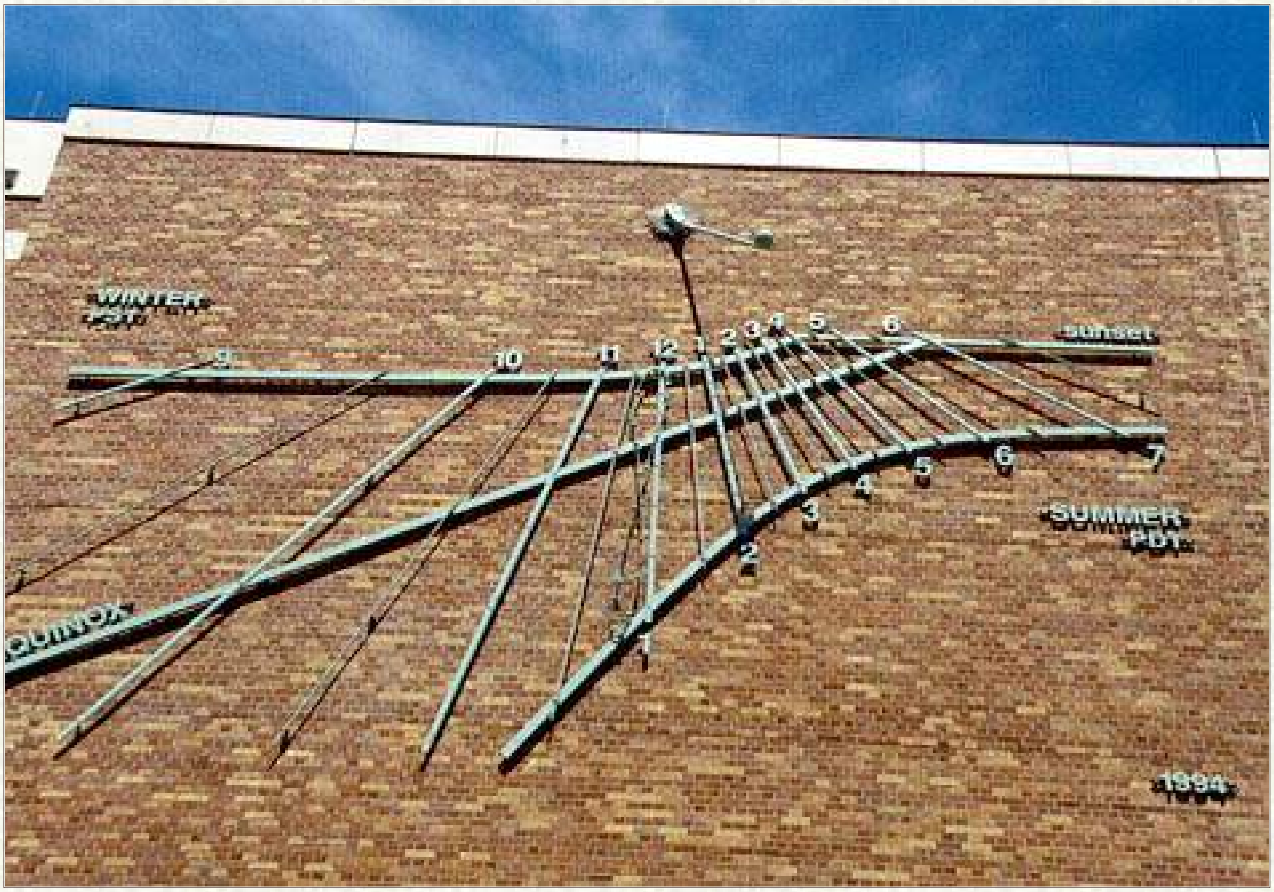
This page also includes dials which **recline** from the vertical.



A vertical **direct south**

The dial on the right of the cube is another **direct south** To the left is a vertical **direct west**. The line through the center and the curves along the edges indicate the dates of the solstices and equinoxes. The gnomons have been removed.

A rare vertical **direct north**. This dial will only receive sunlight in the early morning and late afternoon. Note the numerals - morning is to the right. The gnomon appears to be inverted, but it must be so as to be aligned with the polar axis.

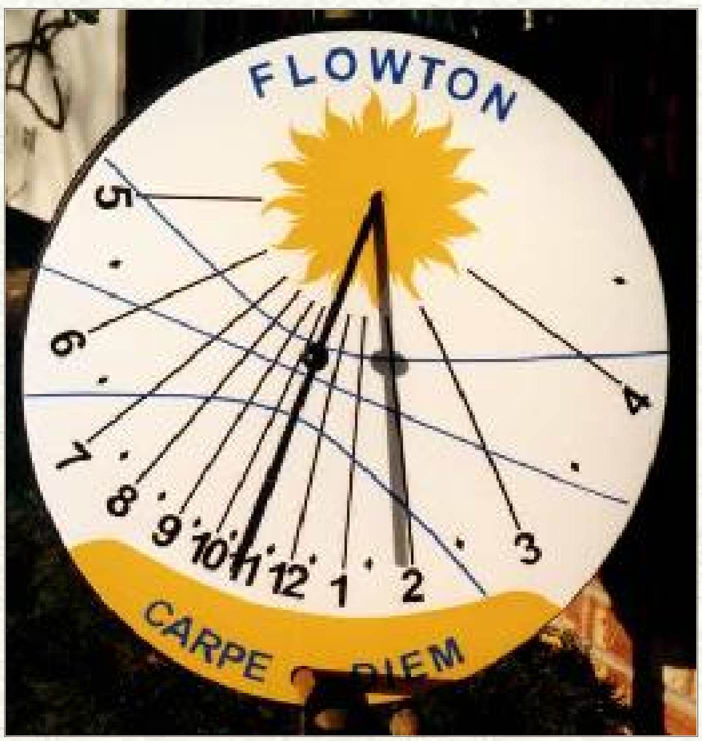


A **vertical declining** dial facing a direction between south and west. This dial includes the longitude correction, but no correction for the Equation of Time. The upper numerals indicate Pacific Standard time and lower ones Pacific Daylight Time - but Local Solar Time, not Standard Time.

Another **vertical declining** dial on the side of a barn. Note the compass directions at dial center. Because the 12:00 line is vertical, this dial indicates Solar Time. Compare with the dial above where the 12:00 line is not quite vertical.

A **reclining** dial. The dial is oriented due south, but the face reclines from the vertical.

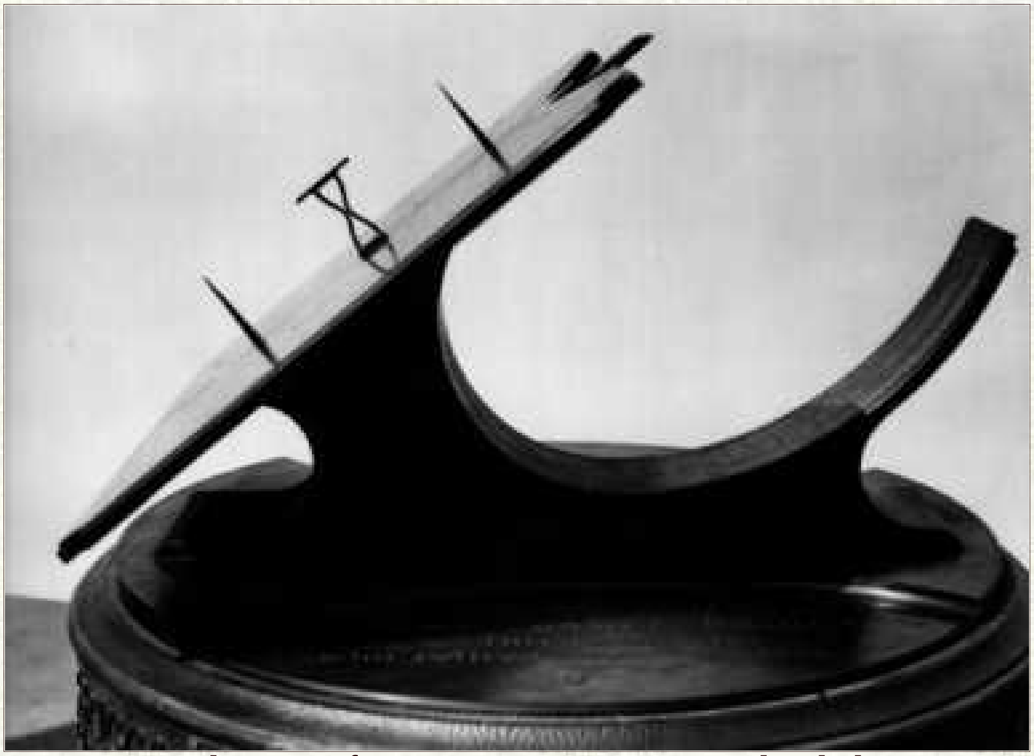
Another dial **reclining** so it is nearly horizontal. It was specifically designed so both the gnomon and face would be equilateral triangles.



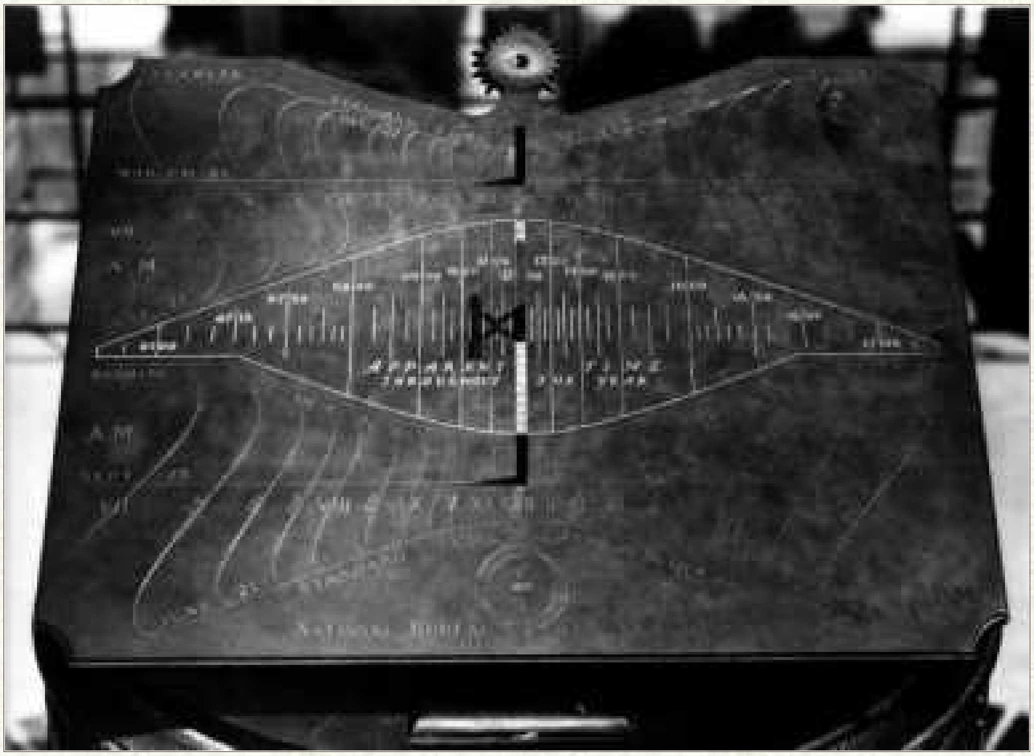
A **declining reclining** dial. The face reclines from the vertical and faces somewhat east of south. This unique dial is realized on a thin plastic membrane affixed to a satellite receiver dish.

Polar

The plane of the shadow-receiving surface is parallel to the polar axis.



Side view of an important American polar dial

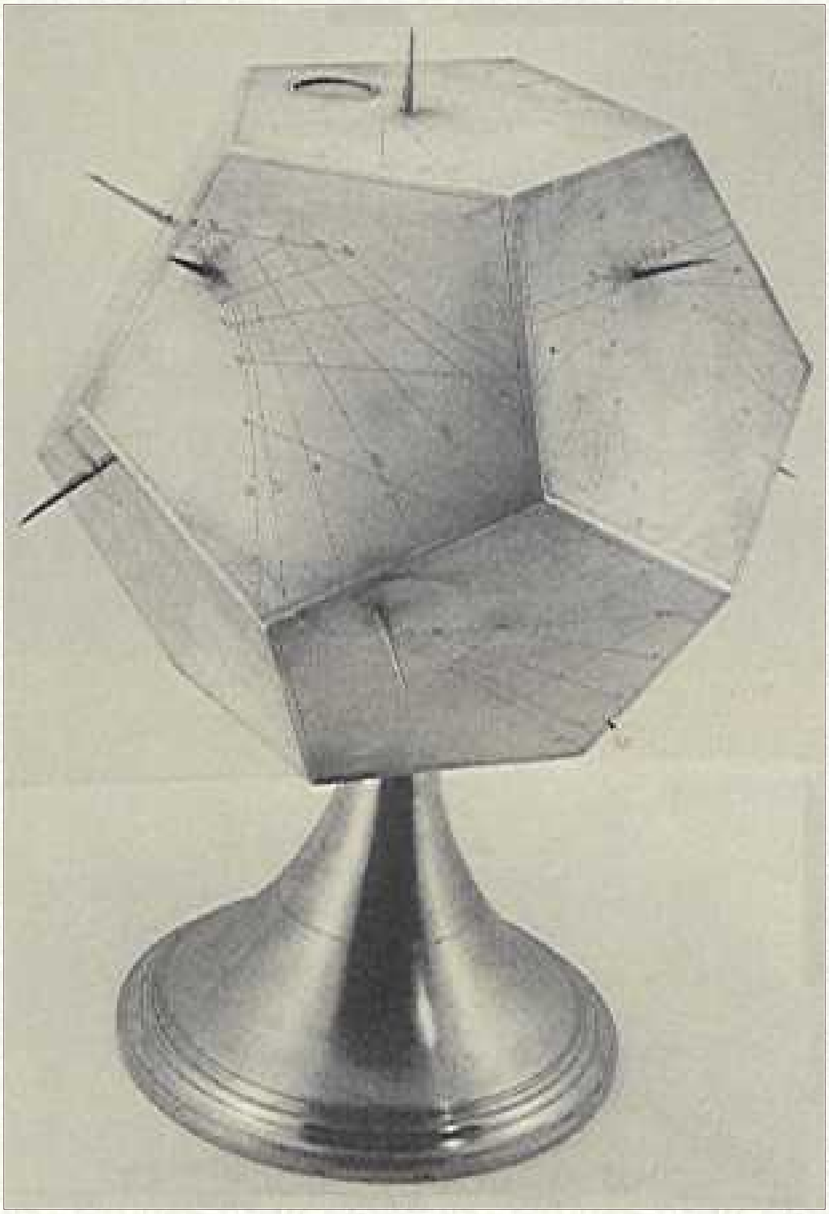


Front view. The face of the dial has curves corresponding to the analemma. The curves correct for the Equation of Time and the dial indicates both Solar and Standard Time.

A link to a page about this dial.

Polyhedral

Combining various orientations on multiple faces



A silver polyhedral dial in the form of a dodecahedron with dials on eleven faces. By Hans Koch. 16th century.

A polyhedral dial in the form of an octahedron. By Stefano Buonsignori, Florence, 16th century.

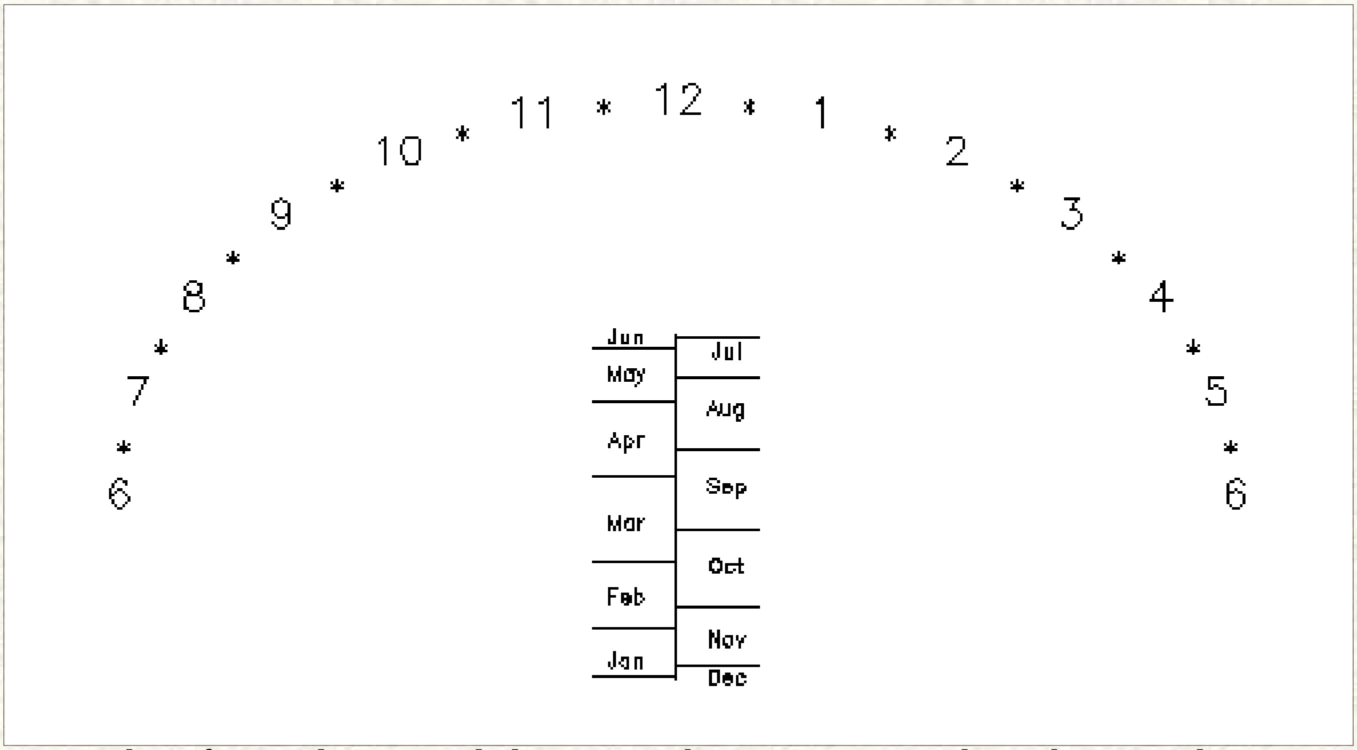
A polyhedral dial with faces oriented to tell time in various world cities.

A cross dial - there are sundials on most of the surfaces.

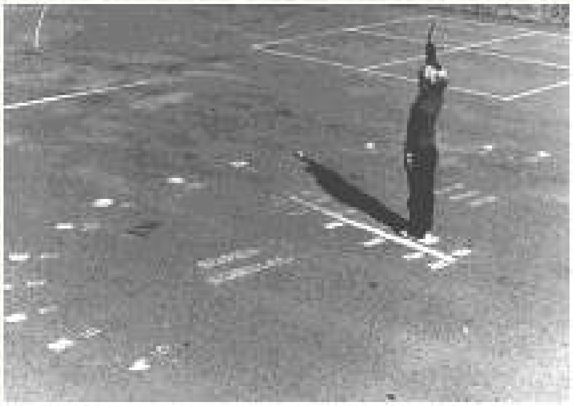
Analemmatic

Time is told by the sun's azimuth on a specific date.

Analemmatic dials are popular in public places as you are allowed to participate by being the gnomon!



Plan of an analemmatic dial at 45ºN. The "gnomon" stands on the center line corresponding to the date.



An analemmatic dial in use

Another analemmatic dial

Other Dial Types

(In no particular order)

A pillar or shepherd's dial

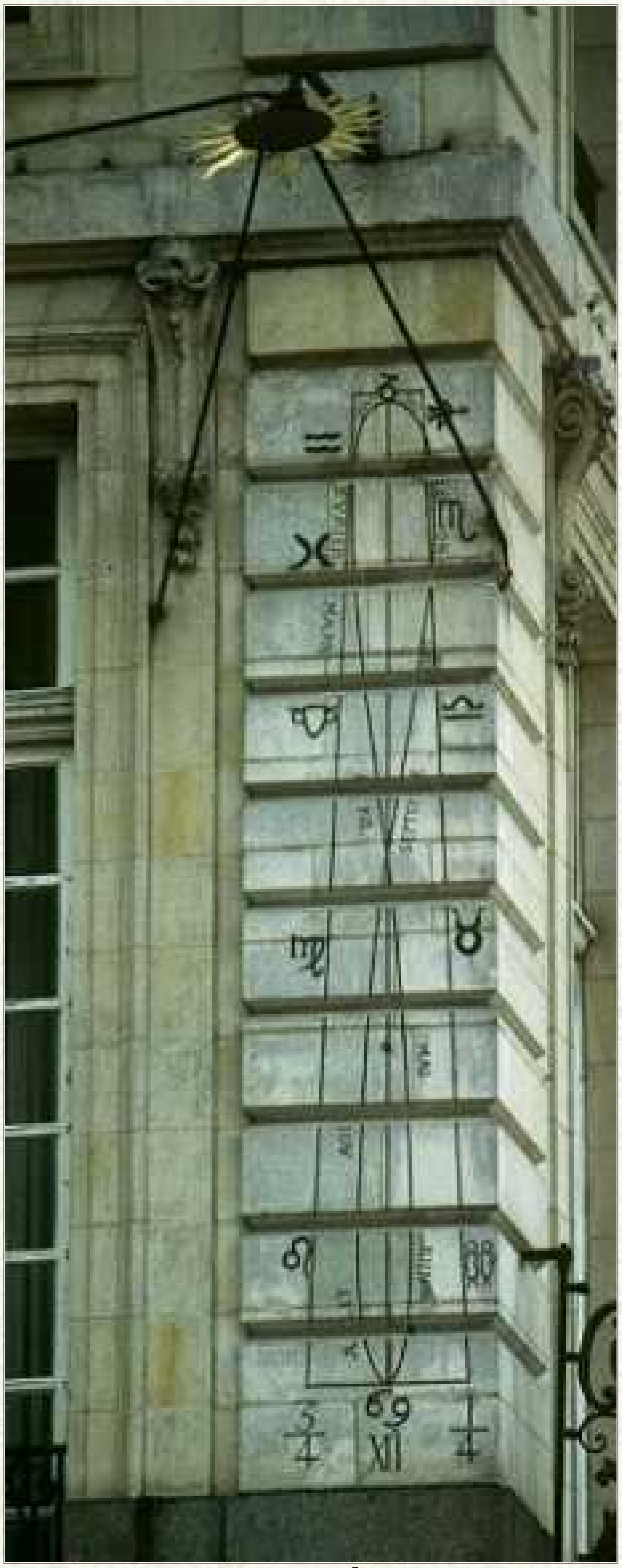
Universal ring dial

Thew patent dial

Heliochronometer
the most accurate sundial

Scaphe dial

Diptych dial



Noonmark or Meridian

Frans' sundial site

Best viewed at 800x600

Nederlands

Home

Introduction

Classification

Index

Analemmatic
o extra info

Pole-style:
o equatorial
o vertical
o horizontal
o spherical
o multiple
o other

Nodal & meridian

Miscellaneous types

Related objects

Sundials ??

Sundial Park
Genk (Belgium)

Equation of time

Symbols

Sundial societies

Links & literature

Frans' homepage

Guestbook

E-mail

Welcome to the Sundial site of Frans Maes

Enjoy my picture gallery of sundials which I came across on holiday trips or in the (physical or digital) vicinity, and which I found somehow interesting. Short, personal annotations accompany most objects. And slowly, some theoretical background is seeping in.
Unfortunately, it is not always sunny during our outings, so sometimes the dials are suffering from a timeout.

New or updated

- Rescue plan for historic sundial in Besançon. Your support is appreciated!
- Analemmatic dial survives Mount Stromlo Observatory disaster

Other things to see:

- annotated pictures of some 200 sundials, arranged according to type; see the main menu at the left
- the largest collection of analemmatic sundials on the web: about 50. They are my favorite type, because they are so modest, and of course because we have one in our garden.
- additional information on analemmatic dials
- another favorite section: is it a sundial ??
- an index in case you look for a particular city or keyword
- a discussion on the equation of time
- sundial societies and sundial registers
- some links to other sundial sites
- literature on sundials

Be sure to visit the Sundial Park in Genk (Belgium). A real gem! (Dutch with English summary; we're working on it...)

You are visitor 019968 since 18 April 2001

Last update: 18 December 2003

non-commercial purposes. In that case, refer to this site and send me an e-mail.

Sponsored by the Faculty of Mathematics and Natural Sciences of the University of Groningen

Types of sundials

Sundials are as varied as surfaces on which we can project the shadow of a style. One is accustomed to classify sundials according to the shape and the orientation of their table. Here is a fast list of the most current sundials.

Horizontal Sundial

It is a dial on a horizontal plane, with a style inclined towards the pole. It gives the hour during all the day. It is generally drawn on the ground or installed on a column in a garden. The angle between the style and the table of the dial is equal to the latitude of the place.

Vertical Direct South Sundial

It is a dial on a vertical plane facing exactly the south. It gives the hour only when the Sun is more in the south than the East-West line. Its style is parallel to the pole axis and points towards the ground. It is the more frequent dial, often seen on the bell-towers of churches and the frontages of the public buildings.

Vertical Direct East Sundial

It is a dial on a vertical plane facing exactly the east. It gives the hour only the morning, until a little before midday. Its style is parallel to the wall, directed towards the pole.

Vertical Direct West Sundial

It is a dial on a vertical plane facing exactly the west. It gives the hour only the afternoon. Its style is parallel to the wall, directed towards the pole.

Vertical Declining Sundial

The dial is on a vertical plane, oriented in any direction.

Declining and Reclining Sundial

It is a plane sundial which is not vertical and oriented towards any direction. This kind of sundial is quite rare.

Equatorial Sundial

This dial is drawn on a disc from which comes out a perpendicular style, beam right through, directed towards the pole. The disc is in the plane of the celestial equator. The higher face is lit from the spring equinox to the autumn equinox, whereas the lower face is lit from the automn equinox to the spring equinow. The hour lines are regularly spaced every 15° and the declination lines are concentric circles. There are also equatorial dials on which the shade of the style is casted on an equatorial strip. (like here).

Polar Sundial

The polar dial has the characteristic to have the axis of the pole passing by its table. The hour lines are parallel between them. The style is also parallel to the table, and is oriented towards the pole. The polar dial can also be cylindrical. (like here).

Analemmatic Sundial

It is an elliptic horizontal dial which has the characteristic to have a mobile style. This style must be moved according to the date along an axis (small axis of the ellipse). This type of dial is often realized in great dimension on the ground and a person cast her shadow while being placed on the graduation corresponding to the date. There are also analemmatic dials with tilted style.

Meridian Sundial

The meridian dial is a particular case of the vertical direct south dial which gives the hour only around local midday. This type of dial was used to synchronize clocks and portable watches with the Sun. The analemma curve is often drawn around the noon line, to give the mean time. Many meridian have been installed on churches (like here).

We can also quote: the bifilar sundial, the cylindrical sundial, the armilliary sphere, the scaphe...

You can build almost all the above sundials without any calculation, by using the Shadows Freeware.

Sundials on the Internet

For a full overview [click here]

Types of Sundials

Sundials are classified into a number of different types, mainly by the plane in which the dial lies, as follows:

- horizontal dials
- vertical dials
- equatorial dials
- polar dials
- analemmatic dials
- reflected ceiling dials
- portable dials

A picture of examples of the first five of these types are shown on the Connoisseur Sundials page. Other pictures of sundials are on the Cambridgeshire sundial trail, the East Sussex sundial page, and the Toronto sundial page. A picture of many portable dials is shown on the Sundials in Poland page. There is also a page of links to other sundial pictures on the Internet, A diagram of a simple model equatorial dial, with instructions on how to build it, is shown on the projects page

Horizontal

This is the type found commonly on pedestals in gardens. The dial plate is horizontal. The gnomon (which casts the shadow) makes an angle equal to the latitude of the location for which it was designed (which is not necessarily the location now, see How to set up a horizontal sundial

Vertical

This is the type found on the walls of churches and other buildings. Vertical sundials may be **direct south** dials if they face due south (in which case the gnomon will be at an angle equal to the co-latitude of the place, and the hour lines, if delineated for local time at the place, will be symmetrical about the vertical noon line).
If they do not face directly south, they are described as **declining** dials, and in this case the gnomon will be at a lesser angle than the co- latitude, and the hour lines will generally be grouped more tightly in the morning hours, for **south-east decliners** and, conversely, grouped in the afternoon hours for **south-west decliners**
Though much less common, there are dials with dial plates which are neither vertical nor horizontal. These are called **reclining dials**

Equatorial dials

have the dial plate fixed in the plane of the equator. The gnomon is perpendicular to the dial plate. The hour lines are spaced equally at 15 degree intervals. The **armillary sphere** is a development of this idea, and consists of a series of rings in the planes of the equator and the meridian, and a rod parallel to the earth's axis and passing through the center of the rings.

Polar dials

have the dial plate fixed parallel with the earths axis. The gnomon is parallel to the dial plate, typically the edge of a rectangular plate fixed to the dial plate. The hour lines are parallel to the gnomon and thus to each other.

Analemmatic dials

are not very common. They are unusual because the gnomon is vertical, and the hours are marked not by lines but by points falling on the circumference of an ellipse. The gnomon has to be moved depending on the time of year, so that the shadow falls on the correct point. Analemmatic dials are particularly suitable for sundials laid out on lawns, where a person can act as a gnomon; the position where the person should stand at any given month of the year is marked out along the north-south axis which crosses the mid-point between the foci of the ellipse.

Reflected ceiling dials

are even less common. They are a special form of horizontal sundial, in which a mirror laid on a south-facing windowsill reflects the sun onto the ceiling. The hour lines are drawn on the ceiling.

Portable dials

come in many varieties, such as the shepherd's dial, the tablet dial, the ring dial and others. They are not strictly a separate type of dial, but can be of the types listed above.

For a full overview of Sundials on the Internet click here

This site designed and maintained by Inter*net*works Ltd of Epsom, England

first posted July 1997 last revision

Comments/ suggestions/ problems, please get in touch with the Webmaster

Find Latitude and Longitude

From Internet Sources

These services vary somewhat in their accuracy and flexibility, probably depending on the country of interest. For USA addresses I recommend starting with Maporama.

International Maporama Offers the coordinate in both deg/min/sec and decimal notations. Movable target.

International MultiMap Offers only deg/min/sec. No movable target in USA.

USA only Geocode.com A GPS testing service. Both deg/min/sec and decimal degrees.

USA only U.S. Census Bureau / Tiger Mapping Decimal degrees; difficult interface. Start by scrolling down and entering the Zip Code, then "Browse Tiger Map".

Global Seismic Monitor An earthquake location site. Full degrees only. Place your cursor over the map.

Convert from deg/min/sec to decimal degrees or vise-versa

Law of sines

From Wikipedia, the free encyclopedia.

In trigonometry, the **law of sines** (or **sine law**) is a statement about arbitrary triangles in the plane. If the sides of the triangle are (lower-case) *a*, *b* and *c* and the angles opposite those sides are (capital) *A*, *B* and *C*, then the law of sines states

$${\sin A \over a}={\sin B \over b}={\sin C \over c}$$

This formula is useful to compute the remaining sides of a triangle if two angles and a side is known, a common problem in the technique of triangulation. It can also be used when two sides and one of the non-enclosed angles are known; in this case, the formula may give two possible values for the enclosed angle. When this happens, often only one result will cause all angles to be less than 180°; in other cases, there are two valid solutions to the triangle.

The reciprocal of the number described by the sine law (i.e. $a/\sin(A)$) is equal to the diameter *D* of the triangle's circumcircle (the unique circle through the three points *A*, *B* and *C*). The law can therefore be written

$${a \over \sin A }={b \over \sin B }={c \over \sin C }=D$$

Derivation

Image:Law of sines proof.png

Make a triangle with sides *a*, *b*, and *c*, and opposite angles *A*, *B*, and *C*. Make a line from the angle *C* to the opposite side *c* that cuts the original triangle into two right triangles, and call the length of this line *h*. Therefore:

$$\sin A = \frac{h}{b}, \; \sin B = \frac{h}{a}$$

$$h = b\,\sin A = a\,\sin B$$

$$\frac{\sin A}{a} = \frac{\sin B}{b}$$

Doing the same thing with angle *A* and side *a* will yield:

\frac{\sin B}{b} = \frac{\sin C}{c}

See also:

- triangulation
- law of cosines
- trigonometry

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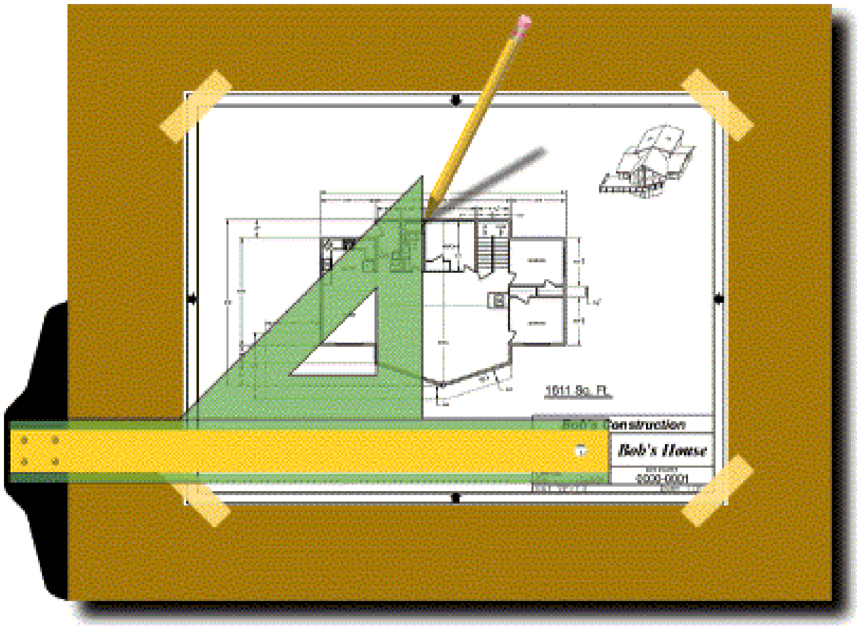

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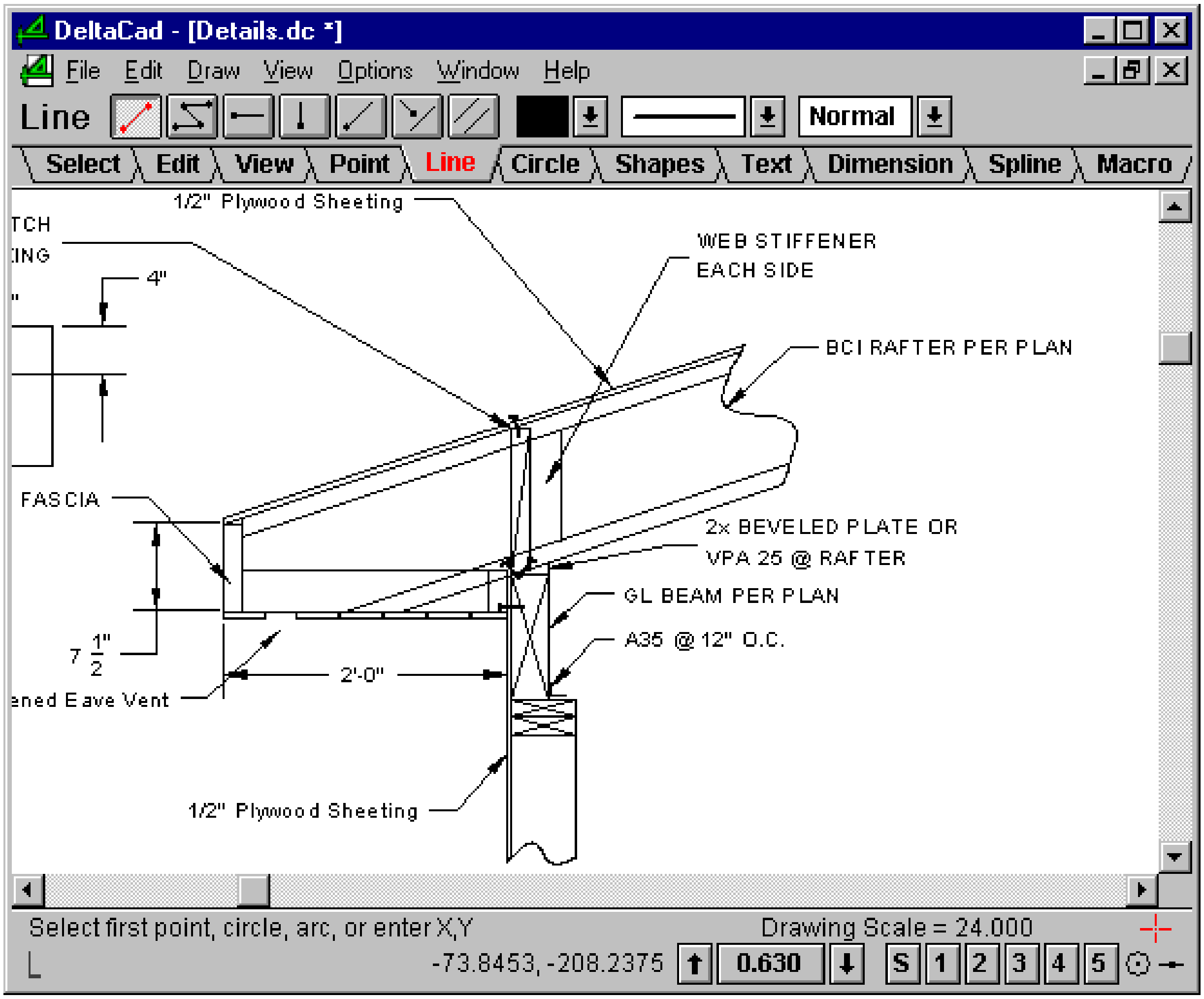
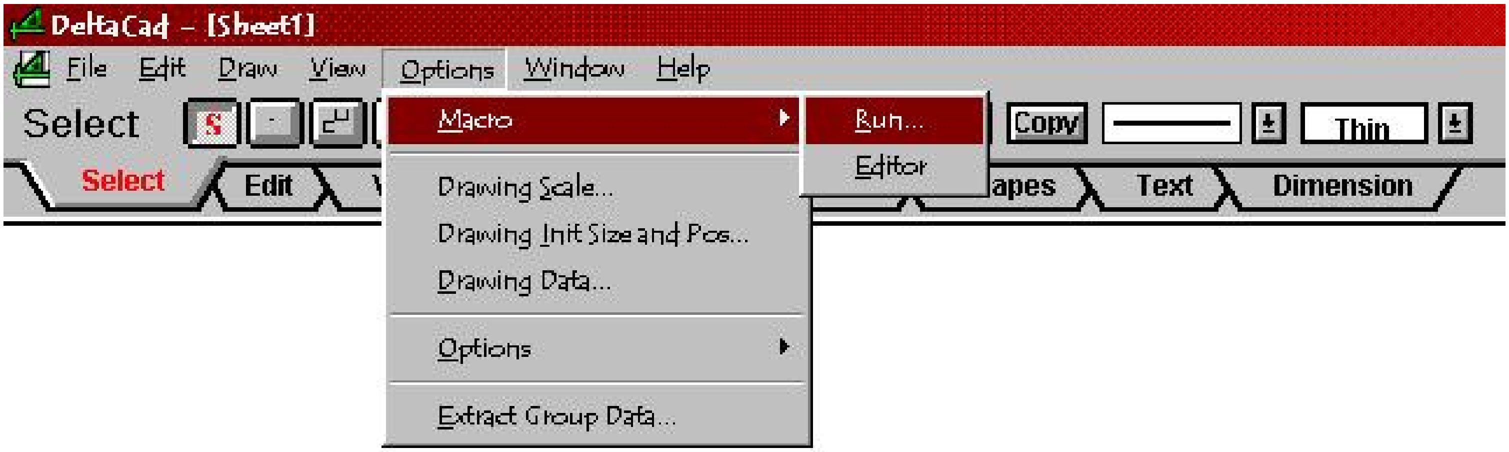

DeltaCad - [Details.dc *]
File Edit Draw View Options Window Help
Line
Normal
Select Edit View Point Line Circle Shapes Text Dimension Spline Macro
1/2" Plywood Sheeting
WEB STIFFENER
EACH SIDE
BCI RAFTER PER PLAN
4"
FASCIA
2x BEVELED PLATE OR
VPA 25 @ RAFTER
GL BEAM PER PLAN
A35 @ 12" O.C.
7 1/2"
2'-0"
1/2" Plywood Sheeting
Select first point, circle, arc, or enter X,Y
Drawing Scale = 24.000
-73.8453, -208.2375
0.630
S 1 2 3 4 5

Sundial software for use with DeltaCad

This page is my inventory of sundialling programs for DeltaCad. These programs are launched as macros from within the DeltaCad application. To use them, first download the file to your DeltaCad directory. Then launch the DeltaCad application, click on the **Options** item on the main menu, and select **Macro**, then **Run**. The rest should be obvious.



These downloads are not guaranteed to be virus-free

When you click the link to download a file, your browser may show you the source of the program instead of offering you the chance to download it. If this happens, use your Back button to return to this page, then right-click the link and choose the option for saving the file to disc.

<table>
<tr><td>

NASS collection

The North American Sundial Society maintains the definitive collection of DeltaCad macros for sundials. It is here

</td><td></td></tr>
<tr><td>

SCADD

SCADD is a program for calculating Standard Time horizontal sundials, either azimuth or polar style, using 15 minute intervals. Finite thickness gnomons are catered for. The plots are drawn in several layers, to aid later manual editing and additions. The EoT calculations are fixed to the year 2002. By Steve Lelievre. Latest version is always posted here

The gnomon's shape is not calculated by this program. For a polar-axis dial, it is a triangular piece rising from the centre of the dial at an angle equal to your latitude, pointing towards the North/South Pole. For the upright style dial, it is a wire or cylindrical rod rising vertically from the centre of the dial (give the rod's radius as for the Gnomon thickness parameter)

Note: Current version has a bug, which happens if you use a gnomon width > 0 for a polar-axis dial. Therefore, that facility is temporarily disabled.

</td><td>2000/06/07</td></tr>
</table>

dcMEKKA This is a macro to draw a so-called Mecca Map by Fer de Vries, Netherlands. The map shows the direction and distance of Mecca and is not a sundial. However we think it to be interesting to diallists also. A detailed description is given in the macro source. The macro is posted here	2000/05/05

Back to Steve's site

Armillary and Bowstring Equatorial Sundials

An armillary sundial

A bowstring equatorial

Convert Degrees Minutes Seconds to Decimal Degrees

You must enter all three values separated by spaces.

Latitude:	48 18 40.2	
Longitude:	99 57 56.9	

Convert Decimal Degrees to Degrees Minutes Seconds

Latitude:	48.311167	
Longitude:	99.965806	

NOAA Surface Radiation Research Branch

Sunrise/Sunset Calculator

Air Resources Lab

City:		Deg:	Min:	Sec:	Time Zone	
	Lat: North=+ South=-	40	7	30	Offset to UTC (MST=+7):	Daylight Saving Time:
Click here for help finding your lat/long coordinates	Long: West=+ East=-	105	14	13	7	

Note: To manually enter latitude/longitude, select **Enter Lat/Long ->** from the City pulldown menu, and enter the values in the text boxes to the right.

Month:	Day:	Year (e.g. 2000):

Equation of Time (minutes):	Solar Declination (degrees):	Apparent Sunrise:	Solar Noon:	Apparent Sunset:	Time Zone
					Local
					UTC

Directions:

1. Select a location from the City pulldown menu, OR select **"Enter Lat/Long ->"** from the pulldown menu, and manually enter the latitude, longitude and time zone information in the appropriate text boxes. The following sign conventions are used:

Longitude:	Latitude:
Positive in Western Hemisphere	Positive in Northern Hemisphere
Negative in Eastern Hemisphere	Negative in Southern Hemisphere

Latitude and Longitude can be in deg/min/sec, or decimal degrees entered in the "Deg:" field. If you select a city from the pulldown menu, the latitude, longitude and time zone fields will be filled in automatically. If you want to input latitude, longitude or time zone manually, be sure to select "Enter Lat/Long -->" from the City pulldown box, or your numbers will be overwritten by the selected city's location.

2. You can enter a different time zone for a location by selecting "Enter Lat/Long -->" in the City pulldown box. Otherwise, the time zone associated with the selected city's Local Standard Time will be automatically entered. Selecting "Yes" in the Daylight Saving field will cause the resulting sunrise, sunset and solar noon times to be adjusted forward one hour. If you are uncertain of the time zone for a location, refer to our Time Zone Table.

3. The program retrieves the current date from your computer, and fills the month, day and year fields. To perform calculations for a different date, simply select a month in the pull down menu, and enter the day and four digit year in the appropriate input boxes. When entering a day or year, you will need to click the "Calculate Sunrise/Sunset" button to update the results for this date.

4. Once the calculation results are displayed, you may use your web browser's "Print" function to obtain a hardcopy of the results.

5. For locations above the Arctic Circle and below the Antarctic Circle, when a sunrise or sunset does not occur on the given day the program locates the local time and date of the most recent sunrise or sunset, and the next sunset or sunrise. When this occurs, the UTC fields will display "prior" or "next" information instead of the UTC times.

6. NOTE: For latitudes greater than 72 degrees N and S, calculations are accurate to within 10 minutes. For latitudes less than +/- 72° accuracy is approximately one minute. See Solar Calculation Details for further explanation.

Solar Position Calculator
Calculation Details
Solar Calculator Links

Time Zone Table
Solar Calculator Glossary
Back to SRRB Homepage

by Chris Cornwall, Aaron Horiuchi and Chris Lehman

The Dialist's Companion

The Dialist's Companion is a new computer program that calculates a wide range of data elements of interest to dialists and others who are concerned with phenomena associated with solar time. These data elements are presented in a dynamic format, changing each second with the tick of the user's system clock. The user can define any latitude and longitude as the platform for his observations, and explore any time or date between 1 A.D. and 2999 A.D. The program further adapts to the user's preferences through the use of start up options and user defined configuration files which can be saved and retrieved.

The program provides three different screens which present the output in different formats. The screens can be switched at a keystroke, and consist of the Main Screen, the Clock Screen, and the Equation Chart.

The **Main Screen** contains tabular output of the various computed values. These values are described and discussed in the program's **User's Guide**, which is provided in both on-line and printable versions.

The **Clock Screen** displays two digital clocks which can be set individually to any of the seven times systems calculated by the program. The display is designed to show selected times with maximum visibility for field use. An alarm can be set to either clock or independently to local apparent noon.

The **Equation Chart** presents the Equation of Time and the sun's declination in a monthly format.

Click a screen to view: **[[Main Screen || Clock Screen || Equation Chart]]**

Dates and Times

The program date and time can be manipulated in two ways, either by direct entry or by incremental changes from the keyboard. The program clock can also be paused, permitting examination of an instant. At any point, a keystroke will return the program to the system date and time.

Dates between 1 A.D and 2999 A.D. (inclusive) are permitted. Dates before Oct 15, 1582 are based on the Julian calendar; dates after October 4, 1582 are based on the modern Gregorian calendar.

Data Elements

The following is a list of the included data elements. All values can be viewed simultaneously. Dynamic elements are updated every second.

- Solar Ephemeris
  - Sunrise and Sunset
  - Altitude and Azimuth
  - Declination
  - Equation of Time
  - Zodiac
- Time Systems
  - Local Standard Time
  - Greenwich Mean Time
  - Dial Time
  - Sidereal Time
  - Julian Day Number
  - Babylonian and Italian Hours
  - Temporal Hours
- Factors affecting a specific sundial
  - Longitude Correction
  - Refraction Correction
  - Total Correction
- Other Useful Data
  - Solar Noon
  - Shadow
- Mottos
  - If all of the above isn't enough, the program also randomly displays a series of 23 appropriate sundial mottos.

The Dialist's Companion is written for DOS platforms and requires 336k of disk space and a VGA monitor. It runs well under Windows 9x, but Windows 3.1 users may find performance improvements when run from DOS.

The Dialist's Companion was written by

Robert Terwilliger
2963 Bird Avenue
Coconut Grove, FL

Frederick Sawyer
8 Sachem Drive
Glastonbury, CT

33133 06033

bobt@twigsdigs.com frederick.sawyer.es.72@aya.yale.edu

The program was originally released as part of the **North American Sundial Society's** Digital ***Compendium*** as one of the many benefits of NASS membership. It is now being released to non-members as Shareware. The registration fee is $15 US, and may be sent to Fred Sawyer at the address above. (Please make checks payable to NASS.)

If you choose to join NASS, the registration fee may be applied to your first year's dues. Basic dues are $25, but there are options. See the **Join NASS** link at:

http://sundials.org

The Dialist's Companion is a DOS program,
available as a self-extracting EXE of 168,378 bytes.

Download the Dialist's Companion

History of Releases

```
Version 1.1b   Released May 2003
               Updated author's email addresses and NASS website URL.
               Converted DIALIST.DOC to plain text
               and renamed to DIALIST.TXT

Version 1.1    Released January 1997
               Fixed a bug which occurred only in latitudes south
               of the Equator, when the Refraction Correction option
               was selected.

Version 1.0    Released as part of The Compendium 3-3, September 1996
```

National Geophysical Data Center (NGDC)
NOAA Satellites and Information

go
search NGDC

NOAA > NESDIS > NGDC > Geomagnetic Data Home privacy policy

Compute Values of Earth's Magnetic Field (Version 4.0)

This form computes the estimated values of Earth's magnetic field, including magnetic declination (D), based on the current International Geomagnetic Reference Field (IGRF). While results are typically accurate to 30 minutes of arc, **users should be aware that solar storms can cause intense, short-term disturbances in the magnetic field.** For more information, visit the following resouces:
Answers to some **frequently asked questions**| **Instructions** for use | **Today's Space Weather**

If you are unsure about your city's latitude and longitude, look it up! In the USA try entering your zip code in the box below or visit the U.S. Gazetteer. Outside the USA try the Getty Thesaurus.

Search for a place in the USA

Zip code: [ ] Get Location

Enter Date (1900 to 2005): Year (1900-2005): [2004] Month (1-12): [01] Day (1-31): [11]

For Range of Dates Please also Enter:

Start Date:

Year (1900-2005): [ ] Month (1-12): [ ] Day (1-31): [ ]

Step Size: Compute for every n years [1]

Enter Location: (latitude 90S to 90N, longitude 180W to 180E). For decimal degrees, enter the number as is (i.e. 45.508). For degrees, minutes, seconds enter space separated fields (i.e. 45 30 30).

Latitude: [ ] (•) N ( ) S

Longitude: [ ] ( ) E (•) W

Enter elevation: [0.0] (•) km (-1 to 600) ( ) mi (-0.6 to 372) ( ) ft (-3281 to 1,968,503)

Compute! Reset

---

http://www.ngdc.noaa.gov/cgi-bin/seg/gmag/fldsnth1.pl
Developed and Maintained by NOAA's National Geophysical Data Center
Susan.McLean@noaa.gov
Geomag Home

INTRODUCTION

There are two other important Internet sources for information on Sundials. The first is Sundials on the Internet. Links to pages on SotI are included in the list below, and are suffixed with [SotI].

Second is The Sundial Mailing List maintained by Daniel Roth. The Internet dialing community is indebted to Daniel for the mailing list, as well as his list of links from which those below were originally derived.

Here is a link to the AltaVista translation utility which may help you with pages that are not in your native language.

Please report new or dead links to the Webmaster.

NEW!! - a category for New Links

SEE WHO IS LINKING TO US!

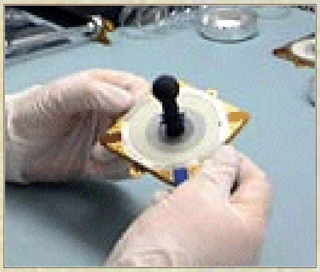
FEATURED SITE

THE MARS SUNDIAL

One Sun

Two Worlds

- **The Mars Sundial**
- **Spirit Updates**
- **What time is it on Mars?**
- **I mean really... What time is it on Mars?**
- **Sundial to calibrate Pancam, the camera on the rovers**
- Bill Nye, the science guy on **The first interplanetary sundial**
- **The overhead view of the rover indicating the sundial**
  (At work?) - large image - 1694x1690x200k
- **Mars Sundial to Help Teach Kids About Time, Sun**
- **NASA Flash presentation: M2K4** (**Noisy** but nice)
- **The EarthDial Project**



MORE FEATURED SITES

- The Sundial Site of Frans Maes (English) & (Dutch)
- Sotheby's auction of sundials from the Time Museum (Rockford, IL)
- Epact - Scientific Instruments of Medieval and Renaissance Europe
- A starting point for the many sundial pages at the Bremen Planetarium (German)
- Stained Glass Sundials From Around The World

NEW LINKS

New links will be kept here for a few weeks before they are categorized.

- The Jaipur Observatory Sundial (Follow the Links)
- Piet Hein's helical sundial (Click #25)
- The U.K.'s £1.2-million Stainless Steel Sundial (Proposed)

Images of the Analemma

- Some beautiful images of the analemma by Anthony Ayiomamitis
- The Analemma Project
- Analemma
- Astronomy Picture of the Day - July 9 2002

The Sun Dagger in Chaco Canyon

- Archaeoastronomy in the American Southwest
- The Sun Dagger
- A Unique Solar Marking Construct

GENERAL

- Daniel Roth's comprehensive Sundial Links
- Search previous postings to the sundial mailing list
- A Glossary of Sundial terms by John Davis
- Solursida (Norwegian)
- Sundials in the Lycée Louis-le-Grand
- Santiago Calatrava's Turtle Bay Sundial Bridge and The Official Web Page
- Design Options for Horizontal Monumental Dials (PDF) - John Carmichael
- The Gregorian Calendar and the vernal equinox also the autumnal equinox
- The fantastic sundial made for Charles II in 1669
- A sundial on the Greenwich Meridian
- Sundials At New College, Oxford
- Sundials at Wadham College, Oxford

- The John Garrey Tippit Memorial Sundial
- Bob's Sundial Page
- University of Sydney Museum Sundials and Other Time Pieces
- A Quest for a Civil Time Polar Sundial
- Iowa State University's Polaris Project Unit Six - Sundials
- L'arte della Gnomonica - site has more links
- Nonvedolora Gnomonics and Fabio Savian
- Sundials - The New Zealand Garden Journal
- Sundial at the ancestral home of George Washington [More]
- The Sundial
- Find Latitude and Longitude From Internet sources
- Convert from deg/min/sec to decimal degrees and vise-versa
- Carpe Diem El mundo de los Relojes de Sol en una página (Spanish)
- Make a Quadrant Sundial - Valentin Hristov
- The Pilkington Gibbs Heliochronometer and how it works (Mike Shaw)
- Me and My Shadow Making the Sun-Earth Connection
- Relojes de Sol (Spanish)
- Cadrans Solaires 3D (Macromedia required)
- Introduction to sundials (German)
- Three exceptional sundials at the Adler Planetarium
- Metal has proven itself indispensible in telling time.
- Sundial Page - David M.F. Chapman
- Sundials- Brooke Clarke - many links
- Geometric sundial construction - T. Gebhardt (German)
- Mike Shaw's sundial page
- Quadranti Solari - Franco Martinelli (Italian)
- Sonnenuhren (German)
- The Homepage of Mario Arnaldi
- A series of sundial pages by K.P. Cheung (Hong Kong)
- Convert geographical co-ordinates: - decimal to d,m,s; and vise-versa
- NOAA Solar Calculator Glossary
- Sundials National Institute of Standards and Technology
- Make your own horizontal sundial
- Sundials Royal Observatory, Greenwich
- Sundials 'n Stuff
- What is Local Noon?
- Sundial - Brittannica.com

- Clockworks - Britannica.com
- Les cadrans solaires (French)
- Sundial Information
- ***Sundials*** by F. J. Britten (Clocks and Time)
- What is a sundial
- Sundials of the World
- Exploration - Sundials (NASA)
- Sundial Mottos in Latin and French
- World Time Zone Map
- Time Zone Abbreviations
- About the measure of time
- Meridiane in Canavese Mauro Basiglio (Italian)
- Gnomonics Riccardo Anselmi (Italian, English)
- Solis et Artis Opus Mario Arnaldi (Italian)
- Gnomonica Rosa Casanova (Italian)
- Quadrandi Solari Diego Bonata (Italian)
- Meridi@ne Gianni Ferrari (Italian)
- Earth's Equinoxes, Solstices, Perihelion, and Aphelion 1992-2005
- Page personnelle de Gérard Baillet (French)
- Shadow Plane Sundials
- Find your latitude and longitude - from your street address
- An Essay on Hours and Unequal Hours
- Mario Arnaldi (Italian)
- Sundial Books [SotI]
- Sundial Computations - Slawomir K. Grzechnik
- Method to compute flat sundials - Fer J. de Vries
- Zonnewijzer - H. van Winkel (Dutch)
- A sundial page - Patrick Powers
- Jack Aubert's Sundial Page
- Gnomonique par Yvon Massé (French)
- Gruppo Astrofili Piceni: Orologi Solari (Italian)

HISTORY

- Scientists identify a sundial at Qumran
- Lo strumento astronomico di QUMRAN - Nuove interpretazioni (PDF - Italian)
- Astronomisches Meßgerät aus Qumran / „Sonnenuhr" (German)
- A polyhedral dial attributed to Nicholas Kratzer

- Athens: The Tower of the Winds
- Gaffarel's Description of The Dial of Achaz
- Equinox - The Mayan Astronomers
- A Pompeian sundial inscription
- Histoire de la mesure du temps (French)
- Queens' College Dial
- A Brief History of Time - From Thales to Callippus
- The MacTutor History Archive
- History of Astronomy - University of Bonn
- Article about Jaipur - Jantar Mantar (English) or (German)
- Augustus' sundial
- Le Champ de Mars: l'Horologium Augusti

PUBLIC DIALS

- Richard Schmoyer's Lyre/Tuning Fork Dial
- The Schmoyer "Sunquest" - an elegant dial that reads Standard Time
- The Schmoyer "Sunquest" revisited
- The Solar Pyramid
- Sun Cannon - Åtvidaberg Sweden
- Keppel Henge
- Tavel Sun Nave
- La Nef Solaire de Tavel (French)
- Sundial by Christian Renonciat in Reims
- The Portland Oregon Union Station (not really a) sundial
- An analemmatic dial near Lichfield, England
- Perranzabuloe Millenium Sundial - Cornwall
- Sundial at the Griffith Observatory
- Precision sundial in Tholey (German)
- The Lyman Briggs Standard Time Sundial
- Equatorial dial at New Mexico State University
- The Amble Dial - (England)
- Sundial at the University of Hawaii
- Digital Sundial Patent
- A giant sundial in Cornwall (Proposed)
- The Heidenheim sundial (Proposed)
- The beautiful dolphin dial at the Greenwich Maritime Museum
- Lumbutts Sundial - West Yorkshire

- A bifilar dial in Barcelona (Spanish)
- Sundial at the public observatory in Mainz, Germany
- Sundial on the Atelier Acacia in Mont-Dauphin (Haute Alpes, France)
- Large horizontal dial at Binghamton University, New York
- Armillary sphere at Penn State
- Horizontal dial at the University of Kentucky
- "The Cycle of Life" an armillary sphere by Paul Manship
- Armillary dial at Heritage Plantation, Sandwich MA
- Equatorial dial at the University of Nevada, Reno - another view
- Sundial at the former Québec Astronomical Observatory (2 Photos)
- Sundial at the Dows Planetarium in Montreal
- Sundial on Terrasse of the Québec Parliament
- Vertical dial at the Séminaire de Québec
- Sundial in the Forbidden City, Beijing
- Dial by Thomas Tompion, at Hampton Court Palace in London
- Polyhedral dial - Stropshire England
- Equatorial dial at New Mexico State University
- Armillary dial at the University of Virginia
- Horizontal dial at the University of Virginia
- Polyhedral dial on the Isle of Man
- Vertical Declining Dial, Paris
- Eastern Michigan University A Dial Rededication
- The Pinawa Heritage Sundial
- "Child Sundial" at the Missouri Botanical Garden
- An original Russell Porter SunClock
- The Richard D. Swensen sundial at the University of Wisconsin
  Web Cam
- The Physics-Astronomy Sundial at the University of Washington
- Sundial at the public observatory in Mainz (German)
- Church sundial, Jausiers
- Vertical dials at Palladio's Villa Barbaro at Maser, Italy
- Sundial at the Justice Center, Hunterdon County NJ
- Vertical dial on a church in Cornwall
- St. Peter's Cathedral, Geneva
- Queens' College Dial
- Sundial in front of the planetarium in Berlin (German)
- Sundial at Fort Oranje, St. Eustatius, Dutch Caribbean

- Sundial at the University of Limerick
- A sundial at Kochi Castle, Japan

Mass Dials

  - The Aldbrough Sundial, a Mass Dial in East Yorkshire
  - The Kirkdale Sundial, a Mass Dial in North Yorkshire
  - The Kirkdale Sundial - the inscription

MONUMENTAL DIALS

- Word's biggest sundial is in Pajala
- Te Ra Tu - The Standing Sundial (Proposed)
- Large Sundial in grass. Pekin Illinois
- Mount Laguna Observatory sundial
- Sundial at Hong Kong University
- SunPath Designs
- Haym Kruglak Sundial at Western Michigan University
- The sundial for Reutte

ANALEMMATIC DIALS

- A new analemmatic sundial in Torreón, Mexico
- A Table Top Analemmatic by John Carmichael
- A Jubilee Sundial for West Somerset
- Sundial Garden at Michigan State University
- Make your own Sundial
- Two mean-time analemmatic sundials - Yvon Massé
- Central projection analemmatic sundials - Yvon Massé
- Analemmatic Sundials How to build one and why they work
- The Sundial of Human Involvement
- M. Vitruvius Pollio and the Analemma
- Thunder Bay, Ontario
- Dial at The Flandrau Planetarium and Science Center, University of Arizona
- Analemmatic sundial, Riverwalk, Augusta, Georgia
- Of Analemmas, Mean Time, and the Analemmatic Sundial - Frederick W. Sawyer III
- Sunclocks - human sundials

PORTABLE DIALS

- Three sundials in the collection of the Adler Planetarium
- The Ansonia Sunwatch

- A German string-gnomon dial circa 1680
- 15th century navicula, or "little ship of Venice" sundial
- Shepherd's Dial
- A cube sundial with Italian hours
- Old quadrant in the Museum of the History of Science, Oxford
- St. Peter's Cathedral, Geneva; German diptych dial
- Portable sundials at the Manor House Museum, Bury St Edmunds

BY LOCALE

- Cadrans Solaires en Alsace
- Sonnenuhr in Bad Bevensen
- Sundials in Manchester
- More on the Manchester sundials
- Meridiane in Piemonte
- A new sundial in Bremen (German)
- Sundials in Italian Schools (Italian)
- Sundials in the Czech Republic
- Sundial Gallery (Czech)
- Sundial in Isan, Thailand
- Orologio Solare Equatoriale - Pisa (Italian) (English)
- Cadrans solaires en Queyras - France (French)
- Murcia - Spain (Spanish)
- Die Sonnenuhr in Bad Bevensen
- Sundials in Nürnburg
- Germany sundials & other astronomical clocks - Peter Lindner
- Various locations - mostly Europe (German)
- Bremen - (German)
- Paris
- Ancient Sundials of Ireland
- Barcelona (Spanish)
- Andalucia - includes Islamic dials (Spanish)
- Alsace, France
- Québec
- Leeds, England
- Sundial Trails [SotI]
- Nova Scotia
- China

- France
- Brittany (French)
- The Netherlands
- Germany (German/English)
- Berlin, Germany
- Austria

COLLECTIONS

Here you will find anything from Museum exhibits to personal collections of photographs.

- Deutsches Museum Der Sonnenuhrengarten
- Sundials at the Franklin Institute
- The Homepage of Frans Maes (English) & (Dutch) Excellent illustrations of dial types

  Antique Dealers who may have sundials for sale
  - Galai Collectibles
  - Tesseract
  - The Gemmary
  - Artifice
- Pictures of sundials & astronomical clocks - Peter Lindner (German/English)
- Sundials at the Deutsches Museum, Munich (German)
- Sundials at the AstroGallery (China, India, South Tyrol)
- Sonnenuhren - Daniel Roth (German)

ARTISANS

This category includes anyone who makes sundials, either as a hobby or a commercial venture.

- Custom Consulting Work - Bill Gottesman
- GNOMÒNICA Rellotges d'Autor - Joan Olivares Alfonso
- Villalcor Una compañía dedicada a la recuperación y fabricación de instrumentos antiguos.
- The sundial site of Angelo Brazzi (English) (Italian)
- The Universal Pocket Sundial

  If you indicate on the order form that you are a NASS member, the price is $40 + shipping
- HinesLab Digital Sundial
- The sundial page of Giuseppe Ferlenga (Italian)
- John David Cooney Art in Platinum and Gold
- Westwood Dials
- Sundial Sculptures by John L. Carmichael Jr. (Site re-written)
- David Brown
- Sally Hersh
- David Harber Sundials)

- Accurate Sundials
- Artisan Industrials - The Spectra Sundial
- Meridia Net - Sundial plans
- Helios Astronomical Timepiece
- Sol Invictus GmbH (German)
- Sonnenuhrengestaltung - Arno Ruckes (German)
- Wearable sundials
- Helios - high precision sundials by Carlo Heller (German)
- Analemmic-Equatorial Sundials - Peter Swanstrom
- Solaria - L.M. Morra e Fabio Garnero (Italian)
- Carlo Heller high precision sundials (German)
- Orologi Solari & Meridiane - Enio Vanzin (Italian)
- Meridiane ed Orologi Solari - Giovanni Paltrinieri (Italian)
- Orologi Solari - Ugo Beccheroni (Italian)
- Sundials and Moondisks - Daniel Oberti
- Forging Ahead - Paul Margetts
- The Universal Ring Dial - Saunders and Cooke
- Sundials for the Connoisseur - Silas Higgon
- The Wenger Sundial
- David L. Aho - Metalworking
- Sunclock (Human Sundial)
- Kate Pond
- Accurate Standard-Time Sundials
- Flowton Dials - John Davis
- Harris Morrison's web site for Shepherdswatch portable sundials
- Precision Sundials LLC - Bill Gottesman
- Great Circle Studio - Luke Coletti
- Michael Malleson
- David Harber Sundials
- Harriet James
- “The Accurate Sundial”
- Astromedia - Scientific stuff, including cardboard sundials (German)
- Stephen Luecking
- Interior Sundials - Reflected Ceiling Dials
- Carlo G. Croce
- Timeless Instruments - Norman Greene
- Orologi Solari - Ugo Beccheroni (Italian/English)

- Tony Moss, Lindisfarne Sundials
- Giuseppe Viara
- Saunders and Cooke, Antique re-creations
- About Time - Mike Manning
- Sundial designers and makers [SotI]
- Heliochronometers by Gunning Sundials
- Merlin Design - Etchers in Brass
- Some sundials by Piers Nicholson
- Welcome in the world of the sundials - Philippe Langlet
- Suntiles
- Jack Aubert's Sundial Page
- The Astrolabe - James E. Morrison
- Universal Ring Dial by Ames Instrument Company
- Colonial Brass - sundials
- About Time - engravings from computer-generated files for sundials etc.
- Blades of Tara
- Sundials at Radnor Forge
- Kenneth Lynch & Sons
- Armillary sundials by New England Garden Ornaments
- Robert Terwilliger's Homepage
- SunPath Designs: outdoor sundials as functional works of art
- Sundial cannon - The Arsenal Store
- Travelsundial for Europe: for hiking and beach

EDUCATION (Elementary)

- An Educator's Guide to Equatorial Sundials
- Sunshine in your pocket! Making a sundial for the northern hemisphere.
- What is a sundial?
- Fabriquer un cadran solaire (French)
- What is a sundial?
- Sundials - NASA Kids
- Making a Sun Clock
- Sundial Planning
- Building a Simple Sundial
- Cosmic Gnomon
- Sun tower at Gullett Elementary School, Austin, TX
- Urbana IL high school "Merging Science and Art" sundial project

- The Event Inventor, including Sun Fun
  Time on your hands

TRIGONOMETRY

- Dave's Short Trig Course
- Frequently Asked Questions About Trigonometry
- The Trigonometry Forum
- Math Archives - Trigonometry - Links
- An introduction to Trigonometry
- Spherical Trigonometry - a new approach (Advanced)

THE EQUATION OF TIME

- The fabulous photograph of the analemma by Dennis di Cicco
- Another Sunrise Analemma
- The Equation of Time - The Royal Observatory, Greenwich
- Analemma - an extensive explanation - Bob Urschel
- The Analemma (C program)
- A digression on the equation of time
- The equation of time (scientific approach) - Art Carlson

SUNDIAL GENERATORS & CALCULATORS

- AstroCalculator - includes sundial calculations
- SUNDI Sharweware sundial generation program
- Calculate and Chart the Analemma
- An online solar calculator
- Sun Positions, Formulas, & Sundials
- Generate sundials - PDF output
- Sustainable By Design - various solar calculations
- Computing Local Noon
- Almanac of Solstices, Equinoxes and Cross Quarters -2003
- Azimut und Elevation der Sonne
- U.S. Naval Observatory Data Services
- NOAA Sunrise/Sunset/Solar Noon/Position Calculator
- Generate a Virtual Sundial based on the Queens' College dial, Cambridge, UK.
- Sun Position Calculator
- MrCalculator's Sundial Calculator - Vertical south dials - with optional declination
- Animated java design for a dial in Damongo, Ghana

- Jürgen Giesen's GeoAstro Java Applets
- Solar data JavaScript calculator
- Sun's Information and Sight Reduction
- View the earth from the sun
- USNO Sun or Moon Rise/Set Table for One Year
- Astronomical Time Calculations
- You can make a sundial! (PostScript files)
- Bob's Sundial Generator (PostScript file)
- Great Circle Studio - Many options
- Collection of Sun Maps / Sun Clocks (Java applets)

MOON DIALS

- The Moondial
- Moon Calendar
- Celestial Products: Moon Posters

MERIDIANS

- Merdienne in Serres (Hautes Alpes, France)
- Images of the solar eclipse of August 11, 1999 seen as pin-hole projections on various meridian lines in Italy.

MISCELLANY

These are links that don't fit anyplace else. You will find some strange and wonderful things here.

- A Martian Analemma
- The Kellogg's Raisin Bran Sundial
- GEOCACHING - Sundials (Interesting!)
- Some pages on solar alignments with the Arc de Triomphe
  Link 1 Link 2 Link 3
  A gnomonic experiment
- The Pilkington Gibbs Sol Horometer
- FAQ: Roman IIII vs. IV on Clock Dials
- Make a sundial and compass from your fingers
- Coffee Can Time Machines
- Sunrise on the Equinox + 1
- The first US coin had a sundial on it! (Click any picture and scroll down.)
- Stolen Sundial - From Kent, England
- Tridux 2000 - a device for laying out mirror sundials
- Sundial memorial to cyclist Fabio Casartelli

- There used to be a sundial here **...**
- Compendium Article (PDF) A "Digital" Dial – Time At Your Fingertips by Karen Robinson
- The Solar Telescope at Kitt Peak is becoming a sundial!
- Il Notturnale (The Nocturnal) (Italian)
- A discussion of the polyhedral and cylindrical sundials in Holbein's *Ambassadors*
- Earth Viewer
- Mike Shaw's Remote Reading Sundial - using fiber optics
- The fabulous photograph of the analemma by Dennis di Cicco
- References to sundials in the works of Shakespeare
- Web Cam of the Swensen sundial at the University of Wisconsin (if available)
- A Mirror Sundial in Bremen
- A Mechanical Sundial, or Sunpointer in Amersfoort, The Netherlands
- A sundial made of Legos
- Reviews of Universal Ring Dials being offered for sale
- A Sundial Park in Genk, Belgium featuring a dozen different sundials (English) & (Dutch)
- The Abbey of Mont Saint-Michel as a sundial? (French)
- The Washington Monument as a sundial?
- Play Sundial Games!
- To IV, or not to IV? That is the question.
- A Stonehenge watch
- Article on "Horologium"
- 103 commercial sundial images - that you can send as an E-card
- Sundial Patents - Search on "sundial".
- The Analemma Society A proposed astronomy park.
- Calendrical and Astronomical Links
- Use the wisdom of the sun to aim a satellite dish.
- An Anglo-Indian sundial project
- 7 Sundials +1 at the Robert Doisneau lycée in Vaulx-en-Velin
- Construction of a hemispherium - Fer J. de Vries
- The Measurers: a Flemish Image of Mathematics in the Sixteenth Century
- Sundial trails [SotI]
- Sundial on a computer chip
- Live Webcam on the sundial at Pembroke College, UK
- Startime Sundial
- Digital Sundials International
- Théorie sur le cadran solaire bifilaire vertical déclinant - D. Collin (French)

SOCIETIES

- Asociación de Amigos de los Relojes de Sol
- How to join your national sundial society [SotI]
- Sundial Organizations (Clocks and Time)
- Austrian Astronomical Society - Working Group for Sundials
- De Zonnewijzerkring (The Dutch Sundial Society)
- English summaries of the journal of the Dutch Sundial Society
- The British Sundial Society
- Arbeitskreis Sonnenuhren (German)
- The National Association of Watch and Clock Collectors
- La Commission des Cadrans solaires du Québec
- Societat Catalana de Gnomònica (Catalan)

SOFTWARE

- DeltaCad Macros for drawing sundials and other applications
- Precision Sundials LLC Software and Other Downloads
- The Sun API- solar values for programmers & Excel spreadsheets
- An Excel spreadsheet for analemmatic dials by Gianni Ferrari
  The file is Zipped and can be downloaded directly.
- zw2000 - very popular and easy to use
- The Dialist's Companion
- Sonne Software (English) (German) - Including an Excel spreadsheet for analemmatic dials
- The USNO MICA - The Multiyear Interactive Computer Almanac
- Cadrans Solaires Shadows Software
- Welcome to the Sundial Calculator.

INTERNET HOROLOGICAL SITES

- Clocks and Time
- Horology - The Index
- Time Measurement
- WorldTempus.com (French)
- Antiques Guide

The Sundial Mailing List

The Sundial Mailing List is owned by Daniel Roth at: sundial-approval@rrz.uni-koeln.de, and was created 15 February 1996. The list is managed by the Majordomo software program.

Once you subscribe to the list, you can send an e-mail message to the list address and it will be forwarded to all the other subscribers. Responses to your message will similarly be sent to all subscribers.

Join the list and participate! Submit questions. Help others with your answers. The list is an an active forum, and includes most of the scholars, experts, and other knowledgeable members of the Internet dialing community.

If you have something interesting on the topic of sundials, post it to the list!

Subscribing

To subscribe to the mailing list send a message consisting of the following two lines:

subscribe sundial
end

to: Majordomo@rrz.uni-koeln.de

Please don't forget the "end" because otherwise your signature may be misinterpreted by the list processor.

Or, just click here: Subscribe to the sundial mailing list. - add "end" as the last line of the body, and send the message. Be sure you are sending from the email address to which you want the list to be sent.

Posting

Once you have subscribed, send your messages to be forwarded to all subscribers to:

sundial@rrz.uni-koeln.de

Messages to the list should not include any binaries (images) since some subscribers pay for their Internet access by connect time.

In the interests of security, any message sent from an e-mail address that does not correspond to a subscriber will be refused. (i.e. The return address on any message you post must be the address you use to receive the list messages.)

Keep in mind that postings should be at least reasonably on the topic of sundials, and that the usual standards of decorum and language should be observed.

Unsubscribing

To unsubscribe from the mailing list send a message consisting of the following two lines:

unsubscribe sundial
end

to:

Majordomo@rrz.uni-koeln.de

Please don't forget the "end" because otherwise your signature may be misinterpreted by the list processor.

Or, just click here: Unsubscribe from the sundial mailing list. - add "end" as the last line of the body, and send the message. Be sure you are sending from the email address to which the list was being sent.

Requesting the List of Subscribers

To receive a list of the subscribers to the list send the following two lines:

who sundial
end

to:

Majordomo@rrz.uni-koeln.de

Please don't forget the "end" because otherwise your signature may be misinterpreted by the list processor.

Problems

If any problems occur, you may contact Daniel Roth at:
sundial-approval@rrz.uni-koeln.de

altavista

Home › Tools

Babel Fish Translation

Help

Translate a block of text - Enter up to 150 words

Use the World Keyboard to enter accented or Cyrillic characters.

English to Spanish | Translate

Translate a Web page

http://

English to Spanish | Translate

Add Babel Fish Translation to your site.

Tip: Click the "World Keyboard" link for a convenient method of entering accented or Russian characters.

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Add translation to your personal or business site.

Seamless translation plugins for MSOffice - Word, PowerPoint, Excel, Internet Explorer and Outlook!

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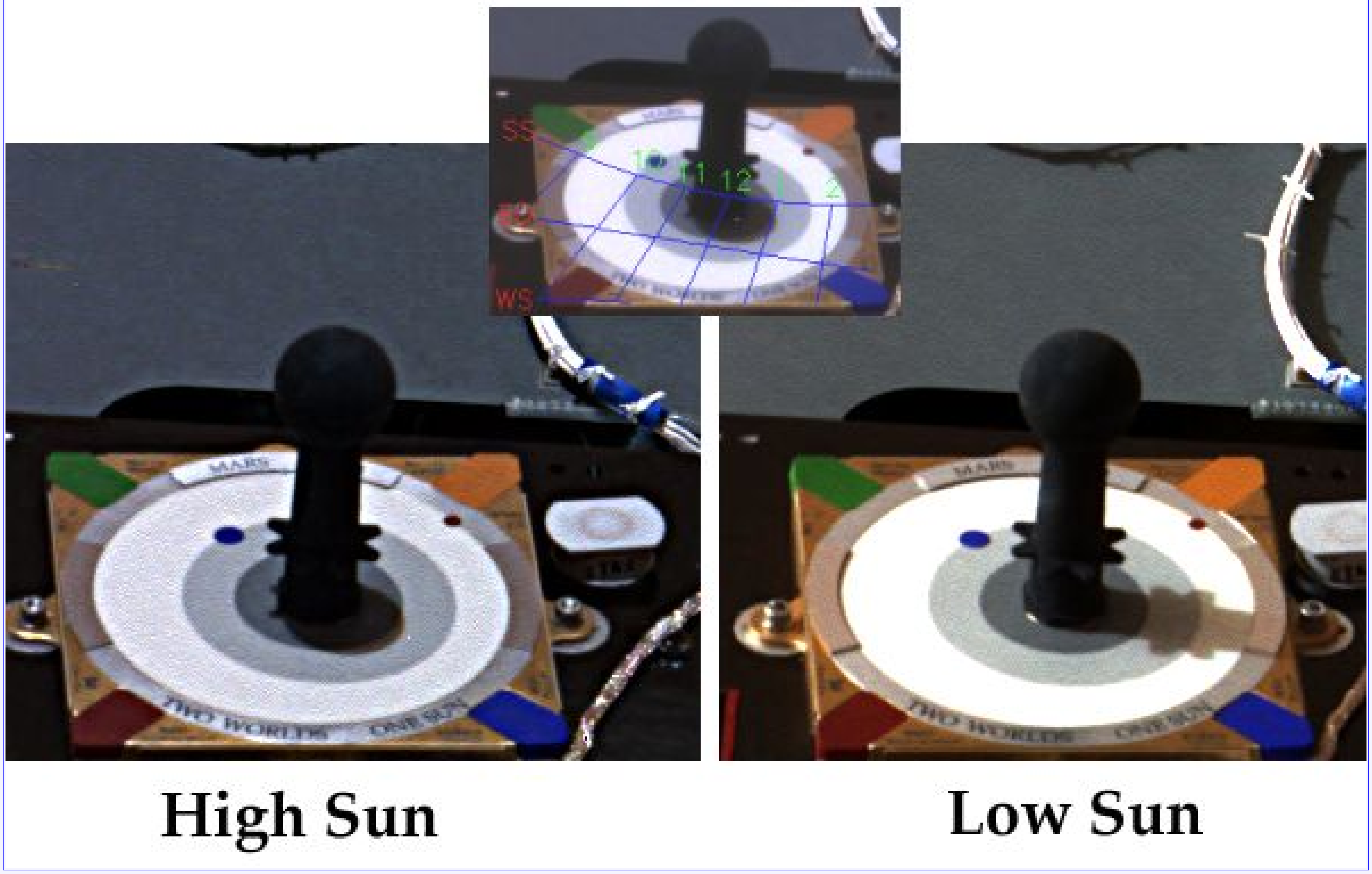
Astronomy Picture of the Day

Discover the cosmos! Each day a different image or photograph of our fascinating universe is featured, along with a brief explanation written by a professional astronomer.

2004 January 10



Two Worlds, One Sun
Credit: Cornell University, Mars Exploration Rover Mission, JPL, NASA

Explanation: Two Worlds, One Sun, is the legend emblazoned on the Spirit rover's camera calibration target. Resting on the rover's rear deck, it also doubles as a sundial, allowing students to determine the solar time at Spirit's landing site on Mars. Examples of the sundial or Marsdial are shown above where the left image, captured near local noon, shows the effect of the Sun high in the martian sky. The right image from later in the afternoon with the Sun lower in the sky, shows a long shadow cast by the Marsdial's central post. Based on the computer generated grid overlay, students determined the local time in the central inset image to be about 12:17 pm local solar time. Did you know, the Marsdial idea was a brainchild of Bill Nye, the Science Guy? (Now you know ...)

Tomorrow's picture: Cocoon of a New White Dwarf

Home

Opportunity Lands:
January 24, 2004
about 9:05 pm PST

Rover Landing Site Details
Rover Landing Site Weather
Rover Landing Site Flash Animation
Mars24 - Time on Mars

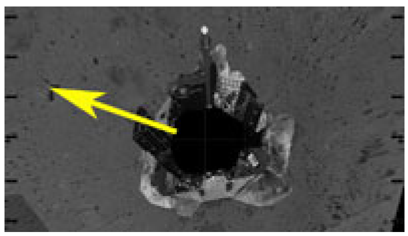
ATHENA INSTRUMENT SITE
RED ROVER GOES TO MARS
M2K4 MARS 2004 ROAMING THE RED PLANET
EXPLORE MARS MAESTRO

Spirit: Time on Mars

Latest Images From Mars - *Jan 11, 2004*

[Today's Press Images] [Today's Press Release]

[All Press Images] [All Press Releases] [All Raw Images] [All Videos]



Spirit Rover Nearly Ready to Roll - *Jan 11, 2004*
The rover is currently facing toward the right hand side of this image. Engineers need to turn the rover so it can leave the lander in the direction of the yellow arrow. >>
[Medium Image]
[Large Image] 500 kB
[Full Res TIF] 2 MB

Meanwhile, back on Earth... - *Jan 11, 2004*
Last night, back here on Earth, mission team members test a rover model in preparation for turning Spirit around on the lander for its new path onto the surface. more images >>
[Medium Image]
[Large Image] 162 kB
[Full Res JPG] 1.5 MB / [TIF] 6 MB

ANNOUNCEMENTS

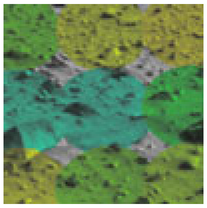
Look for museum events around the country

"First Look" from Spirit, Webcast for Students
Saturday, January 17, 12 pm Pacific
Hosted by Bill Nye the Science Guy

Kids! Send us your rocks!

FEATURES

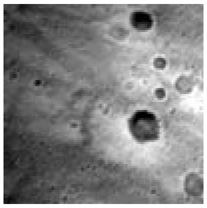
Scientists Don't Judge a Book by its Cover - *Jan 10, 2004*
Landscapes that look familiar at first glance can have surprising geologic histories, so scientists are patiently searching for the right clues that will lead them to understand the processes that formed Spirit's landing site, Gusev Crater. >>



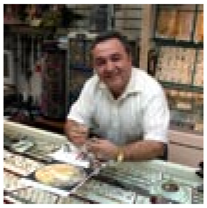
Spirit Lowers Front Wheels, Looks Around in Infrared - *Jan 9, 2004*
Traces of carbonate minerals showed up in the rover's first survey of the site with its infrared sensing instrument, called the miniature thermal emission spectrometer or Mini-TES. >>

Kids! Send us your rocks! - *Jan 9, 2004*
Mars scientists are asking students from around the world to help them understand the red planet. Send in a rock from your region of the world, and we will use a special tool like the one on the rover to tell you what it's made of. >>

A Standing Ovation For Spirit's Stand-up - *Jan 9, 2004*
Imagine your delight at deplaning after a six-month-long flight in a packed coach cabin. After a lengthy, seriously confined journey, Spirit, too, got some relief by stretching her legs. >>



How Do Scientists and Engineers Find Spirit? - *Jan 8, 2004*
Like working a jigsaw puzzle, scientists and engineers piece together data to uncover Spirit's location. >>



Watchmaker With Time to Lose - *Jan 8, 2004*
Most people would be irritated by a watch that loses 39 minutes a day - not so for the members of the Mars Exploration Rover mission. Watchmaker Garo Anserlian is helping them slow down time. >>

MULTIMEDIA

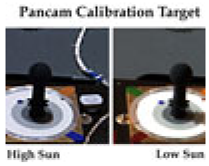
Rover Mission to Mars Animation

The Challenges of Getting to Mars: Impact to Egress

The Challenges of Getting to Mars: Entry, Descent, and Landing

The Challenges of Getting to Mars: Cruise

The Challenges of Getting to Mars: Launch

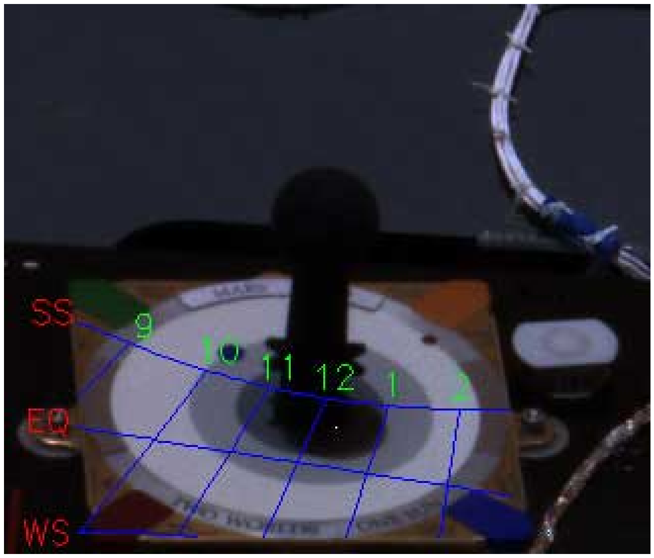


High School Students Land on Mars - *Jan 8, 2004*

While their peers sweat out their next geometry quiz, high school students Courtney Dressing and Rafael Morozowski are sweating out the commencement of surface activities with the rest of the Mars Exploration Rover team. >>

more features >>

What Time is it on Mars?
Jan. 8, 2004



This image of the martian sundial onboard the Mars Exploration Rover Spirit was processed by students in the Red Rover Goes to Mars program to impose hour markings on the face of the dial. The position of the shadow of the sundial's post within the markings indicates the time of day and the season, which in this image is 12:17 p.m. local solar time, late summer. A team of 16 students from 12 countries were selected by the Planetary Society to participate in this program. This image was taken on Mars by the rover's panoramic camera.

Image credit: NASA/JPL/Cornell University

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» Time on Mars - Sunrise, sunset, Earth-rise and Earth-set on Mars

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» Mars Finder Chart - Where is Mars ?

» Mars from Earth - Day-Night Map (JAVA applet)

Sunrise Sunset Mars-rise Mars-set time on Earth

» Solar System Viewer

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What time does Mars rise ?

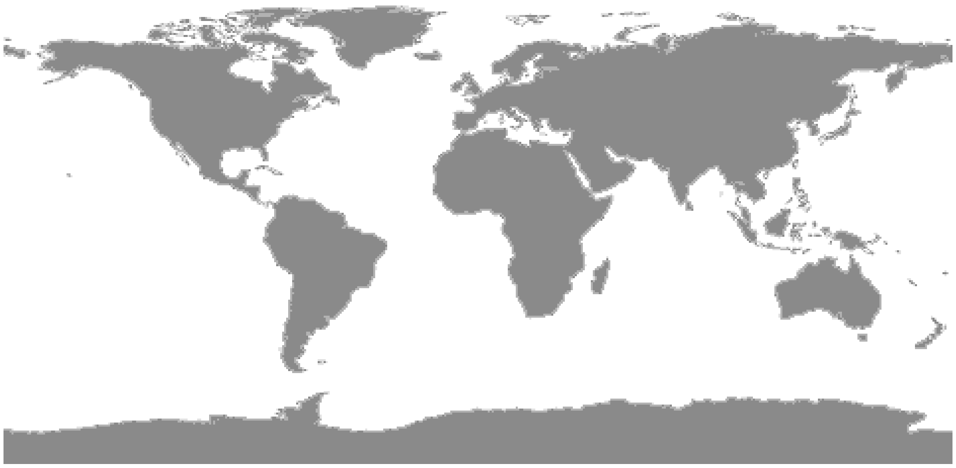
Calculate the rise and set times of Sun and Planet Mars on Earth. Additionally the right ascension and declination is computed.

The calculation is based on VSOP87 - RA and DEC at 00:00 UT.

Sunrise, sunset, marsrise and marsset time on Earth

Sunrise, sunset time on Mars

1. Click on the map to determine your location
(needs an iFrame capable browser - if a click on the map doesn't show any values in latitude/longitude, enter the values manually)



2. Check latitude, longitude, timezone and daylight savings if correct

Latitude (north positive): [ ] Longitude (east positive): [ ]

Timezone (east of GMT positive): [0] Daylight saving: ○ Yes ◉ No

3. Enter the date and click 'calculate'

Day [11] Month [1] Year [2004] [calculate]

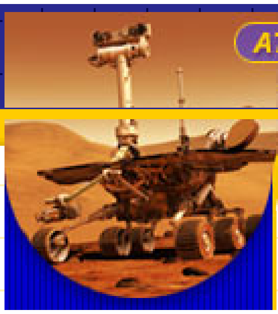
Latitude = Longitude =

Timezone = DST =

Date: 11-1-2004 (dd-mm-yyyy) - Julian Date: 2453015.5

Sun:	**Rise: 06:03**	**Transit: 12:07**	**Set: 18:10**
Mars:	**Rise: 11:34**	**Transit: 17:36**	**Set: 23:38**
Sun:	RA: 19h 26' 41"	DEC: -21d 56' 36"	
Mars:	RA: 0h 55' 43"	DEC: 6d 15' 33"	

Rise Set Times: + ... never sets ; - ... never rises



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FUN FACTS

SUNDIAL

The Mars Exploration Rovers will carry the first-ever interplanetary sundial. This martian sundial will also be used to calibrate Pancam, the panoramic camera on the rovers.

A simulated image of the Mars Rover showing the Mars Sundial on the rear solar panel.

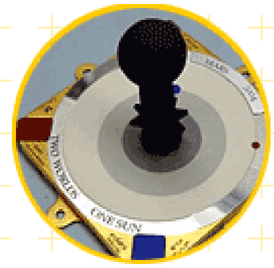
Sundials have long been used on Earth as timekeepers. They are also works of art. Much thought goes into the design of a sundial, and the drawings and motto that each boasts. The same is true of the martian sundial. It was designed by seven people associated with the Athena science team. They used designs and ideas from students in schools across the United States. The rings around the center post symbolize the orbits of Earth and Mars. The word Mars is displayed in 17 different languages. Each side of the sundial has an inscription that tells why we made the journey to Mars, and is illustrated by drawings that were submitted by students.

While on Mars, Pancam will image the sundial many times. Some of these pictures will be put together into a "movie" that will show the passage of time on Mars. Scientists will also use the Pancam images of the sundial to calibrate or adjust images from Mars. They will use the colored blocks in the corners of the sundial to calibrate the color in images of the martian landscape. That means you'll see Mars in its true colors. Pictures of the shadows that are cast by the sundial's center post will allow scientists to properly adjust the brightness of each Pancam image.

Learn About the EarthDial Project and How You Can Participate

Make Your Own Sundial
Make a Wrist Sundial
The Sun Tower

LEARN MORE



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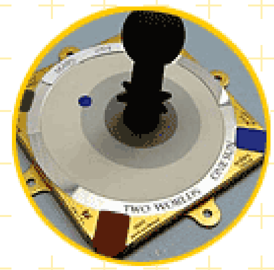

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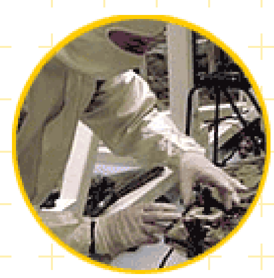

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CORNELL

Interview with Bill Nye: The Sundial Guy

Summary: Early next year, the first interplanetary sundials will be tested on the surface of Mars if all goes according to plan. The sundials, inspired by a flash from Bill Nye, the Science Guy, also will allow scientists to calibrate the pink color of the martian sky. Astrobiology Magazine interviewed Nye on how the sundials came to ride on the Mars science package, called Athena.

Display Options:

Bill Nye, the Sundial Guy

The first interplanetary sundial is expected to make it to Mars on Jan. 4, 2004.

Identical sundials, each about 3 inches square, are being carried by the two Mars Exploration Rovers, the first of which was launched from Cape Canaveral Air Force Station on June 10. The second rover launched one month later, on July 7. Both carry a suite of scientific instruments called the Athena package, and one very ancient timekeeper, a pair of sundials, which in addition to tracking the sun on the mobile rovers, will also allow photographic calibration of colors as they are displayed on all the martian images returned digitally to earth.

Each sundial is inscribed with the words "Two Worlds, One Sun" and bears the name "Mars" in 17 languages, including Bengali, Inuktituk, Lingala and Malay-Indonesian, as well as ancient Sumerian and Mayan. Four gold panels along the sides of the sundials are inscribed with stick-figure drawings of people [called 'sticksters'], as well as a message to future Mars explorers.

Behind the idea for the martian sundial is the Cornell graduate and educator Bill Nye, whose contagious passion for science made him a

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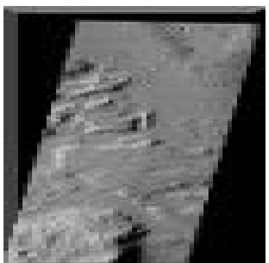
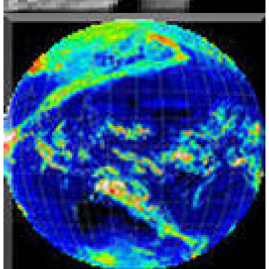
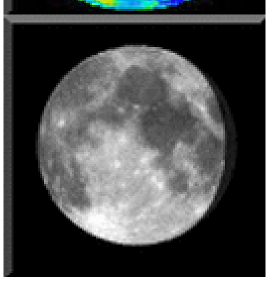






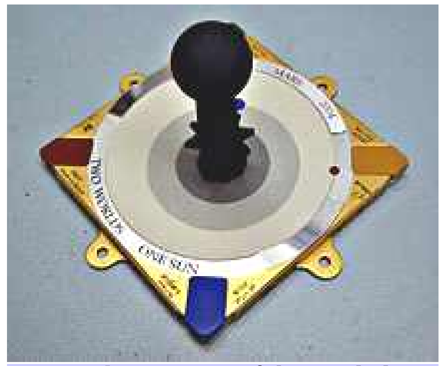
television star. Nye is equally enthusiastic about the forthcoming martian missions. Nye said: "I'm very proud of the sundial, and I'm honored to be part of the team."

Astrobiology Magazine had the opportunity to interview Nye about his forthcoming contribution to science and education on the twin martian probes.

Astrobiology Magazine (AM): What triggered your first inspiration to suggest sending the sundials to Mars?

Bill Nye (Nye): Jim Bell, the Cornell astronomy professor in charge of the Panoramic Camera (pancam), approached me on a flight to Ithaca, NY. He asked me if I'd like to attend a meeting about the Mars Exploration Rovers, which were on the drawing boards in the early winter of 2000. I was thrilled.

I attended the meeting in the Space Sciences building, where Carl Sagan had worked. I took one look at the "photometric calibration target," and exclaimed or quickly proposed with a weird urgency, "That's got to be a sundial," or something like that.



In an earlier version of the sundial, the gnomon was gold, but the bright color interfered with callibration
Credit: *NASA/JPL/Cornell*

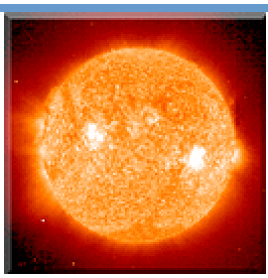
My dad was fascinated with sundials. He photographed hundreds of them and wrote a book about them. He designed a Nye family dial that kept time at our house in Washington, DC.

Sundial enthusiasts (gnomonicists) reach a point, where every shadow-casting thing you see should perhaps be converted into a sundial. This would include telephone poles, loosened nail heads on wooden decks, picnic sandwich toothpicks, birdfeeder posts, and the Washington Monument. The shadow-casting post on the calibration target was an obvious opportunity for proselytizing, perhaps enriching the lives of Mars scientists.

AM: You began designing the sundial for the 2001 Surveyor Lander, which was cancelled, correct?. Any differences between that original design and what is flying on both exploration rovers now, other than the change of the sundial's gnomon from gold to black?

Nye: I guess the work was originally for the 2001 Surveyor. I am pretty sure it got "re-scoped" to become the Mars Exploration rovers. The time-reckoning portion of the design for the Rover dials did not change much after Woody Sullivan got on it. One of the fundamental features of these dials is that they have no hour lines. They can't, because the platform they're mounted on will move often.

When sundials are near the equator of a planet, you don't want a triangular shaped gnomon (shadow-caster). You want a rectangle or simply a post. These two things I was able to point out right away in that meeting. For the next level of detail, I said, the guy for this is Woody Sullivan. Everybody felt that these features and getting Woody involved made the dials even a little more intriguing.



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Glossary

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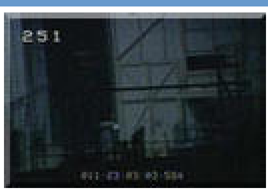


Today's Story

Today's most read story is:
Planet First Magnetic Roaster

But to address your question a bit more, it might depend what you mean by "design." The writing had to be changed to read "2004," which necessitated a plate being bonded over the original engraving. The gnomon was originally black. But as you mention, the top hemisphere of the upper nodus, or ball, was gold as was the lower nodus, or star. These are, in an art designer's view, design changes, I suppose.

After testing, we found some "glints" or "glinting," so the gnomon had to be painted with that eerily flat, black paint. It's so non-reflective; (How non-reflective is it?); it's so non-reflective that it looks like it's not there, or that it's some sort of odd cut-out in a few of the close-ups of the dial.

AM: Any differences needed because of the different landing sites for the twin rovers? Presuming that both sundials are identical?

Nye: Both dials are the same. Since the hour lines are going on long after the shadows are cast (say 11 minutes or so), and since they're both landing near the equator, they can be exactly the same.

Bill Nye demonstrates the day(left) and night views of the Mars sundials, as the position changes over a typical "Sol", or martian day.

Making science entertaining and accessible is something that Nye has been doing for most of his life. Humor runs rampant in his family - "we get together and just laugh for hours" - and his parents made sure he knew the value of education. Nye discovered he had a talent for tutoring in high school, and while growing up in Washington, DC, he spent his summers demystifying math and science for fellow students. When he wasn't hitting the books, he was hitting the road on his bicycle, which he spent hours taking apart and rebuilding, to "see how it worked." Nye's fascination with how things work led him to Cornell University and a degree in mechanical engineering. After graduation, he headed for Seattle to work as an engineer at Boeing. "I've always loved airplanes and flight," says Nye. "The space program was really important to me as a kid. I still have a photo of Armstrong and Aldrin on the moon in my living room."

It was in Seattle that Nye began to combine his love of science with his flare for comedy, when he won a Steve Martin look-alike contest and developed dual

The positions of the Earth and Mars were designed for earlier launch dates, which were postponed after the Polar Lander aand Climate Orbiter failures. The dial faces are made with fancy silicone rubber dots that represent the Earth and Mars. They're embedded in circles (annuli) that represent the orbits of the planets made of the same sort of material.

The reflectance of these features is precisely known. To move the Earth and Mars rubber dots would have required recasting, reradiating, and recalibrating, so we left them were they were. That is, where they are-- perhaps a little mystery for the Martian archeologists that may one day visit there.

AM: Because the rovers are moving around in orientation all the time, you are going to superimpose an electronic hour mark on top of the sundial, which adjusts for the rover's orientation to the sun? Will this time have to be adjusted for the 11 minute transit time to get the images back to Earth?

Nye: Yes to the first question, "sort of" to the careers as an engineer by day and a stand-up comic by night. Eventually, he segued into a fortuitous combination of both science and comedy as Bill Nye the Science Guy, performing and writing on KING-TV's late night ensemble comedy show, "Almost Live" (on Comedy Central), guesting on The Disney Channel's "Mickey Mouse Club" and "Late Night with David Letterman" and answering science-related questions on local and national radio programs.With fellow KING-TV alumni, Jim McKenna and Erren Gottlieb, Nye has also made a number of award-winning educational videos and programs for school-age children and adult audiences, among them "Fabulous Wetlands" for the Washington State Department of Ecology. Along with his duties as head-writer of "Bill Nye," he has also written "The Science Guy's Big Blast of Science," an introductory science text, and will be featured in forthcoming episodes of "Eyes of Nye" television shows.

As a signature example of terrestrial life on our pale blue planet, another important piece of human culture is represented on the sundial: baseball, since both Nye and sundial expert, Woody Sullivan are fans. To save weight, six holes in the shape of home plate were cut out of the underside of the aluminum base.
Photo Credit: *Cornell;* Caption Credit: *Wm. Morris Agency*

second. We will superimpose a full complement of hour lines each time we get a good view sent back. There are no conventional hour lines at all on these dials. Because unlike regular sundials, they are on moving platforms.

One of the charming challenges is roughly, "What is an hour on Mars?" Is it a "Mour?" Is it a "quadraduodeci-sol," a twenty fourth of a sol, a Mars day? Why a 24th, for example?

Right now, we're planning Earth time, marking the hours electronically, changing them roughly continuously.

When we see the shadow on our images, are we seeing the time eleven minutes ago on Mars? Or are we seeing the time on Mars as observed from Earth now? It's like time travel problems in science fiction. When is now; when was then?

With information and events moving through the cosmos at the speed of light, can we say that events are happening on Mars, or do we have to say those events don't happen here for eleven extra minutes? Hmmm.

Bear in mind also that the eleven minutes is approximate, and it's always changing. Right now, I imagine we'll post the local solar times on Mars with the shadow images. Since there may be other lost time in signal processing and especially in getting the images posted, the delay will be reported or placarded rather than accounted for in the hour line positions.

Earth bound sundials, the only ones that humans have set in place so far, measure solar time. The duration of daylight varies every day. So, in sundialing we think of solar time and clock time. We somewhat arbitrarily, albeit logically, divide the Earth's solar year up into 31,556,926 seconds with clocks.

In ancient times, the day was divided only by the shadows, solar time.

The first color image transmitted to Earth from the Viking 1 lander, with its saturated red color and orange-pink sky. The lander went about its business collecting 4,500 images for more than six years, from July 20, 1976 until November 1982, substantially exceeding its design lifetime of 90 days. *Credit: NASA*

AM: What happens if the sun is not apparent, from dust or clouds? For instance, there is one entire day devoted to sundial observation. Has that day been set for both rovers yet--or is that changing depending on what happens on the surface?

Nye: If it's dusty out, we won't do the sundial observation time-lapse that day. But, the photometric calibration targets are still useful on dusty days. They have color patches and reflective surfaces, and so on. If the shadow is washed out by diffused light, well, the useful effects of pink or orange shadows have to be inferred and approximated without observation. As far as I know the science-powers-that-be will pick the all-day dial observation time after we have gathered and secured an acceptable number of other images and data. Those data can be analyzed, while more pictures are taken that include the dials. This is as far as I know.

AM: How long are the panoramic cameras slated to be available? During the daytime for the full 90-day primary mission, say from January to April 2004?

Nye: As far as I know, the pan-cams are to be run every day or sol. The useful time for the missions and the cameras is probably going to depend on how much dust settles on the solar panels. It's an odd or surprising constraint. But that's it, if nothing else goes wrong.

We may be able to fire the space crafts back up during the next Martian summer. We'll see, perhaps literally.

AM: How will the cameras use the colors on the sundial to adjust brightness and color? Basically, these will subtract off the dominant pink color seen on the surface, based on the known colors on the dial to calibrate for 'over-pinking'?

Nye: The colors of the color "coupons" are very well known or calibrated. And, so is the brightness of each of the white, gray, and nearly black circles (annuli). So, we adjust the images so that the colors and brightness come out right, the way we know them to be from our calibrations back here on Earth.

The orange and pink business comes from the following charming feature of shadows. Try this: Get a very white piece of paper, and go outside in the sun. Make a shadow on the paper with, say, a pencil, or your finger. Look carefully at the shadow. It's not black, not really black at all. It's gray, but it's also light blue. Scattered sky light fills in behind your shadow-caster. The same thing happens on Mars. Only there, the light is pink or orange. So, to get closer to true colors, we have to subtract the sometimes very strong effect of dust in the Martian sky, which adds a lot of pink light. I say pink. Some people would say it's closer to orange. Well, that's why we have the calibrated coupons. One guy's orange is another guy's pink. But 620 nanometers is the same for all of us.

Before people figured this out back in the first era of Mars probes (also the first Disco Era) the images from the Viking spacecraft were too pink or orange. Those "over-pink" images still show up in Mars science fiction movies and Mars-themed posters and restaurant walls.

AM: What is the history behind selecting what was inscribed on the sundials? The "Two Worlds, One Sun" motto in 17 languages, and so forth?

Nye: As a student of Carl Sagan's, a Planetary Society Board Member, I came of age during the Voyager missions. I was in the lecture on during the days, when Professor Sagan asked the class which songs we thought were worthy of being sent out of our Solar System, messages in bottles to be cast into the Cosmic Ocean. These were whimsical in a sense, almost silly, self-delusional perhaps. The chance that they will ever be found is almost unimaginably remote. But, it is also a notion that fills us with wonder and hope. The idea is irresistible-- a message from humankind for all time.

Carl Sagan described the Plaques that were affixed to the side of the spacecraft. These were to be sent where no one has gone before for roughly eternity. That made quite an impression on me as a student.

So, when this came up, I immediately suggested an inscription on the one place, where I believed there would be space available, the edge of the aluminum photometric calibration target, the sundial. I wrote the copy and sent it to the Mars team members I knew.

Everyone liked the idea. People made a few suggestions. Steve Squyres [Cornell project scientist on the Mars Athena science] liked it very much and made it better.

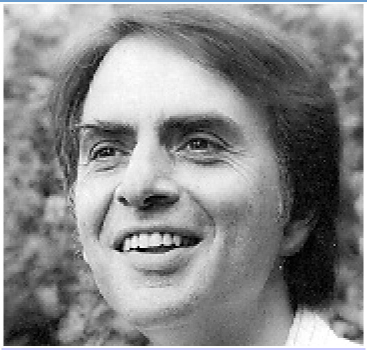
Now, two of these inscriptions are on their way to Mars. It gives me chills. I feel as though I contributed to something big and worthy of the best of humankind--exploration:

"People launched this spacecraft from Earth in our year 2003. It arrived on Mars in 2004. We built its instruments to study the martian environment and to look for signs of water and life. We used this post and these patterns to adjust our cameras and as a sundial to reckon the passage of time. The drawings and words represent the people of Earth. We sent this craft in peace to learn about Mars' past and about our future. To those who visit here, we wish a safe journey and the joy of discovery."

Woody Sullivan, who is one serious gnomonicist, pointed out, or maybe insisted that sundials should have a motto. We mulled a few of the traditional ones over: "I only count the sunny hours," "Tempus fugit," or "Time Flies."

Woody knows of a dial in France that says, "Every hour injures; the last one kills." Wow.

Anyway, I was having dinner with Lou Friedman and Bruce Murray.


The National Academy of Sciences awarded Sagan the 1994 Public Welfare Medal for "communicating the wonder and importance of science."

We're all part of the Planetary Society, the organization those guys started with Carl Sagan. We got to talking about the dial, and Lou came up with "One Sun; Two Worlds". In a few moments, we agreed that it should be "Two Worlds; One Sun". We also agreed that that we were onto something. Sure enough, everyone embraced it. I guess I'll never forget it.

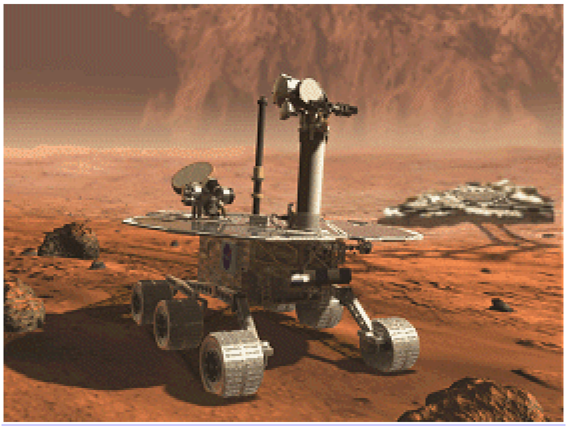
Lou and Bruce got Jon Lomberg involved, the guy who did the artwork on Sagan's landmark "Cosmos" series. He, along with some thoughtful school kids, created the artwork along the edges. They're stick figures that I like to call the "sticksters."

They give the instrument a little whimsy, and they are, to me, so human. How different are engravings in hardened aluminum catching Martian sun from petroglyphs laboriously scraped into south-facing rocks on Earth aligned with the sunrise? People made them.

AM: How do you personally feel about contributing this kind of permanent 'message in a bottle' to the future?

Nye: It's a thrill I may never match. I am honored to have been included and given a chance to contribute to space exploration.

AM: A big part of the Apollo 12 mission was recovering a piece of a lunar surveyor lander and bringing it back to Earth. This profile was to demonstrate precise lunar landing and also to see for effects of weathering and aging on the lunar surface. What do you think about future Mars landings having something to do with bringing back the sundials, for some of the same reasons? Would that be an intriguing outcome to your team's unique story?


The next generation: an artist's rendition of a Mars Exploration Rover, due to land on the Red Planet in January 2004.
Credit: NASA

Nye: I guess it would be intriguing, but I hope nobody feels like they have to take these things apart and haul them back. In a hopeful view of the future, I can imagine the landing sites becoming part of Martian history.

The Martian residents in the distant future could go on occasional outings to see the old Rovers and hear the story of the sundials, and check their time pieces against the dials which, I am pretty confident will still be reckoning the passage of Martian time.

In a less ambitious view of the future, people might go to the rovers and take them apart for analysis, because they need to know what happens to the material over that much time, because they're engaged in the developing new weapons or new ways to cope with an uncomfortably changing environment back on Earth. Or perhaps they'll just tear them apart to see what's inside without any sense of history or need to preserve them.

For now, I hope there will someday be future visitors, who can admire them as calibration instruments and as sundials.

An astonishing part of the story concerning the recovery of parts from the Surveyor spacecraft is that there were microbes on the spacecraft that had accidentally been left on board, and they successfully stowed-away. They survived for years in the harsh environment of the Moon. When they got back to Earth, they continued to grow. It's compelling evidence for astrobiologists that the environmental limits for living things are set pretty far apart. [*Ed. note: see debate on this issue from Surveyor's project scientist, Leonard Jaffe*].

I hope these Mars Exploration Rover spacecraft are sterile.

I leave it to future explorers to decide their fate.

AM: Any future plans for including sundials as a general calibration in the future, since that is likely part of any imaging project in space exploration?

Nye: I sure hope so.

Sundials are so much a part of human history. Eratosthenes inferred the diameter of the Earth within perhaps 4% using the shadows of sticks.

Our world is driven by our remarkable ability to carefully measure and divide units of time. In a reasonable sense, the invention of clocks has had a greater effect on our lives than the invention of wheels. You can invent wheels relatively easily, if you live where trees fall over.

Clocks are hard to come up with. Our clocks still run clock-wise, because the first sundial shadows ran clockwise. We've probably only begun to exploit what information and inspiration we might get from shadows in the sun.

What's Next

Orbital projections of where the Mars Exploration Rovers are right now, can be continuously monitored over their half-year journeys, which culminate in their landing around January 2004.

Collaborators on the Mars Sundial project include:

* Bill Nye, a 1977 Cornell engineering graduate, Rhodes Class of '56 Professor and host of the PBS show, "Bill Nye the Science Guy", and the upcoming "Eyes of Nye" television shows
* Steven Squyres, Cornell professor of astronomy and principal investigator for the Athena suite of science instruments carried by the rovers;
* Jim Bell, Cornell assistant professor of astronomy and lead researcher for the high-resolution stereo Pancams carried by both rovers;
* Woodruff "Woody" Sullivan, sundial enthusiast and professor of astronomy at the University of Washington;
* Tyler Nordgren, Cornell Ph.D. '97, an artist and astronomer at the

University of Redlands in California;
* Jon Lomberg, an artist and creative consultant to the Mauna Kea Center for Astronomy Education, University of Hawaii at Hilo;
* Louis Friedman, executive director of the Planetary Society.

JPL, a division of the California Institute of Technology, manages the Mars Exploration Rover project for NASA's Office of Space Science, Washington, D.C. Additional information about the project is available from JPL and from Cornell University, Ithaca, N.Y

Related Web Pages

Cornell sundial page
Where is Spirit Now?
Athena Science: Cornell University
Five Year Retrospective: Mars Pathfinder
Sundial Links

Note: *Mars Life: [2003-10-08]*

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Mars Sundial to Help Teach Kids About Time, Sun

John Roach
for National Geographic News
December 9, 2003

Organizers of the EarthDial Project are encouraging children and other curious minds to think about the concepts of time and planetary motion. They hope to have people from all corners of the globe build sundials (above) similar to the one that will ride on the solar panel of the Mars rovers scheduled to land in January.

Photograph courtesy Bill Nye

If all goes according to plan this coming January, the twin *Spirit* and *Opportunity* rovers will land on Mars. At that same time continuously updated images of sundials built by school children and individuals around the world will launch on the Internet.

The link between the two lies in science and the sun.

Read the full story >>

NATIONAL GEOGRAPHIC

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The rovers are on a months-long quest to understand the history of water on the red planet, a key ingredient for past—or present—Martian life. They'll cruise around the planet, probing and imaging rocks and soils for liquid clues. They also carry the first sundials ever placed on another world.

The Web site project, called EarthDial [see link at the bottom of this story], aims to give humans a sense of how the sun's passage across the sky controls time around the world. The design of all the dials on Earth ties in with the dials on Mars.

"It grows out of the MarsDial project that was taking a science instrument on a spacecraft on its way to Mars," said Woodruff Sullivan, an astronomy professor and sundial expert at the University of Washington in Seattle.

The *Spirit* and *Opportunity* rovers are based in part on designs for the scuttled Mars Surveyor 2001 Lander. In examining plans for that mission, Seattle, Washington-based television personality Bill Nye, "the science guy," noted that a small square and post mounted on the rover's deck to calibrate images relayed back to Earth could double as a sundial.

Project scientists at Cornell University in Ithaca, New York, loved Nye's idea and together with the help of Sullivan they

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designed the first sundial destined for another planet. The sundial was inscribed with the motto "Two Worlds, One Sun."

The Mars Surveyor 2001 Lander mission was cancelled after the loss of the Mars Polar Lander in 1999, but the motto-inscribed sundials made it onto the *Spirit* and *Opportunity* rovers currently en route to Mars.

During the time gap between the original and current missions, Sullivan and Nye in collaboration with the Pasadena, California-based Planetary Society hatched the EarthDial project, which aims to have school children and individuals around the world construct sundials similar to the one on the Mars rovers.

"The EarthDial project presents an elegant way to teach students and the general public about a variety of aspects of planetary motion in the deceptively simple sundials," said Bruce Betts, director of projects at The Planetary Society.

Project organizers hope comparisons of the sundials on Earth and Mars will prompt people to ask questions such as: How does time work on Earth? Does the concept of a month make sense on Mars? What should be the name of time units on Mars?

"The idea is for MarsDial and EarthDial to trigger all these questions and be an education vehicle," said Sullivan.

EarthDial Construction

The Planetary Society, Nye, and Sullivan are encouraging school children, community organizations, and individuals around the world to build their own sundials and display them on the Internet using 24-hour webcams.

The organizers hope to post a broad sample of sundials to a single webpage, illustrating the difference in shadows between time zones as well as between the northern and southern hemispheres. As people sweep their eyes across the page, they'll get a sense of time across the globe.

Instructions for how to build an EarthDial are posted to the Web site of The Planetary Society, which will also host the project Web site at least throughout the life of the Spirit and Opportunity missions.

The cost to participants is anticipated to be no more than U.S. $50 for building materials in addition to the cost of acquiring and maintaining a webcam with an around-the-clock Internet connection that refreshes the image regularly.

Each EarthDial will be about 32 inches (81 centimeters) in diameter, or about ten times the size of the MarsDials on the rovers. Like the MarsDials, each EarthDial will have the motto "Two Worlds, One Sun," but in the native language of its owners.

And while the project organizers want the EarthDials to be similar in functionality and appearance, they want individuals to decorate the perimeter of each dial with personal touches and expressions of local culture.

"We want a nice degree of uniformity as you scan across the page so you can be oriented, but we also want some variety," said Sullivan.

Sullivan has already gotten considerable feedback from potential participants in North America, Chile, Holland, Spain, Australia, and even the South Pole. He is hoping that the project will also attract participants from geographically isolated places like the Seychelles in the Indian Ocean.

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Related Websites

- The EarthDial Project
- MarsDial
- Mars Exploration Rover Mission
- Bill Nye, "The Science Guy"

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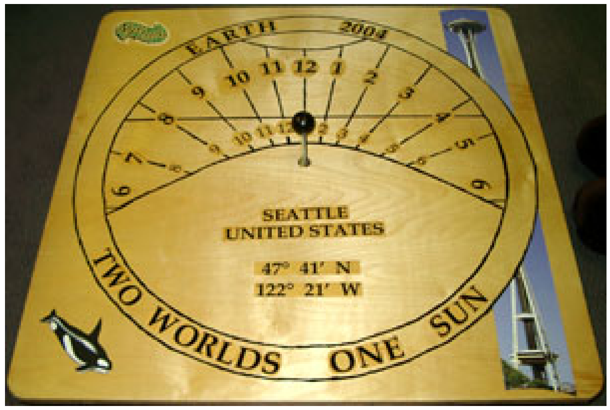
The EarthDial Project



EarthDial Links

EarthDial Project Home
- About the EarthDial Project
- EarthDial Press
- EarthDial Press
- EarthDial Instructions
- EarthDial Specifications
- EarthDial Calculator
- Books & Links
- Glossary

Find your latitude and longitude at the Global Gazetteer

And check out the MarsDial!

For centuries humanity used Sundials to mark time by tracking the motion of the Sun across the sky. The EarthDials project will use a network of sundials around the world to show the passage of time in this ancient manner. This network of sundials is being created at the same time that sundials will be roving on Mars with the *Mars Exploration Rovers*.

Images of each EarthDial will be posted on this website every 5-10 minutes. The project is a partnership between The Planetary Society (the world s largest space interest group), Bill Nye, the Science Guy® and Nye Labs, and Woody Sullivan at the University of Washington.

You can **get involved** right now by **building your own EarthDial**. Individuals and schools around the world are invited to participate, with each location creating its own unique EarthDial, embellished with designs representative of their regions. Become a part of the EarthDial network. Send us just a single image of your EarthDial to post here on this site, or set up a webcam that can serve regular images of your EarthDial for posting.

Either way, we will give you instructions to build your own EarthDial here on this site, including help adjusting it for your latitude.

Whether you build your own or not, check back on this site to see live images of EarthDials added from around the world.

So, learn more about this project, build your own Earthdial, or just browse our site and learn about the fascinating world of sundials. You can also visit our press section to see our press releases. Visit our home page to learn more about planetary exploration and how you can get involved with it through The Planetary Society.

About the EarthDial Project
EarthDial Instructions
EarthDial Specifications
EarthDial Calculator
Books & Links
Glossary

Questions or comments? Email us at comments@planetary.org.

Frans' zonne-wijzers

Beste resolutie 800x600

English

Welkom op de Zonnewijzer-site van Frans Maes

Op deze site vind je plaatjes van zonnewijzers die ik in de omgeving, op vakantie of op internet tegenkwam en die ik interessant, mooi of leuk vond. Ik probeer er meestal ook wat bij te vertellen. En langzamerhand komt er ook wat achtergrond-informatie bij.
Jammer genoeg is het niet altijd zonnig tijdens onze tripjes, dus je ziet de zonnewijzers niet altijd 'in actie'...

Nieuw of vernieuwd

- Redding voor historische zonnewijzer in Besançon onderweg. Ok jouw hulp is welkom!
- Analemmatische zonnewijzer overleeft ramp Mount Stromlo Observatorium

Je vindt hier verder onder andere:

- plaatjes met verhaaltjes over ca. 200 zonnewijzers, gerangschikt volgens type; zie het hoofdmenu hiernaast
- de grootste collectie analemmatische zonnewijzers op het web: ca. 50 stuks. Mijn favoriete type, omdat ze zo bescheiden zijn, en natuurlijk omdat we er zelf een in onze tuin hebben
- hierop aansluitend: achtergrond-informatie over analemmatische zonnewijzers
- ook een favoriete rubriek: wel of geen zonnewijzer ??
- een index wanneer je een bepaalde plaats of trefwoord zoekt
- een beschouwing over de tijdsvereffening
- zonnewijzer-verenigingen en -inventarisaties
  met o.a. de Nederlandse Zonnewijzerkring
- links naar andere zonnewijzer-sites
- literatuur over zonnewijzers

Breng in elk geval ook een bezoek aan het Zonnewijzerpark in Genk (België). Uniek in Europa!

Bijgewerkt: 18 december 2003

Deze site is mede mogelijk gemaakt door de Faculteit Wiskunde en Natuurwetenschappen van de Rijksuniversiteit Groningen

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Session 1 | 30 Oct 02, 11:00 AM.

1 - 20 of **39 lots**

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Lot #

SUBMIT

Images & Text   Images only   Text only

Lot# 1: A lamp timekeeper in moulded pewter, **18th century or early 19th century**

LOCATION	ESTIMATE	AUCTION DATE
London, Olympia	400 - 500 GBP	Session 1 30 Oct 02 11:00 AM

Lot# 2: f - A small nautical sand-glass, **French, 19th century**

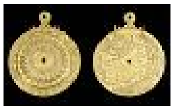
LOCATION	ESTIMATE	AUCTION DATE
London, Olympia	300 - 400 GBP	Session 1 30 Oct 02 11:00 AM

Lot# 3: f - A sand-glass set in sheet metal with four glass ampoules and iron turning mechanism, **German, 18th century**

LOCATION	ESTIMATE	AUCTION DATE
London, Olympia	4,000 - 6,000 GBP	Session 1 30 Oct 02 11:00 AM

Lot# 4: f - A rare wall sand-glass with mechanical turning system, **German, 17th century**

LOCATION	ESTIMATE	AUCTION DATE
London, Olympia	8,000 - 12,000 GBP	Session 1 30 Oct 02 11:00 AM

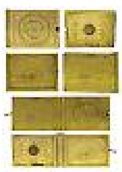


Lot# 5: f - Benvenuto Volpaia; an exceptionally rare gilt brass or copper combined nocturnal and vertical sun-dial, **Italian, dated 1516**

LOCATION	ESTIMATE	AUCTION DATE
London, Olympia	8,000 - 10,000 GBP	Session 1 30 Oct 02 11:00 AM

Lot# 6: f - A combined brass nocturnal, lunar indicator and altitude sun-dial, **probably German, dated 1550**

LOCATION	ESTIMATE	AUCTION DATE
London, Olympia	4,000 - 6,000 GBP	Session 1 30 Oct 02 11:00 AM



Lot# 7: f - Erasmus Habermel; a rare gilt brass or copper book form compendium and notebook, **Bohemian, dated 1596**

LOCATION	ESTIMATE	AUCTION DATE
London, Olympia	60,000 - 80,000 GBP	Session 1 30 Oct 02 11:00 AM

Lot# 8: f - A bronze hour ring from a portable horizontal dial, **European, 14th or 15th century**

LOCATION	ESTIMATE	AUCTION DATE
London, Olympia	400 - 600 GBP	Session 1 30 Oct 02 11:00 AM

Lot# 9: f - An ivory horizontal string-gnomon diptych dial, **French probably Paris, dated 1565**

LOCATION	ESTIMATE	AUCTION DATE
London, Olympia	2,500 - 3,500 GBP	Session 1 30 Oct 02 11:00 AM

Lot# 10: f - Vlrich Schniep, a gilt brass horizontal string-gnomon dial, **German, dated 1585**

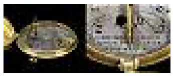
LOCATION	ESTIMATE	AUCTION DATE
London, Olympia	8,000 - 12,000 GBP	Session 1 30 Oct 02 11:00 AM

Lot# 11: f - Adriaan Zeelst (attributed to); a rare gilt brass cross-shaped equinoctial dial and reliquary, **Flemish, dated 1589**

LOCATION	ESTIMATE	AUCTION DATE

London, Olympia	10,000 - 15,000 GBP	Session 1 30 Oct 02 11:00 AM

Lot# 12: f - Christopher Schisler; a silver and gilt brass horizontal string-gnomon dial inclinable for latitude, **German, dated 1597**



LOCATION	ESTIMATE	AUCTION DATE
London, Olympia	8,000 - 12,000 GBP	Session 1 30 Oct 02 11:00 AM

Lot# 13: f - An unusual enamelled gold finger-ring in Renaissance-style inset with rubies and incorporating an horizontal..., **probably Vienna, circa 1860-70**

LOCATION	ESTIMATE	AUCTION DATE
London, Olympia	2,000 - 3,000 GBP	Session 1 30 Oct 02 11:00 AM

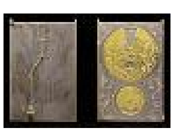
Lot# 14: f - Attributed to Hans Troschel the younger; an ivory diptych dial in the form of a lute, **German, between 1614-1634**

LOCATION	ESTIMATE	AUCTION DATE
London, Olympia	4,000 - 6,000 GBP	Session 1 30 Oct 02 11:00 AM

Lot# 15: f - A brass 'Rojas'- type universal sun-dial with calendar, **English or Spanish Netherlands**, **circa 1600**

LOCATION	ESTIMATE	AUCTION DATE
London, Olympia	3,000 - 4,000 GBP	Session 1 30 Oct 02 11:00 AM

Lot# 16: f - A silvered brass and brass perpetual calender and vertical sun-dial, **German, circa 1700**



LOCATION	ESTIMATE	AUCTION DATE
London, Olympia	4,000 - 6,000 GBP	Session 1 30 Oct 02 11:00 AM

Lot# 17: f - A vertical window dial in coloured and painted glass, **European**, **17th century**

LOCATION	ESTIMATE	AUCTION DATE
London, Olympia	3,000 - 4,000 GBP	Session 1 30 Oct 02 11:00 AM

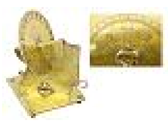
Lot# 18: f - A brass magnetic azimuth dial with changeable month plates, **German, circa 1670**

LOCATION	ESTIMATE	AUCTION DATE
London, Olympia	4,000 - 6,000 GBP	Session 1 30 Oct 02 11:00 AM

Lot# 19: f - A good oval silver portable horizontal dial by Michael Butterfield, **French, circa 1700**

LOCATION	ESTIMATE	AUCTION DATE
London, Olympia	1,500 - 2,000 GBP	Session 1 30 Oct 02 11:00 AM

Lot# 20: f - Thomas Haye; a brass sciaterra, **French, early 18th century**



LOCATION	ESTIMATE	AUCTION DATE
London, Olympia	3,500 - 5,000 GBP	Session 1 30 Oct 02 11:00 AM

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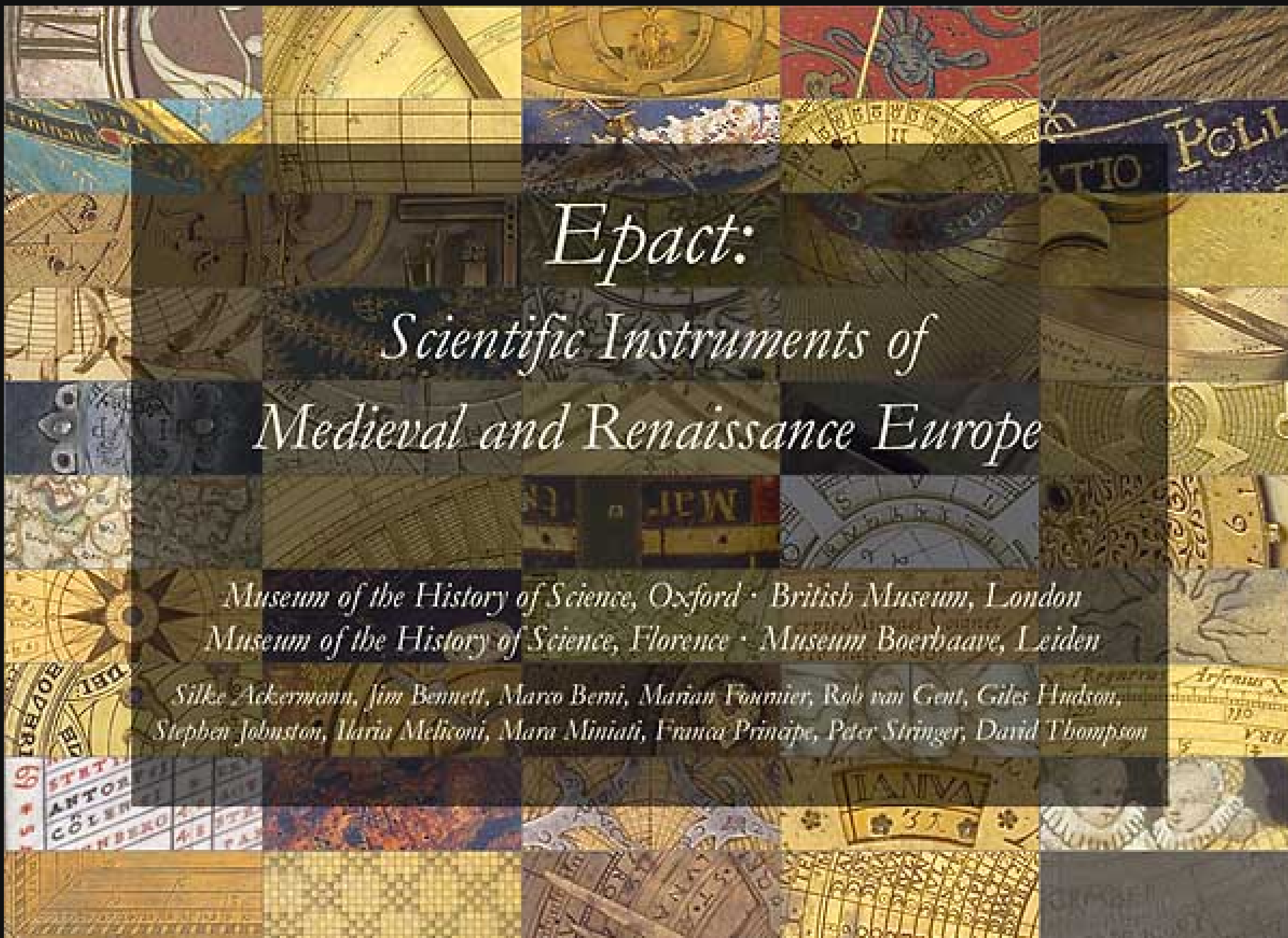

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Sonnenuhren in Bremen und umzu

Gibt es überhaupt Sonnenuhren in Bremen?
Es existieren mindestens 120 ortsfeste Sonnenuhren in der Hansestadt.
Damit ist Bremen das Bundesland und die Großstadt mit der größten Sonnenuhrendichte in Deutschland!
Hinzu kommt eine große Zahl von Reisesonnenuhren in Museen und in Privatbesitz. Insgesamt sind mir weit über 150 *Sonnen*uhren in Bremen bekannt - die *Dunkel*ziffer dürfte in derselben Größenordnung liegen.

Sonnenuhren in Bremen
Sonnenuhren in Bremerhaven
Sonnenuhren in Ostfriesland

Sonnenuhr-Museum in Wittmund
Sonnenuhr-Atelier Lohmühle
Videodokumentation: Sonnenuhren in Bremen

Sonnenuhren überall ...
Clocks Mailing List

Eine "Mond-Uhr"
A "moondial"

Clocks and Time
Horology site for books, magazines, organizations, museums, PC synchronization software, time standards.
Clocks Mailing List (Diskussionskreis Sonnenuhren)
Arbeitskreis Sonnenuhren/Deutsche Gesellschaft für Chronometerie

Sonnenuhren Unterrrichtshilfen
Hinweise zum Ablesen und zur Funktion von Sonnenuhren

North American Sundial Society
The Dutch Sundial Society
Cadrans solaires
Sundials on the Internet
SUNDIAL WITH MIRROR by Gustav Biriell
Astronomie in Bremen und Umzu

Videodokumentation: Sonnenuhren in Bremen

Die Landesbildstelle Bremen, Uhlandstr. 53, 28211 Bremen, Tel 0421-361-3350, bietet ein Videoband zum Thema Sonnenuhren an. Holger Wessels hat die Entstehungsgeschichte von drei Sonnenuhren begleitet. Neben den Entwicklungs-

schritten wird die Konstruktion und die Funktion von Sonnenuhren auf einfache und anschauliche Weise erklärt.
Der Preis des Bandes beträgt 25,- DM (zuzüglich Porto).

Sonnenuhr-Museum in Wittmund

Im Heimatmuseum Peldemühle ist ein Sonnenuhrzimmer eingerichtet worden.
26409 Wittmund, Esenserstr. 16.

Geöffnet im Sommerhalbjahr (Mai bis Oktober)

Dienstags	10:00 -12:00 Uhr 14:00 -17:30 Uhr
Sonntags	10:00 - 12:00 Uhr

im Winterhalbjahr auf Anfrage unter Tel. 04462-5279.

In der Sammlung sind folgende Objekte zu sehen:

- Polyeder-Sonnenuhr mit 13 Flächen, ca. 1720
- Ring-Sonnenuhr
- Halbzylinder-Sonnenuhr
- Etwa 20 Sonnenuhrmodelle und Kachelsonnenuhren
- 10 Fotos von Sonnenuhren aus der Umgebung
- Viele Informationen zu Sonnenuhren

Für die fachliche Betreuung ist zuständig:
Prof. Dr. Heine, Tel. 04421-44526.

Sonnenuhren-Atelier Lohmühle

Malte Groh fertigt u.a. kunstvolle Sonnenuhren an, die er für die entsprechenden Orte berechnet. Seine Werkstatt befindet sich in
27793 Wildeshausen, Tel. 04431-5560.

Stained Glass Sundials From Around The World

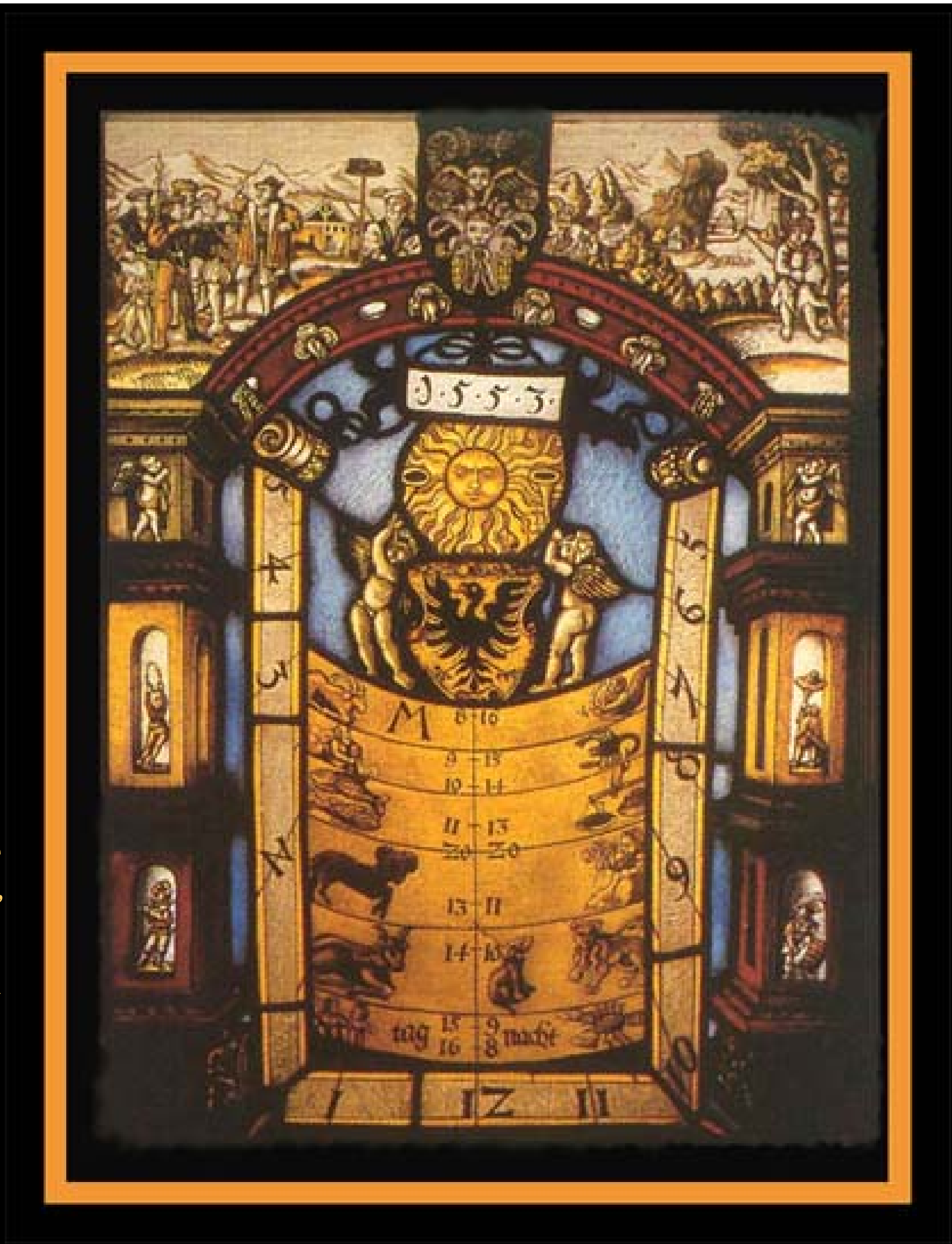
By John L. Carmichael (author) and Dave Bell (webmaster)

Website last updated 08 January, 2004

(For optimum viewing, set View to Full Screen and monitor resolution to 1024 or 1280.)

The main purpose of this not-for-profit website is to reawaken interest in these rare wonderful works of art and science with the hope that more of them will soon be constructed. We want to stimulate and promote working relationships between glass artisans, sundial designers, and the public, bringing these people together though the links on this site. With many people's generous help we collected, categorized and restored all available glass sundial images for safekeeping and included all available dial information. We developed this web page in July 2003 and we'll try to keep it updated with new information and photos you send us.

Thank you. David Bell (dbell@TheBells.net) and John Carmichael (johncarmichael@mindspring.com)



Imagine an ordinary, stained glass window with a beautiful design on it that includes a sundial face. A metal rod or sheet protrudes from the window on the outside of the building and casts a shadow on the sundial face design. You can read the correct time from inside or outside!

Stained glass sundials can be beautiful works of art that are also functional timepieces which keep the precise time. This is that rare marriage of art and science that inspires wonder among scientists, artists, and the public most of all. Sadly, few were made and many have been lost or destroyed. We have only found examples in Europe, and just a handful in The US and Canada. We haven't located any in the rest of the world. England has the most, followed by Germany, Switzerland and Italy. Most have been lost, or removed from their original locations and some now reside in museums and private collections.

The art and science of their fabrication nearly died out in the 19th century, but today's stained glass craftsman can build them almost as easily as a normal window if they have a little help with their sundial drawings. To function as accurate precision timepieces, these sundials must be custom-designed for specific locations. Both the face and shadow caster are different for different locations. A qualified sundial designer who understands all the mathematics involved, must determine the sundial part of the design in order for a stained glass sundial to function properly!

Photo Collection
Technical Information
References
Commissioning a Glass Sundial

Google Search

WWW AdvanceAssociates.com

Astronomy Picture of the Day

Discover the cosmos! Each day a different image or photograph of our fascinating universe is featured, along with a brief explanation written by a professional astronomer.

2003 December 6

Jaipur Observatory Sundial
Credit & Copyright: Tim Feresten

Explanation: Walk through these doors and up the stairs to begin your journey along a line from Jaipur, India toward the North Celestial Pole. Such cosmic alignments abound in marvelous Indian observatories where the architecture itself allows astronomical measurements. The structures were built in Jaipur and other cities in the eighteenth century by the Maharaja Jai Singh II (1686-1743). Rising about 90 feet high, this stairway actually forms a shadow caster or gnomon, part of what is still perhaps the largest sundial on planet Earth. Testaments to Jai Singh II's passion for astronomy, the design and large scale of his observatories' structures still provide impressively accurate measurements of shadows and sightings of celestial angles.

Tomorrow's picture: planetary nebula

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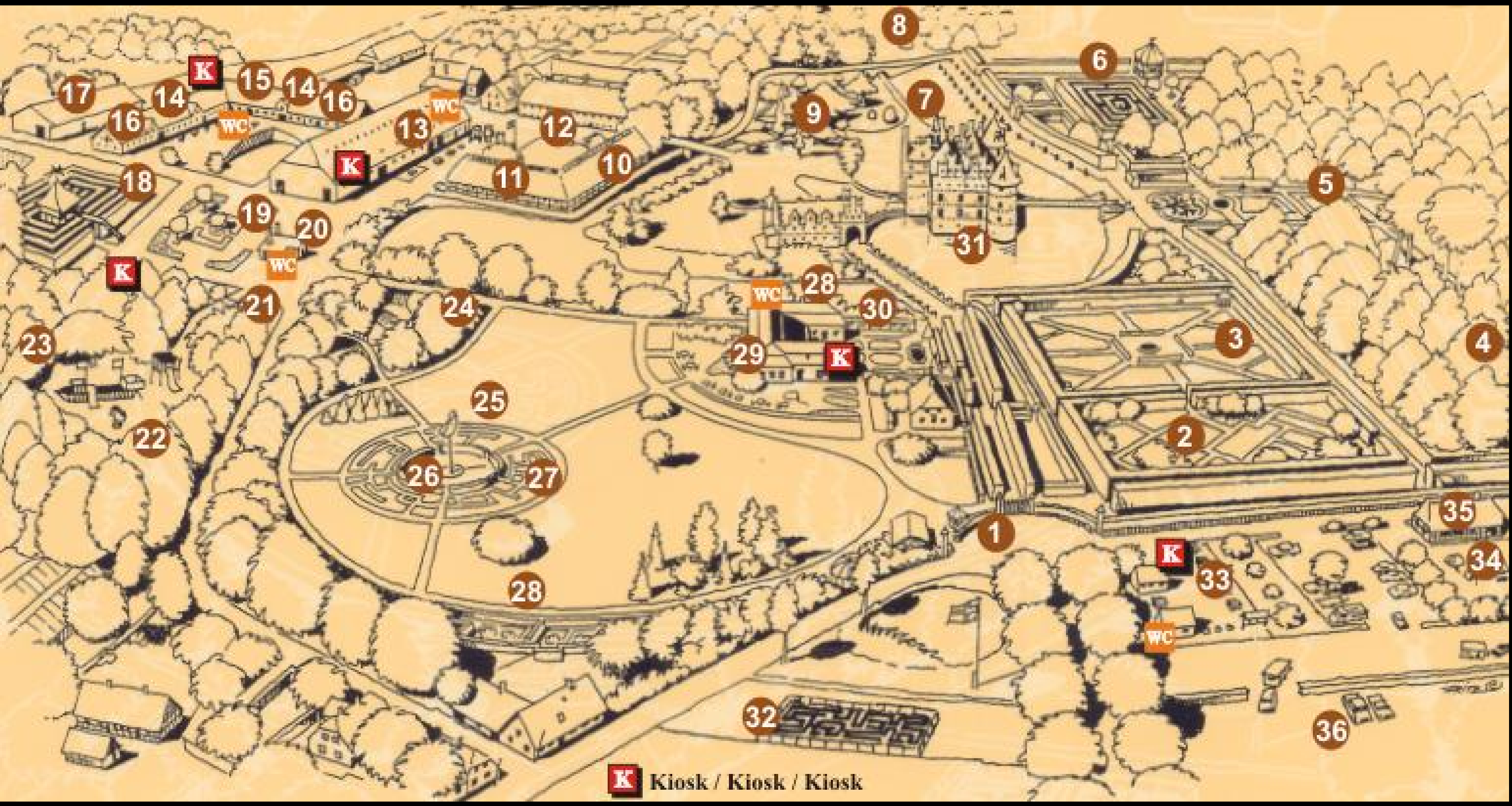
Authors & editors: Robert Nemiroff (MTU) & Jerry Bonnell (USRA)

Egeskov Sightseeing
-A Day of Adventure

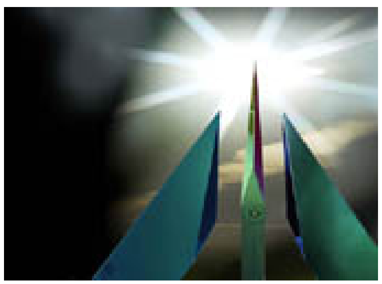
Click on the numbers or on the descriptions below in order to see more about the attractions



1. Ticket entrance
2. Fuchsia Garden
3. Kitchen Garden
4. Aviary
5. Renaissance Garden
6. The Old Maze (1730) (Closed to the public)
7. Piet Hein 's Super-ellipse
8. Deer Park
9. The English Garden
10. The Museum of Agriculture
11. The Museum of Horse-drawn Vehicles
12. Scent garden
13. The Veteran Car Museum
14. The Motor Cycle Museum
15. Draculas Crypt
16. Open stores
17. Falck Museum
18. Piet Hein's Maze
19. The Herb and Dahlia Garden
20. The Old Smithy
21. Tree Top Walking
22. Playground
23. Goat pen
24. Water Garden
25. Piet Hein's Sundial
26. Rose Garden
27. Yew Maze
28. Herbaceous Garden and The Grey Garden
29. Cafe Jomfru Rigborg
30. The White Garden
31. Egeskov Castle
32. Larch Maze
33. Plant shop
34. Camping site
35. Information
36. Car park

SEARCH Entire Website GO

NICKEL



COLOURED STAINLESS steel will be used to clad three 40-metre-high gnomons in Derbyshire, England.

SHADOWS CAST by the gnomons onto a stone piazza will indicate the time of day.

IN USE

The U.K.'s £1.2-million Solar Pyramid

This coloured stainless steel sundial will be the world's largest.
By Virginia Heffernen

Nickel magazine, February 2003 --The world's largest working sundial, a pyramid clad in "coloured" stainless steel, is expected to mark the longest day of the year when it opens on June 21st, 2004.

The 40-metre high "solar pyramid," a confluence of vertical triangular planes, will dominate the skyline adjacent to the M1 motorway in Derbyshire, England (just a few kilometres, incidentally, from where stainless steel was discovered 90 years ago by Sheffield metallurgist Harry Brearley).

The design consists of three gnomons, or planes, constructed of mild steel and inclined towards each other at an angle of 53° to create a pyramid shape. The gnomons will tell time by casting shadows across a 50-metre-wide stone and brick piazza.

What sets the sundial apart from most metal sculptures is the cladding: a mirror-polished, coloured S31600 stainless steel developed by Rimex Metals, a specialist in metal finishes and one of the sponsors of the project.

Also in this Issue

DESIGNERS Adam Walkden and Richard Swain chose nickel stainless steel for its durability, versatility and recycling potential.

THIS MODEL shows how the three gnomons form a pyramid shape. Construction is to begin in April 2003.

PDF of this article (210 kB)

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Technical Design Elements:

For more information, visit our Architecture Web Portal

NiDI technical papers:

Stainless Steel in ABC

Timeless Stainless

In Nickel Magazine:

Stainless Steel Sculpture

The designers of the solar pyramid, Adam Walkden and Richard Swain, chose the material for its durability and versatility. They also appreciate the way the mirror finish reflects the perpetual changes in land and sky.

"The illusion of colour created by the process captured our imaginations and seemed perfect for this situation," says Walkden. "The ability to silkscreen images and logos onto the material was also important," he adds.

Rimex Metals' Colourtex process does not use paints or dyes, says Rimex representative Keith Wilson, but instead takes advantage of the passive oxide layer that gives stainless steel its corrosion resistance. By immersing the steel in a hot solution of chromic and sulphuric acid, Rimex increases the thickness of this oxide layer, thereby enhancing the natural phenomenom of light interference and creating colour. For a simple analogy, imagine the colours generated when oil floats on water.

Rimex produces a range of colours, including champagne, black, blue, gold, red and green, depending on the thickness of the oxide layer. The company can also adjust the appearance of the steel from matt (dull) to lustrous by adjusting the surface texture. In any case, the steel remains colourfast, even when exposed to the elements.

The ColourTex process enhances the cladding on several other architectural projects worldwide, including the Experience Music Project in Seattle, Washington, U.S.A., a Frank Gehry design inspired by the bright hues of electric guitars. On this building, red and blue painted aluminum is interspersed with 10,000 square metres of stainless steel shingles in red and gold to create a myriad of colours designed to symbolize the energy and fluidity of music.

Walkden and Swain have selected green as the dominant colour for the solar pyramid, but hues will vary depending on the angles of natural light and the perspective of the viewer. At night, the pyramid will be illuminated. The design team is exploring the possibility of using self-generating photo voltaic cells for the lighting.

A three-dimensional, welded tube framework, assembled in a fabrication shop and then transported to the site in manageable sections, is designed to support the cladding and resist the stresses of wind loading. Each gnonom will have a piled foundation to protect the structure from ground movement.

Walkden says construction is scheduled to begin in April, 2003 and finish in time for the summer solstice on June 21st, 2004. About one third of the £1.2 million needed for the project has been contributed by sponsors. Fundraising for the remainder is ongoing, and the designers are still seeking a major sponsor interested in having the pyramid bear its name.

Green Design Elements:

How recycleable is nickel in this application? Click here.

Need some data to do a life cycle analysis for nickel in this application? Click here

Construction will be followed by British television station "Channel 5", while BBC's Blue Peter, a top children's program in the UK, will run a nationwide competition to design the seating areas at each of the 12 hour positions on the dial.

Virginia Heffernan is a Toronto-based science writer.

Photos: RIMEX METALS/ART IN THE ENVIRONMENT

MORE INFO:

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Tel: Adam (mobile) - 07939 176647
E-mail: adam@Art-E.fsnet.co.uk
Web site: www.solarpyramid.co.uk

Keith Wilson
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Fax: +44 (0) 20 8804 7275
E-mail: keithw@mail.rimex.co.uk
Web site: www.rimexmetals.com

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E-Mail:

Subject:

Message:

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Link Title:

Optional Image URL:

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NASS Message Board - Read Me

PURPOSE

The Message Board is intended to provide a forum for dialog between individuals interested in sundials. It is hoped that those with dialing knowledge or skills will respond to requests and inquiries, and contribute to the existing message threads.

CAVEAT

Inappropriate messages will be deleted. Please address remarks to the Webmaster

NOTES

- When you respond to a message, the original text will not be quoted in your composition window. You can quote by scrolling up the page to the original message, then copy and paste.

- When you post a message or reply, there is a field for your e-mail address. This field is optional. Leaving it blank will compel replies to the board where we can all share the fun.

- You are allowed to change the subject field when responding. This is encouraged in hopes it will make the replies in the thread more interesting and precise.

- A URL typed into the message body will not be an active link (clickable) as with e-mail, but it can be copied and pasted into the browser window.

- Images are included by reference to existing images on the Web. They cannot be uploaded or appended to your message as with e-mail.

  If you would like to add an illustrated message to the board and and have no way to put the images on the Web for reference - send an e-mail to the Webmaster outlining your contribution. Please do not send the images until they are requested.

Notes for those with Web space and a bit of HTML...

ADDING an IMAGE or LINK to your message

- Adding a single image or link

  - For a link, use the "Optional Link URL:" fields below the text box. The syntax is:

    http://yoursite/yourwhatever
    Important Be sure to fill in the "Link Title" - it provides the hypertext

  - For an image, use the "Optional Image URL" field
    the syntax is the same as for a link.

  - Images will appear above the message text.
    Links will appear below it.

ADDING IMAGES and LINKS in the body of your message using HTML

Allowing HTML in the body text involved some trade-offs, and it is intended to encourage the poster to illustrate his message with images and links. Please use it in good taste. The occasional underline is Ok.

* Do not use the paragraph tag - the board formats as text.
* HTML Document tags (<HTML>, <HEAD> etc.) are not required.
* The message verification does not resolve the HTML tags, so it is recommended that you test your message before posting it.

- Adding an image within the body text

  - Include the HTML <IMG> tag in the text. The syntax is:

    <IMG SRC="yoursite/yourimage">

  - The image will appear where the tag is placed in the text.

- Adding an Anchor pointing to the image in the body text.

  This method will let the readers decide whether they want to view the image. Perhaps a bit more courteous, and it will save some bandwidth.

  - Include the HTML <ANCHOR> tag in the text. The syntax is:

<A HREF="yoursite/yourimage">hypertext</A>

- The Anchor will appear where the tag is placed in the text.

- Adding an Anchor pointing to a URL in the body text uses the same syntax as images. URLs typed into the message body as text will not appear as hyperlinks, but plain text.

The NASS Message Board

[Post Message] [Read Me] [Message Board Home]

- sundial accuracy - **Josh** *1/9/2004* (2)
    - Re: sundial accuracy - **Bill Gottesman** *1/10/2004* (1)
        - URLs for the message above - **Bill Gottesman** *1/11/2004* (0)
- Small Sundials - **Bree** *1/9/2004* (1)
    - Re: Small Sundials - **Webmaster** *1/10/2004* (0)
- Advice re: Designing a Sundial - **Walter Sanford** *1/2/2004* (0)
- Sundials and ratios - **Rachel** *12/30/2003* (1)
    - Re: Sundials and ratios - **Uno Kurvet** *12/31/2003* (0)
- Registry entries #75 and #10 - **John Decker** *12/29/2003* (1)
    - Thank you! - A dial is found. - **Webmaster** *12/30/2003* (0)
- The EarthDial Project - A Golden Opportunity for NASS - **Walter Sanford** *12/7/2003* (0)
- sundial time... - **lindsey besthorn** *12/5/2003* (1)
    - Re: sundial time... - **Bill Gottesman** *12/7/2003* (0)
- Memento Mori - **Frank Mand** *11/29/2003* (4)
    - Re: Memento Mori - **Frans Maes** *1/6/2004* (0)
    - Re: Memento Mori - **Uno Kurvet** *12/1/2003* (2)
        - Re: Memento Mori - **Frank Mand** *12/1/2003* (1)
            - Re: Memento Mori - **Uno Kurvet** *12/2/2003* (0)
- Armillary Sphere Instructions - **Eric** *11/23/2003* (1)
    - Re: Armillary Sphere Instructions - **Roger Bailey** *12/5/2003* (0)
- Construction of a sundial - **Richard Westfield** *11/22/2003* (0)
- Portable Sundial - **F F** *11/19/2003* (4)
    - Re: Portable Sundial - **F F** *11/19/2003* (3)
        - Re: Portable Sundial - **John Davis** *11/20/2003* (2)
            - Re: Portable Sundial - **John Davis** *11/20/2003* (1)
                - Re: Portable Sundial - **F F** *11/22/2003* (0)
- vertical direct dial in the tropics - **Carla** *11/17/2003* (2)

- Re: vertical direct dial in the tropics - **Bill Gottesman** *11/18/2003* (1)
  - Re: Thank you Bill Gottesman - **Carla** *11/19/2003* (0)
- Help with a science fair question - **Marlon** *11/9/2003* (1)
  - Re: Help with a science fair question - **Uno Kurvet** *11/12/2003* (0)
- How best to adjust a horizontal sundial for a new latitude? - **Albert Franco** *11/3/2003* (4)
  - Re: How best to adjust a horizontal sundial for a new latitude? - **Roger Bailey** *12/5/2003* (0)
  - Re: How best to adjust a horizontal sundial for a new latitude? - **Walter Sanford** *11/6/2003* (0)
  - Re: How best to adjust a horizontal sundial for a new latitude? - **Webmaster** *11/4/2003* (1)
    - Re: How best to adjust a horizontal sundial for a new latitude? - **Albert Franco** *11/28/2003* (0)
- The Sundial Group at Yahoo Groups - **Albert Franco** *11/1/2003* (0)
- Arkansas' Sesquicentennial Sundial - **Albert Franco** *10/31/2003* (0)
- sundials - **kw** *10/29/2003* (1)
  - Re: sundials - **Uno Kurvet** *10/30/2003* (0)
- sundial question - **rayna denneler** *10/14/2003* (1)
  - Re: sundial question - **Mac Oglesby** *10/15/2003* (0)
- Length of Gnomon - **Edwin C Goodrich** *10/10/2003* (1)
  - How long should my gnomon be? - **Bob Terwilliger and Fer deVries** *10/15/2003* (0)
- Sundial location - **Glen** *10/5/2003* (1)
  - Re: Sundial location - **Webmaster** *10/10/2003* (0)

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sundial accuracy

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Posted by Josh on 1/9/2004 from 205.188.209.9:

Can you make a sundial accurate enough to read minutes? If so, how?

Follow Ups:

- Re: sundial accuracy - **Bill Gottesman** *1/10/2004* (1)
  - URLs for the message above - **Bill Gottesman** *1/11/2004* (0)

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Subject: Re: sundial accuracy

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Re: sundial accuracy

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by Bill Gottesman on 1/10/2004 from 205.188.209.9:

In reply to: sundial accuracy posted by Josh on 1/9/2004 from 205.188.209.9:

Can you make a sundial accurate enough to read minutes? If so, how?

Yes, you can. Size matters, as does alignment with the celestial north pole.

Shadows do not have have sharp edges, but rather have edges which are blurred by the width of the sun. This "blur" is 2 minutes of time wide. There are ways of overcoming the inaccuracy caused by this blur. There is such an example at . The ultimate precision I know of is in a super-specialty sundial that casts a focused cursor about 15 seconds wide, and can be seen at .

The great sundial at Jaipur, India is maybe 100 feet tall, and boasts of accuracy to 20 seconds. I have never seen it, but it would have the same "blur" problems as all shadows, and so I doubt this claim.

Bill G.

Follow Ups:

- URLs for the message above - **Bill Gottesman** *1/11/2004* (0)

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Subject: Re: sundial accuracy

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URLs for the message above

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by Bill Gottesman on 1/11/2004 from 66.245.109.172:

In reply to: Re: sundial accuracy posted by Bill Gottesman on 1/10/2004 from 205.188.209.9:

The URL's are:

www.precisionsundials.com/renaissance.htm

and

www.precisionsundials.com/sundial_list.htm

-Bill

Follow Ups:

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E-Mail:

Subject: Re: URLs for the message above

Comments:

Optional Link URL:

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Small Sundials

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by Bree on 1/9/2004 from 66.227.149.113:

Ok, here's my question: I'm trying to design a small sundial to be worn on the wrist, much like a wristwatch. I'd like to make them as authentic & functional as possible. I'm not really sure on the construction of sundials, but am eager to learn. I'd really love any and all information anyone tosses my way. I'm new to the whole thing, so I'm really quite the newbie.

Thank You!!
Bree

Follow Ups:

- Re: Small Sundials - **Webmaster** *1/10/2004* (0)

Post a Followup

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Name:

E-Mail:

Subject: Re: Small Sundials

Comments:

Optional Link URL:

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Re: Small Sundials

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by Webmaster on 1/10/2004 from 66.245.109.172:

In reply to: Small Sundials posted by Bree on 1/9/2004 from 66.227.149.113:

Take a look at the **NASS FAQ**

Follow Ups:

Post a Followup

Note: Your Followup will not appear on the board until you Reload / Refresh the page.

Name:	
E-Mail:	
Subject:	Re: Small Sundials
Comments:	
Optional Link URL:	
Link Title:	
Optional Image URL:	

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Advice re: Designing a Sundial

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by Walter Sanford on 1/2/2004 from 151.200.240.195:

I'm designing a sundial. The "foundation" of the design is a PDF file. I'm told that PDF files are vector files. Question is, can one use apps like Adobe Illustrator or DeltaCAD to open/import and manipulate a PDF file just like any other object created by a drawing program? Thanks for freely sharing your hard-earned wisdom!

Follow Ups:

Post a Followup

Note: Your Followup will not appear on the board until you Reload / Refresh the page.

Name:

E-Mail:

Subject: Re: Advice re: Designing a Sundial

Comments:

Optional Link URL:

Link Title:

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Sundials and ratios

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by Rachel on 12/30/2003 from 204.186.129.167:

As an avid science student, I have searched in books, websites, and science magazines, but still cannot find the answer to a pressing question. I was hoping you could help.

I am assuming the parts of a sundial must be proportional in order for it to properly tell the time. (If I am wrong, please do not hesitate to correct me!) For a sundial to work correctly, is there a specific ratio that must be used? For example, 1:2 or 2:3 (The first number represents the diameter of the face of the sundial, while the second represents the height of the gnomon)

I hope you can answer my question or at least direct me to some place or person that can. Thank you for your help!

Follow Ups:

- Re: Sundials and ratios - **Uno Kurvet** *12/31/2003* (0)

Post a Followup

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E-Mail:

Subject: Re: Sundials and ratios

Comments:

Optional Link URL:

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Re: Sundials and ratios

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by Uno Kurvet on 12/31/2003 from 213.35.193.138:

In reply to: Sundials and ratios posted by Rachel on 12/30/2003 from 204.186.129.167:

Dear Rachel,
in this NASS Message Board on 10/10/2003 Edwin C Goodrich posted a question: Length of Gnomon.
I can recommend you to read the answer, posted by Bob Terwilliger and Fer de Vries, posted on 10/15/2003, How long should my gnomon be?

Follow Ups:

Post a Followup

Note: Your Followup will not appear on the board until you Reload / Refresh the page.

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E-Mail:

Subject: Re: Sundials and ratios

Comments:

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Registry entries #75 and #10

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by John Decker on 12/29/2003 from 129.219.3.154:

To whom it may concern.
The Tempe #75 and #10 are one and the same, and it does still exist, after the construction. Note that the theater is just a half block west of the City Hall. The sundial is still located west of City Hall but is now a hundred feet or so south east of the Valley Arts Theater. Before the construction it was only a few feet from the SE corner of the theater.

Follow Ups:

- Thank you! - A dial is found. - **Webmaster** *12/30/2003* (0)

Post a Followup

Note: Your Followup will not appear on the board
until you Reload / Refresh the page.

Name:

E-Mail:

Subject: Re: Registry entries #75 and #10

Comments:

Optional Link URL:

Link Title:

Optional Image URL:

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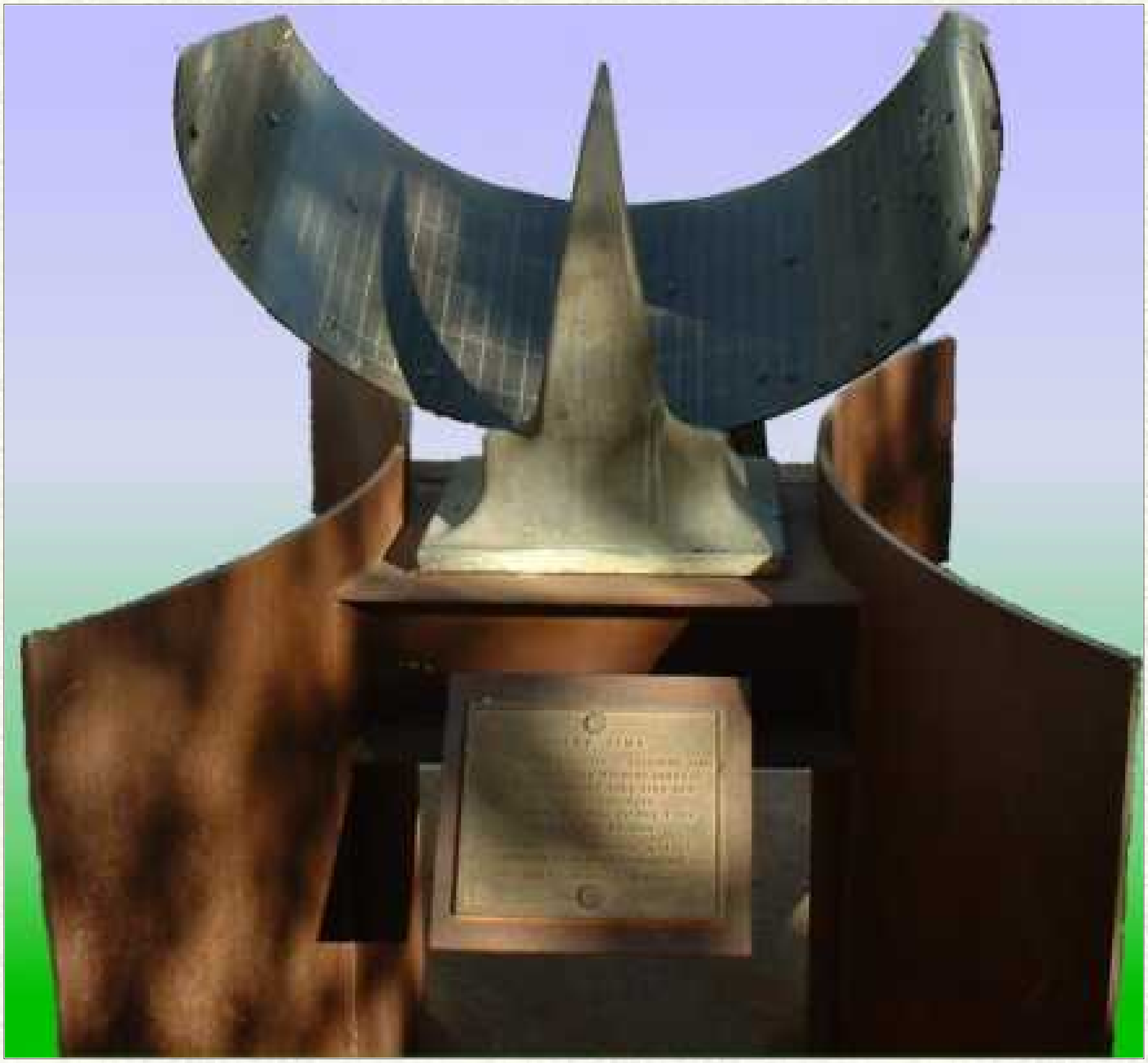
Thank you! - A dial is found.

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by Webmaster on 12/30/2003 from 66.32.127.197:

In reply to: Registry entries #75 and #10 posted by John Decker on 12/29/2003 from 129.219.3.154:



The database entry for this fine Mayall dial will be updated, then the the change will be made online.

Bob Kellogg, the NASS Registrar and I appreciate your taking the time to send us this information.

For future reference, corrections to the Register can be made by going to:

The NASS Register

and clicking on Add & Update in the right frame.

Bob Terwilliger
NASS Webmaster

Follow Ups:

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E-Mail:	
Subject:	Re: Thank you! - A dial is found.
Comments:	
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Link Title:	
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The EarthDial Project - A Golden Opportunity for NASS

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by Walter Sanford on 12/7/2003 from 141.156.174.101:

The EarthDial Project is a collaborative partnership among The Planetary Society, Bill Nye, the Science Guy and Nye Labs, and NASS member Woody Sullivan at the University of Washington. In a nutshell, the EarthDial Project will use a network of sundials around the world to show that Planet Earth is truly a magnificent timepiece!

The EarthDial Project is a golden opportunity for NASS and its members to participate in a worthwhile, high-profile educational outreach initiative. With every opportunity, there are challenges to be met. After careful thought regarding how to make the biggest impact, I issue two challenges to the NASS membership:

1. Reach out to a local school regarding participation in the EarthDial Project. Offer to share your skills & expertise by either building an EarthDial or guiding teachers/students in the construction of an EarthDial. Lend technical assistance in setting up the Webcam. Trust me, help them to get going and good teachers will take the ball and run with it!

2. Similar to John Hoy's now defunct, "You Can Make a Sundial!" Web site (http://www.grex.org/~jh/dial/), I challenge NASS members to create a new interactive Web site that will generate an on-the-fly customized EarthDial (in PDF format) given user input. (For reference, a scaled-down version of John Hoy's Web site recently resurfaced at the following URL: http://axum.tripod.com/) A large-format printer may be used to produce a larger version of the PDF'ed EarthDial (that meets project specs) that can be mounted on a base (e.g., plywood) and waterproofed. Alternatively, one may take the digital output to their friendly neighborhood print shop.

- The EarthDial Project

Follow Ups:

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Subject: Re: The EarthDial Project - A Golden Opportunity for NASS

Comments:

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Link Title:

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sundial time...

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by lindsey besthorn on 12/5/2003 from 69.4.137.101:

i was wondering, what are some reasons why the sundial time does not always agree exactly with the PST?? (assuming that the sundial is constructed and set up properly) is it simply the latitude correction, longitude correction, and 'equation of time'?? or is there more to it??

Follow Ups:

- Re: sundial time... - **Bill Gottesman** *12/7/2003* (0)

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Re: sundial time...

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by Bill Gottesman on 12/7/2003 from 64.12.96.77:

In reply to: sundial time... posted by lindsey besthorn on 12/5/2003 from 69.4.137.101:

Posted by lindsey besthorn on 12/5/2003 from 69.4.137.101:
i was wondering, what are some reasons why the sundial time does not always agree exactly with the PST?? (assuming that the sundial is constructed and set up properly) is it simply the latitude correction, longitude correction, and 'equation of time'?? or is there more to it??

That's pretty much it, and throw in Daylight Saving Time from around April to October. A properly constucted sundial, by the way, must be made (or adjusted) for the specific latitude. There is no latitude "correction" that can be easily applied to a sundial set to the wrong latitude. Longitude correction can easily be calculated and applied to the sundial's reading, or it may be incorporated into the sundial's design. The equation of time usually has to added or subtracted by the user. Only a few dials can automatically compensate for this. To view some high-tech sundials that compensate for all these factors, and read civil time directly, and with superb accuracy, see the Renaissance Focusing Sundial and the Sawyer Equant Sundial at www.precisionsundials.com.

Follow Ups:

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E-Mail:

Subject: Re: sundial time...

Comments:

Optional Link URL:

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Memento Mori

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by Frank Mand on 11/29/2003 from 24.51.48.93:

I would like to find a source for the memento mori, the aphorisms that were often inscribed upon sun dials, reflecting on the transitory nature of life/light.

I have a particular poem in mind, that these might help further, but an abiding interest as well in compiloing these.

Follow Ups:

- Re: Memento Mori - **Frans Maes** *1/6/2004* (0)
- Re: Memento Mori - **Uno Kurvet** *12/1/2003* (2)
    - Re: Memento Mori - **Frank Mand** *12/1/2003* (1)
        - Re: Memento Mori - **Uno Kurvet** *12/2/2003* (0)

Post a Followup

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Name:

E-Mail:

Subject: Re: Memento Mori

Comments:

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Link Title:

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Re: Memento Mori

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by Frans Maes on 1/6/2004 from 129.125.157.67:

In reply to: Memento Mori posted by Frank Mand on 11/29/2003 from 24.51.48.93:

Hi Frank,

A search through Daniel Roth's list of sundial links on "mottoes" gives 3 sites, an Italian, a French and a British. The first two have also Latin mottoes.

Hope this helps,
Frans

- Daniel Roth's sundial links

Follow Ups:

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Re: Memento Mori

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by Uno Kurvet on 12/1/2003 from 213.35.193.138:

In reply to: Memento Mori posted by Frank Mand on 11/29/2003 from 24.51.48.93:

"Memento mori" is in Latin and is very ancient. It means literally, "remember that you must die".

Follow Ups:

- Re: Memento Mori - **Frank Mand** *12/1/2003* (1)
  - Re: Memento Mori - **Uno Kurvet** *12/2/2003* (0)

Post a Followup

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Name:

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Subject: Re: Memento Mori

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Re: Memento Mori

Posted by Frank Mand on 12/1/2003 from 24.51.48.93:

In reply to: Re: Memento Mori posted by Uno Kurvet on 12/1/2003 from 213.35.193.138:

Yes, I understand the meaning of memento mori - but what I need is a source for those specifically inscribed upon sundials: they usually address themselves to the fleeting light/hours of life, oftentimes in Latin.

I have uncovered a small source -the UK sundial site, but would like a book, or online site, where I might find numerous examples.

A colleague recently sent me "forsan et haec olim meminisse juvabit.", attributed to Virgil's Aeneid, which translates as "Perhaps this too will be a pleasure to look back upon one day". It was the inscription in a sundial at the Flamingo Gardens of Nassau, Bahama. It is however, not the kind I am looking for (as it has no reference to light, the sundial, etc.)

Let me know if you can, or ask around. Thanks

Main Entry: fors·an et haec olim me·mi·nis·se ju·va·bit
Pronunciation: "for-"sän-"et-'hIk-"O-lim-"me-mi-'ni-se-yu-'wä-bit
Usage: foreign term
Etymology: Latin
: perhaps this too will be a pleasure to look back on one day

Follow Ups:

- Re: Memento Mori - **Uno Kurvet** *12/2/2003* (0)

Post a Followup

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Comments:

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Re: Memento Mori

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by Uno Kurvet on 12/2/2003 from 213.35.193.138:

In reply to: Re: Memento Mori posted by Frank Mand on 12/1/2003 from 24.51.48.93:

Hi Frank, I do understand you problem now. I recommend you to use
www.google.com
Insert: sundial mottoes
and you will have a lot of them, also books will be listed.

Follow Ups:

Post a Followup

Note: Your Followup will not appear on the board until you Reload / Refresh the page.

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E-Mail:	
Subject:	Re: Memento Mori
Comments:	
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Armillary Sphere Instructions

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by Eric on 11/23/2003 from 67.8.121.39:

I purchased an Armillary sphere at a yard sale. I am not sure if it is decorative or functional. Besides the horizon and ecelptic rings, it has two inner rings, one with a sun shape (no appearant function), and the inner most has a solid sphere on an inclined rod and has a ?moon? shape on it.
I have Waugh's Sundial book but does not help. My sphere does not have the standard gnomon through the poles but has the inclined rod on the inner ring.
Does anyone have suggestions?
Thank You

Follow Ups:

- Re: Armillary Sphere Instructions - **Roger Bailey** *12/5/2003* (0)

Post a Followup

Note: Your Followup will not appear on the board until you Reload / Refresh the page.

Name:

E-Mail:

Subject: Re: Armillary Sphere Instructions

Comments:

Optional Link URL:

Link Title:

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Re: Armillary Sphere Instructions

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by Roger Bailey on 12/5/2003 from 206.116.255.92:

In reply to: Armillary Sphere Instructions posted by Eric on 11/23/2003 from 67.8.121.39:

I was also perplexed about armillary spheres. My research on the topic was condensed to a presentation that I gave at the NASS conference in Montreal in 2001. The presentation contains a lot of pictures so the Powerpoint file version is too large to send with email but I can send the 1.38 MB pdf version on request.

Roger Bailey
NASS Secretary
Walking Shadow Designs
N 48.6 W 123.4

Follow Ups:

Post a Followup

Note: Your Followup will not appear on the board
until you Reload / Refresh the page.

Name:

E-Mail:

Subject: Re: Armillary Sphere Instructions

Comments:

Optional Link URL:

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Construction of a sundial

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by Richard Westfield on 11/22/2003 from 67.25.32.111:

I am a business student at Belmont University in Nashville, Tennessee. (Latitude 36.169,Longitude-86.724)I need to construct sundial for a Physics class. Can someone send me instructions?

Follow Ups:

Post a Followup

Note: Your Followup will not appear on the board until you Reload / Refresh the page.

Name:

E-Mail:

Subject: Re: Construction of a sundial

Comments:

Optional Link URL:

Link Title:

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Portable Sundial

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by F F on 11/19/2003 from 68.160.228.245:

Hi,

Mi grandfather built a portable sundial long time ago. He now retired to his home country and wishes to build another one. He called me [from spain] today asking me to use the internet to find the instructions on how to build it. I am very good at searching anything on the net, but on this I'm stumped!

Here's the info he gave me. Bear in mind he's 90 years old so can't tell if this is accurate info or not. So:

This device was published in 1630 by a Jesuit Monk? named Francois Rigaut.
It consists of a 20cmx15cm cardboard with curves drawn on it where a string marks a spot depicting the time. The angle of the string varies when the shadow of a small piece at the edge of the cardboard casts a shadow on a predetermined spot. The curves are drawn in relationship to the latitude of the observer and has details pertaining the months of the year.

I hope someone understood what I tried to explain and can provide me with some info.
In particular I would like to know what denomination does this type of sundial have.

Thanks,

Fernando -
NYC

Follow Ups:

- Re: Portable Sundial - **F F** *11/19/2003* (3)
  - Re: Portable Sundial - **John Davis** *11/20/2003* (2)
    - Re: Portable Sundial - **John Davis** *11/20/2003* (1)
      - Re: Portable Sundial - **F F** *11/22/2003* (0)

Post a Followup

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E-Mail:

Subject: Re: Portable Sundial

Comments:

Optional Link URL:

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Re: Portable Sundial

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by F F on 11/19/2003 from 68.160.228.245:

In reply to: Portable Sundial posted by F F on 11/19/2003 from 68.160.228.245:

ok, I found some information about this.
The name is Rigaud De Saint and he was a Capuchin Monk.
The device is a "Capuchin Sundial" or a "Sailing Wooden Shoe".
I also found a couple of explanatory websites but the better one is in swedish. Seems like altavista/google can't translate swedish :(.
Thanks to all.

Follow Ups:

- Re: Portable Sundial - **John Davis** *11/20/2003* (2)
  - Re: Portable Sundial - **John Davis** *11/20/2003* (1)
    - Re: Portable Sundial - **F F** *11/22/2003* (0)

Post a Followup

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E-Mail:

Subject: Re: Portable Sundial

Comments:

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Re: Portable Sundial

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by John Davis on 11/20/2003 from 213.122.11.136:

In reply to: Re: Portable Sundial posted by F F on 11/19/2003 from 68.160.228.245:

Hi Fernando,

You can see a brass capuchin dial on my website (below). Follow the links to Portable Dials.

Follow Ups:

- Re: Portable Sundial - **John Davis** *11/20/2003* (1)
  - Re: Portable Sundial - **F F** *11/22/2003* (0)

Post a Followup

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Name:

E-Mail:

Subject: Re: Portable Sundial

Comments:

Optional Link URL:

Link Title:

Optional Image URL:

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Re: Portable Sundial

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by John Davis on 11/20/2003 from 213.122.11.136:

In reply to: Re: Portable Sundial posted by John Davis on 11/20/2003 from 213.122.11.136:

The URL did not get posted for some reason. It is

www.flowton-dials.co.uk

Follow Ups:

- Re: Portable Sundial - **F F** *11/22/2003* (0)

Post a Followup

Note: Your Followup will not appear on the board until you Reload / Refresh the page.

Name:

E-Mail:

Subject: Re: Portable Sundial

Comments:

Optional Link URL:

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Re: Portable Sundial

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by F F on 11/22/2003 from 68.160.228.245:

In reply to: Re: Portable Sundial posted by John Davis on 11/20/2003 from 213.122.11.136:

Thanks a lot.
I printed your webpage and sent it along with instructions I found on the net. Too bad he can't remember how to use the computer/web.

Follow Ups:

Post a Followup

Note: Your Followup will not appear on the board until you Reload / Refresh the page.

Name:

E-Mail:

Subject: Re: Portable Sundial

Comments:

Optional Link URL:

Link Title:

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vertical direct dial in the tropics

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by Carla on 11/17/2003 from 200.94.236.55:

How do I determine the exact times of day that the sun will be due east, then west, on various dates during the spring and summer, so that I can then determine for those dates what range of hours will register on each face, north and south, of a vertical direct dial at a latitude of 20 deg 55 min north? I understand how to adjust for longitude, also for the Equation of Time if necessary.

Follow Ups:

- Re: vertical direct dial in the tropics - **Bill Gottesman** *11/18/2003* (1)
  - Re: Thank you Bill Gottesman - **Carla** *11/19/2003* (0)

Post a Followup

Note: Your Followup will not appear on the board until you Reload / Refresh the page.

Name:

E-Mail:

Subject: Re: vertical direct dial in the tropics

Comments:

Optional Link URL:

Link Title:

Optional Image URL:

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Re: vertical direct dial in the tropics

Posted by Bill Gottesman on 11/18/2003 from 205.188.209.9:

In reply to: vertical direct dial in the tropics posted by Carla on 11/17/2003 from 200.94.236.55:

I wrote a program, Cardinaldirections.exe, which tells you the exact times that the sun is east/west/north/south at a given location on a given date. It is free at www.precisionsundials.com/software.htm

-Bill Gottesman

Follow Ups:

- Re: Thank you Bill Gottesman - **Carla** *11/19/2003* (0)

Post a Followup

Note: Your Followup will not appear on the board until you Reload / Refresh the page.

Name:

E-Mail:

Subject: Re: vertical direct dial in the tropics

Comments:

Optional Link URL:

Link Title:

Optional Image URL:

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[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Re: Thank you Bill Gottesman

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by Carla on 11/19/2003 from 148.233.93.62:

In reply to: Re: vertical direct dial in the tropics posted by Bill Gottesman on 11/18/2003 from 205.188.209.9:

Thank you. Your program is perfect for my needs and very much appreciated.

Follow Ups:

Post a Followup

Note: Your Followup will not appear on the board
until you Reload / Refresh the page.

Name:	
E-Mail:	
Subject:	Re: Thank you Bill Gottesman
Comments:	
Optional Link URL:	
Link Title:	
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Help with a science fair question

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by Marlon on 11/9/2003 from 64.81.204.208:

I am a student at a middle school doing a science fair question. I need an interview as part of my research. well, ill get strait to the point. What IS a sundial? How is it affected by night? What happens at daylight sayings? what happens when a month, 6 months or a year passes? it would be very nice if one of you answered at least on of my questions. thenk you for your help.

Follow Ups:

- Re: Help with a science fair question - **Uno Kurvet** *11/12/2003* (0)

Post a Followup

Note: Your Followup will not appear on the board until you Reload / Refresh the page.

Name:

E-Mail:

Subject: Re: Help with a science fair question

Comments:

Optional Link URL:

Link Title:

Optional Image URL:

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Re: Help with a science fair question

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by Uno Kurvet on 11/12/2003 from 213.35.193.138:

In reply to: Help with a science fair question posted by Marlon on 11/9/2003 from 64.81.204.208:

How about looking the FAQ section of this page.

Follow Ups:

Post a Followup

Note: Your Followup will not appear on the board until you Reload / Refresh the page.

Name:

E-Mail:

Subject: Re: Help with a science fair question

Comments:

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How best to adjust a horizontal sundial for a new latitude?

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by Albert Franco on 11/3/2003 from 216.150.107.220:

In the NASS Sundial Registry, under California, San Francisco, I found this text:

San Francisco #420 (Updated 09-00)
Location: Shakespeare Garden, Golden Gate Park
Remarks: A small 10-inch cast iron dial from England honors Shakespeare in a garden of the same name. The dial is on a small pedestal in the middle of the courtyard walkway and surrounded by trees. Lovely, but many shadows pass over the dial during the day. The dial plate was made for latitude 54 degrees. The gnomon appears to have been cut down to accommodate the 38 degrees for San Francisco. This "hack" method of correcting a sundial does not yield correct time.

My question: If the gnomen were re-cast or otherwise resotred to the original 54 degrees, would it then be possible to simply tilt the sundial downward on the north end by 16 degrees so the gnomen pointed at the Pole Star?

It seems to me that doing so would refurbish the dial to it's original design, and also place the dial in the same orientation in regards to the sun as it was in it's original home. In effect, I'm thinking that we can act as though the earth doesn't exist, and focus on aligning the dial in relation to the Sun. I'm fairly new to sundials, and I may be missing something. I would appreciate feedback for my own knowledge.

Thank you,

Albert Franco
alfranco584@yahoo.com

- NASS Sundial Registry

Follow Ups:

- Re: How best to adjust a horizontal sundial for a new latitude? - **Roger Bailey** *12/5/2003* (0)
- Re: How best to adjust a horizontal sundial for a new latitude? - **Walter Sanford** *11/6/2003* (0)
- Re: How best to adjust a horizontal sundial for a new latitude? - **Webmaster** *11/4/2003* (1)
  - Re: How best to adjust a horizontal sundial for a new latitude? - **Albert Franco** *11/28/2003* (0)

Post a Followup

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Name:

E-Mail:

Subject: Re: How best to adjust a horizontal sundial for a new latitude?

Comments:

Optional Link URL:

Link Title:

Optional Image URL:

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Re: How best to adjust a horizontal sundial for a new latitude?

Posted by Roger Bailey on 12/5/2003 from 206.116.255.92:

In reply to: How best to adjust a horizontal sundial for a new latitude? posted by Albert Franco on 11/3/2003 from 216.150.107.220:

I had the same problem when fixing a dial designed for 42 degrees but installed at 51 degrees. I presented the error analysis of this dial at the NASS conference in Banff this year. The PowerPoint file is too large to send as an email attachment but the pdf version, a 255kb file, is available on request. The mathematical basis is from Fred Sawyer's Compendium article 1-4, Dec 1994.

My conclusions were:
1. The errors are large, over an hour at mid mornng and afternoon, and should be corrected
2.Tilt the dial. This gives an ugly but exact solution.
3.Replace the gnomon with one for the new latitude and use the old dial plate. This cuts the error in half.
4. Rebuild the dial. This is what I did for the NASS 10th Anniversary dial, the Child Find "Sundial of Hope" in Riley Park in Calgary Alberta.

The Banff Retrospective in the latest compendium has notes and pictures of "First Shadow" ceremony commemorating the new dial.

Roger Bailey

Follow Ups:

Post a Followup

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Comments:

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Re: How best to adjust a horizontal sundial for a new latitude?

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by Walter Sanford on 11/6/2003 from 138.88.150.128:

In reply to: How best to adjust a horizontal sundial for a new latitude? posted by Albert Franco on 11/3/2003 from 216.150.107.220:

Albert,

Visit the NASA "How Sundials Work" Web page. Take a look at the applet that shows the relationship between latitude and the hour line angles of a horizontal sundial. Conclusion: if you change the gnomon angle, then you must change the hour line angles as well.

P.S. - I share your endorsement of the use of equatorial sundials in education (as per your posting in "The Sundial Group"). Referring to the same applet, note that if you increase the latitude to 90 degrees (manually enter the number 90, then press enter), then you should see that at the poles a horizontal sundial effectively becomes an equatorial sundial. Cool, figuratively & literally!

- NASA How Sundials Work

Follow Ups:

Post a Followup

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Subject: Re: How best to adjust a horizontal sundial for a new latitude?

Comments:

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Re: How best to adjust a horizontal sundial for a new latitude?

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by Webmaster on 11/4/2003 from 66.245.25.132:

In reply to: How best to adjust a horizontal sundial for a new latitude? posted by Albert Franco on 11/3/2003 from 216.150.107.220:

Please see the NASS FAQ

Click on:
3. I have a sundial. How do I set it up?

Then: **Correcting a dial to your latitude**

Follow Ups:

- Re: How best to adjust a horizontal sundial for a new latitude? - **Albert Franco** *11/28/2003* (0)

Post a Followup

Note: Your Followup will not appear on the board until you Reload / Refresh the page.

Name:

E-Mail:

Subject: Re: How best to adjust a horizontal sundial for a new latitude?

Comments:

Optional Link URL:

Link Title:

Optional Image URL:

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Re: How best to adjust a horizontal sundial for a new latitude?

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by Albert Franco on 11/28/2003 from 216.150.107.161:

In reply to: Re: How best to adjust a horizontal sundial for a new latitude? posted by Webmaster on 11/4/2003 from 66.245.25.132:

I saw the online info at NASS FAQ page; it is a very useful page. But for a newbie such as myself, it is best to run ideas past actual people. If I have a misunderstanding in my logic, then reading the page wouldn't help. Thank you for the responses.

I wonder if anyone has mentioned this fix to the people in San Francisco? They may be very interested in restoring the sundial to its original state, as well as to working order.

Happy Holidays,

Albert Franco

=================
Dial in question:

San Francisco #420 (Updated 09-00)
Location: Shakespeare Garden, Golden Gate Park
Remarks: A small 10-inch cast iron dial from England honors Shakespeare in a garden of the same name. The dial is on a small pedestal in the middle of the courtyard walkway and surrounded by trees. Lovely, but many shadows pass over the dial during the day. The dial plate was made for latitude 54 degrees. The gnomon appears to have been cut down to accommodate the 38 degrees for San Francisco. This "hack" method of correcting a sundial does not yield correct time.

- NASS Registry of sundials in California

Follow Ups:

Post a Followup

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Subject: Re: How best to adjust a horizontal sundial for a new latitude?

Comments:

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The Sundial Group at Yahoo Groups

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by Albert Franco on 11/1/2003 from 216.150.107.224:

I've created a new Yahoo Group called The Sundial Group:
http://groups.yahoo.com/group/thesundialgroup/

It is not intended to detract from or compete with this message board or the world's sundial societies in any way. I had been trying to find a group or message board about sundials, and I only found two: an MSN Group that had 10 people and no postings or links, and a Yahoo Group called "sundial" that has thousands of messages archived, but is not active. I feel that a Yahoo Group is one more place that a newbie to sundials may stumble upon the information they need and links to the other sundial sites online.

There is a chat option (if enough interested people sign up, we can schedule a monthly chat or something to that effect), links, storage for files and photos, a database section (may be useful for creating a database of the world's sundials. If I ever travel somewhere, it would be nice to have one location to check for sundials in the region), a calendar section, etc.

When a member posts a message, his or her e-mail address is not displayed. It is only displayed when the member decides to send a message directly to an individual--and then it's only displayed to that individual.

I've already added a list of links and folders for links, to help keep it organized and easy to find information by subject.

All permissions (posting, creating links, uploading files and photos) are open to members, and reading the archived messages is open to the public to encourage newbies to apply if they happen upon the site.

I'm really hoping that a group of people will work together to make this a world-wide group with relevant information that is organized and searchable. This group can be one way to tie together different sundial societies and organizations around the world.

Anyone interested?

- The Sundial Group

Follow Ups:

Post a Followup

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E-Mail:	
Subject:	Re: The Sundial Group at Yahoo Groups
Comments:	
Optional Link URL:	
Link Title:	
Optional Image URL:	

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[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Arkansas' Sesquicentennial Sundial

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by Albert Franco on 10/31/2003 from 216.150.106.186:

I happened across the linked website one day, and it piqued my interest. If anyone has any information as to the current status of the sundial, I would appreciate an update. Here's a quote from my little website as to why I'm interested:

The Arkansas' Sesquicentennial Sundial was formerly the world's largest horizontal sundial. It was made using stones from around the world. The stones came from interesting and historically significant places such as Anne Frank's house, the Library of Athens, a piece of rubble from Soweto, the Tower of London, a couple of parliament buildings, the pyramids of Mexico, the Vatican and the Great Wall of China. The linked web site explains that it had to be disassembled. I haven't been able to find out what it's current status is. If anyone out there knows, please send me an e-mail.

Albert Franco
alfranco584@yahoo.com
http://www.geocities.com/alfranco584/Sundials_Page.html

- Arkansas' Sesquicentennial Sundial website

Follow Ups:

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sundials

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Posted by kw on 10/29/2003 from 159.134.150.105:

how do sundials work?

Follow Ups:

- Re: sundials - **Uno Kurvet** *10/30/2003* (0)

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Re: sundials

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Posted by Uno Kurvet on 10/30/2003 from 213.35.193.138:

In reply to: sundials posted by kw on 10/29/2003 from 159.134.150.105:

See the F.A.Q. section. The link is on the main page.

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Note: Your Followup will not appear on the board
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Comments:

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sundial question

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Posted by rayna denneler on 10/14/2003 from 152.163.252.164:

Would the numbers on a sundial in the northern hemisphere be in the same direction as in the southern hemisphere? why?

Follow Ups:

- Re: sundial question - **Mac Oglesby** *10/15/2003* (0)

Post a Followup

Note: Your Followup will not appear on the board until you Reload / Refresh the page.

Name:

E-Mail:

Subject: Re: sundial question

Comments:

Optional Link URL:

Link Title:

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Re: sundial question

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by Mac Oglesby on 10/15/2003 from 209.198.114.22:

In reply to: sundial question posted by rayna denneler on 10/14/2003 from 152.163.252.164:

Consider two common horizontal garden sundials, properly designed and installed at latitude 40° in each hemisphere. If you view the north dial with your back to the midday sun, east is to your right, so the morning shadows fall on the left part of the dial, and the hour lines are numbered to increase in a clockwise direction. If you view the south dial with your back to the midday sun, east is to your left, the morning shadows fall on the right side of the dial, and the hour numbers must increase in a counter-clockwise direction.

I hope this helps.

Follow Ups:

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Note: Your Followup will not appear on the board until you Reload / Refresh the page.

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Subject: Re: sundial question

Comments:

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Length of Gnomon

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by Edwin C Goodrich on 10/10/2003 from 66.82.9.43:

I have a stone sun dial, 6 sides, 14 inches per side, 23 3/4 inches wide and 27 1/2 inches long that I am building. How do I calculate the length of the gnomon? Is it a porportion of the length of the sun dial or is there a formula that I haven't seen yet. Any help will be appreciated, Thanks Ed.

Follow Ups:

- How long should my gnomon be? - **Bob Terwilliger and Fer deVries** *10/15/2003* (0)

Post a Followup

Note: Your Followup will not appear on the board until you Reload / Refresh the page.

Name:	
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Comments:	
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How long should my gnomon be?

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by Bob Terwilliger and Fer deVries on 10/15/2003 from 66.245.114.97:

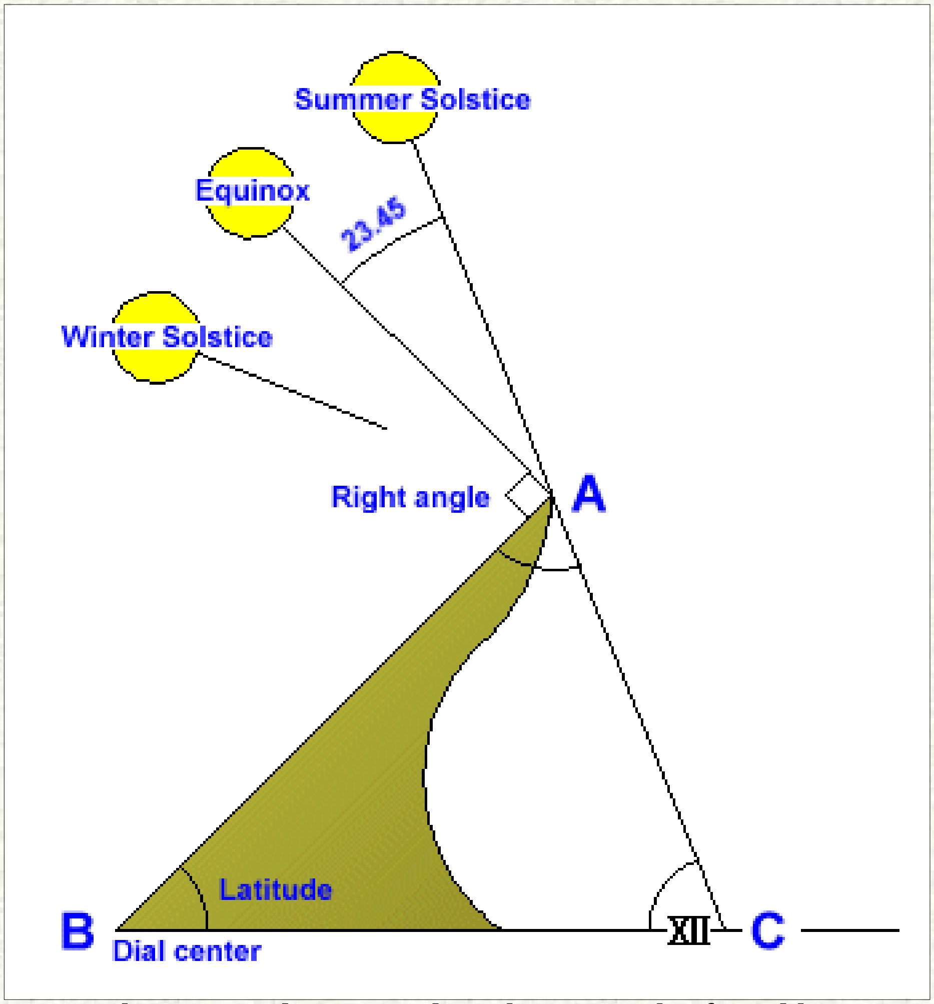
In reply to: Length of Gnomon posted by Edwin C Goodrich on 10/10/2003 from 66.82.9.43:

How long should my gnomon be?

The shortest shadow your gnomon will cast will be at solar noon on the summer solstice. The length of your gnomon is dependent on your latitude and the distance between the center of your dial and the numeral or indication that you require to be in shadow at solar noon.

No doubt you will wish all indications to lie in the shadow of the gnomon on every day of the year. The minimum length of the gnomon to meet this condition is shown by the relationship of the dial center at **B** to the symbol **XII** in the sketch below. Note that **XII** is closer to the dial center than the projection of the shadow on the summer solstice. i.e. The value for **BC** must be long enough to completely shade the numeral or indication.

A horizontal dial in the northern hemisphere



The required gnomon length **BA** can be found by experimenting with the angles in the sketch, or by a formula which solves the triangle **ABC**.

The angle at A is: 90 - 23.45 = **66.55**

The angle at C is: **180 - B - 66.55**

Then by the law of sines:
Side **BA / sin C = BC / sin 66.55**

Sin 66.5 = .91706

$$BA = \frac{BC \times Sin\ (180 - B - 66.55)}{.91706}$$

In some cases the minimum condition may seem somewhat extreme, and your aesthetic sense may suggest that the gnomon should be longer for appearance sake. Don't be concerned, shadows are never wasted.

Follow Ups:

Post a Followup

Note: Your Followup will not appear on the board until you Reload / Refresh the page.

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E-Mail:

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Optional Image URL:

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Sundial location

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by Glen on 10/5/2003 from 64.12.96.77:

In which direction should a sundial be facing when placed in one's backyard? Thanks.

Follow Ups:

- Re: Sundial location - **Webmaster** *10/10/2003* (0)

Post a Followup

Note: Your Followup will not appear on the board until you Reload / Refresh the page.

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E-Mail:

Subject: Re: Sundial location

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Re: Sundial location

[Followups] [Post Followup] [Post Message] [Read Me] [Message Board Home]

Posted by Webmaster on 10/10/2003 from 66.245.78.5:

In reply to: Sundial location posted by Glen on 10/5/2003 from 64.12.96.77:

Please see the NASS FAQ

Click on:
3. I have a sundial. How do I set it up?

Follow Ups:

Post a Followup

Note: Your Followup will not appear on the board until you Reload / Refresh the page.

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| [Decorative Sundials] | [Jahreskalender] |
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"Very Cool... Thanks so much for such a great sundial!"
Deborah O. - Omak, WA

A sundial has to be custom-made for a specific latitude & longitude (which we find from a street address) and time zone to display real clock time. See details, drawings and examples of what must go into accurate sundial design by clicking here.

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NASS PUBLICATIONS

The Compendium

The Society produces a quarterly journal in both print and digital formats. The digital is in PDF format. The content of the print and digital editions is essentially the same, but the digital edition may include programs and other features of interest to computer users. Scroll down for a complete listing of ***Compendium*** back issues and their contents.

A sample copy of the PDF version. Adobe Acrobat Required.

ShadowCatchers

ShadowCatchers A new series of digital reprints of rare works on dialing

The Repository

The NASS Repository. A treasure trove of dialing material on a single CD !

The Dialist's Companion

The Dialist's Companion A computer program written especially for dialists.
Follow the link for a complete overview and a summary of the data elements presented. The program has been released to non-members as shareware and can be downloaded.

The Analemmatic Sundial Sourcebook

The Analemmatic Sundial Sourcebook (PDF) NASS' 10th anniversary festschrift publication
Pre-publication orders terminated December 1, 2003. This publication is no longer availabile as described in the PDF.

Publications Order Form

The Publications Order Form includes a complete list of these, and other NASS publications and instructions for ordering.

If you have questions or comments about editorial matters,
Email the NASS Editor, Frederick W. Sawyer.

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Volume 7 Number 1 March 2000 ISSN 1074-3197

The Compendium*

Journal of the North American Sundial Society

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Cover Photo

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The presence of both light and dark are necessary to seeing.

- Carol K. Anthony

---

* *Compendium... "giving the sense and substance of the topic within small compass." In dialing, a compendium is a single instrument incorporating a variety of dial types and ancillary tools.*

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1638, by SAMUEL FOSTER, then Professor of Astronomie in Gresham Colledge. The Second Edition, With several Additions and Variations of the Authors, deduced from his own Manuscript. With a SUPPLEMENT, Performing all the Instrumental Work of the Quadrant, by Calculation. By help of the Canons of Sines and Tangents, which of all ways is the most Exact. By WILLIAM LEYBOURN Philomath. LONDON, Printed by J.R. for Francis Eglesfield at the Marygold in St. Pauls Churchyard. 1675. (60 pages, 0.8 MB)

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Volume III. William Emerson. Dialling. or The Art of Drawing Dials, on All Sorts of Planes Whatsoever. In Three Parts. Sect. I. The fundamental Principles of Dialling. Sect. II. The Practice of Dialling, illustrated on all sorts of Planes. Sect. III. Of describing the common Furniture of Dials; and the Construction of some useful Dials of other kinds. London. Printed for J. Nourse, in the Strand; Bookseller in Ordinary to his Majesty, 1770. (206 pages, 10.7 MB)

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Volume IIII. Gilbert Clerke. The Spot-Dial, Very useful to shew the Hour within the House. Together with Directions how to find a true Meridian, the Azymuth and Declination; and how to draw a Dial upon a Staff, upon the Cieling, upon any Pillar or Globe. Never Before Published. By Gilbert Clerke. London, Printed by J.M. for Walter Kettilby at the Bishop's-Head in St. Paul's Churchyard, 1687. (30 pages, 1.3 MB)

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The British Sundial Society Sundial Glossary - This glossary of more than 500 terms relating to sundials includes definitions, cross-links, equations and the beginnings of a chronology. Over 50 of the main entries have been linked to more detailed articles available elsewhere on the CD, thus providing the option to choose between a brief definition and a detailed account. (copyright BSS/John Davis)

Cyclopædic Diallist - The comprehensive treatise on dialing by Henry Meikle which appeared in the Eighth Edition (1852-1860) of the Encyclopædia Britannica. The work is augmented by excerpts from the work of Hugh Godfray in the Ninth Edition (1875-1879), and further augmented by extracts from a lecture (1770) by James Ferguson. This compilation is presented here for the first time with annotation, modern mathematical formulation and additional material by Fred Sawyer.

Sciatheric Notes - I - A collection of Fred Sawyer's articles that appeared in the Bulletin of The British Sundial Society in the years 1991 to 1997. The book contains a brief introduction and review of the articles by Fred and a foreword by Charles K. Aked. Charles observes: "These articles are of real importance in the published work on dialling and essential reading for all who wish a deeper understanding of the fundamentals of dialling.... It is an honour to prepare a Foreword to this jewel of a collection of articles."

Dialling Universal by George Serle - A NASS edition of this 1657 book - the first to introduce a comprehensive set of dialing scales on a ruler. The booklet was edited and annotated by Fred Sawyer, and it introduces what

James Ferguson called "the easiest of all mechanical methods, and by much the best." The book itself serves both as an instruction manual and as a discussion on the theory of dialing scales.

Dialing Software - The digital bonuses that NASS has distributed with The Compendium, as well as some new material. Some of the more significant programs include Zonwvlak (with a manual, full discussion of equations, and a beta copy of the new Windows Zonwvlak 2000), The Dialist's Companion, Ferrari's Sund98p, Blateyron's freeware program Shadows, Sonderegger's Sonne, and an interesting new program Helioscope by Tom Kreyche.

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Section II The Historical Period

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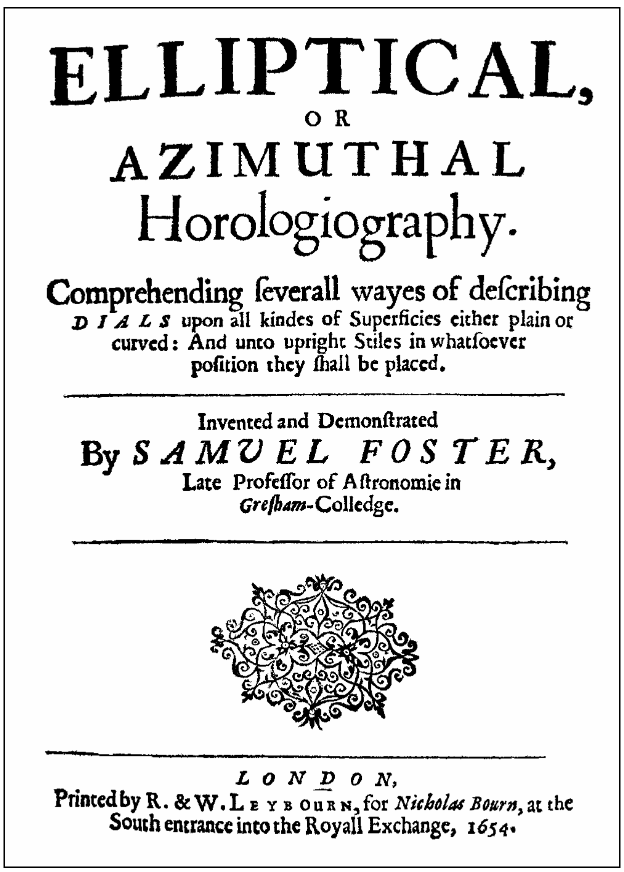

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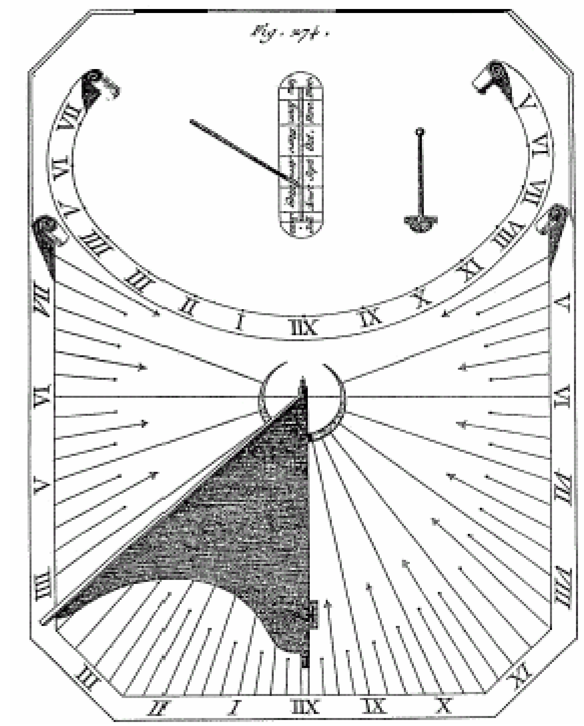

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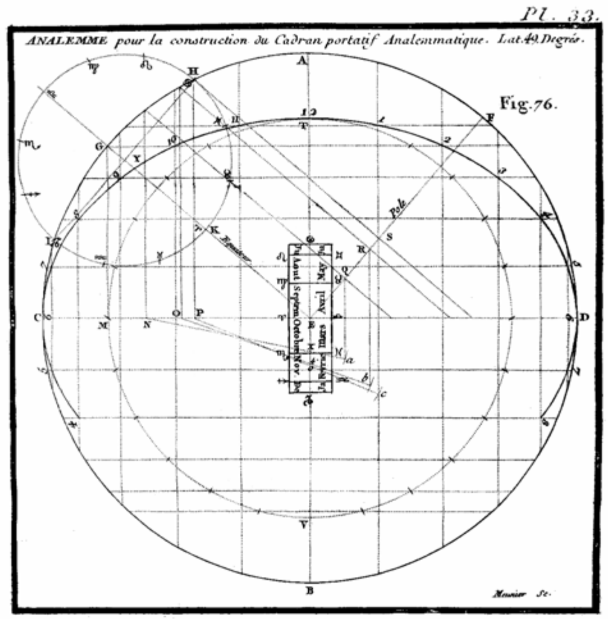

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22 Meikle, 1852. ***Dials with variable centres.***

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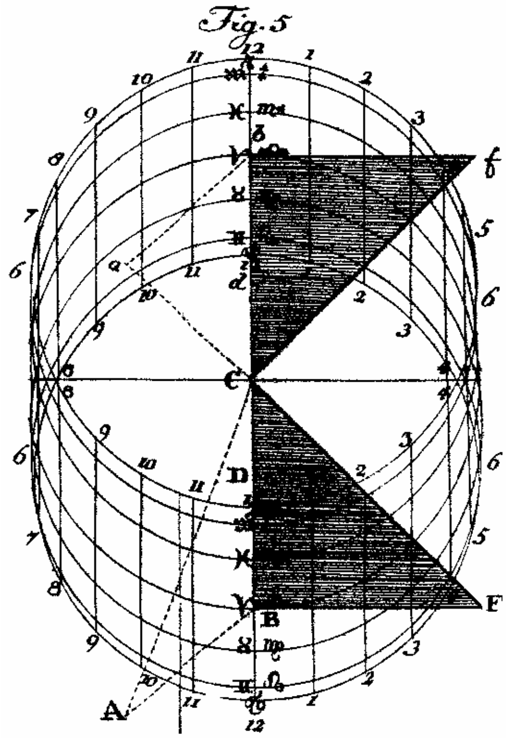

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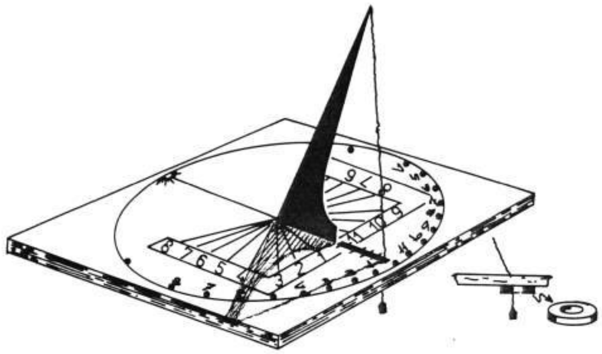

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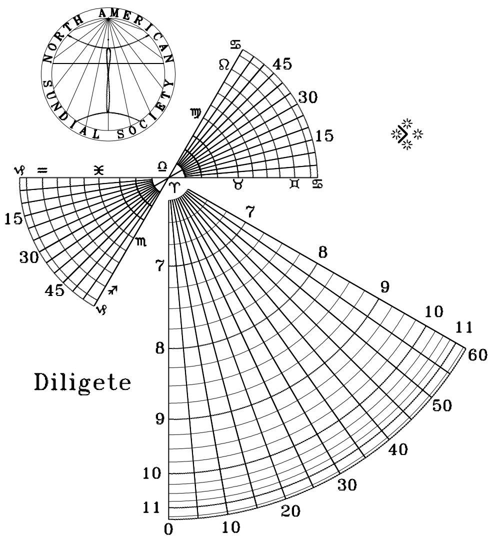

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Unsigned
circa 1500; Italian
Brass; 166 mm in diameter

This is one of the earliest surviving armillary spheres and the assigned date is consistent with its simple form. Only later do such instruments include more complicated motions and planets. Here there is simply the celestial sphere, incorporating the motion of the sun, and a central earth.

However, there is at least one more ambitious feature. Although the surviving instrument is incomplete, it has a very unusual adjustment for demonstrating Italian hours. In this method of reckoning time, hours are counted from 0 at sunset to 24 the following sunset. Thus the relationship between the scale of hours and the celestial sphere has to be adjusted according to the position of the sun in the zodiac. The scale on the equator is in hours from 1 to 24, and it can be moved, being arranged to slide outside the zodiacal band. Scales on the base give the position of the sun in the zodiac according to the date.

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Sundials on the Internet

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How to set up a horizontal sundial

A horizontal sundial consists of the dial plate, marked off in hours, and the gnomon which sits on the noon line and projects out from the dial plate.

In order to tell the correct local time the gnomon must be parallel with the earths axis, or, in other words, that it should point towards the celestial pole. In the northern hemisphere, this means, for practical purposes, that the gnomon should point at the Pole Star. One should first check whether or not the sundial is correctly made for the place at which it is to be set up. If it is not, the base plate of the dial must be corrected so that the gnomon is pointing correctly true north, towards the celestial pole.

Finding the direction of true North

Various methods are suggested in the literature, and are summarised here, with references to published sources if you need them

1. **Use a compass.** This is not very accurate, but it will do for a small garden sundial. **Remember** that the compass points to magnetic north, and a correction must be made for magnetic deviation. (Magnetic deviation at Greenwich in the UK was 3º58 W, and decreasing by 0º08 annually, but in some areas of the world it is much higher, and there are also much more local variations)
2. **Mark a shadow at the exact time of local noon** The shadow must be cast by a true vertical object. You can use a plumb line, a pole aligned vertically with a spirit level, or a vertical corner of a building. You may need to experiment to get a good shadow, and to find a reliable method of marking the shadow at the instant of local noon.

   Remember that the sun travels 15º westwards in one hour, and thus travels 1º westwards every four minutes. (In the latitude of London, this is equivalent to 950 feet per second). The time on your watch must be corrected for this. For example, at Lowestoft (which is the easternmost point of England at 1º45E, local noon is exactly 7 minutes earlier than noon in Greenwich. Penzance in the far West of England is at 5º33W, and local noon there is 22 minutes and 12 seconds later than at Greenwich.

   Remember too that the sun appears to be fast or slow compared to watches by an amount discussed under the Equation of Time The sun is "fast" between 16 April and 14 June, and again between 2 September and Christmas and "slow" at other times of year. "Fast" means that, if you are on the standard meridian for your time zone, the sun will be directly overhead ("sun noon") not at 12:00:00 by your watch, but a few minutes earlier. When you are setting up your horizontal sundial, you want to know the time the sun is directly overhead. So you mentally add the Equation of Time to your watch time, or advance your watch by the amount of the Equation of Time so that, at the instant when your watch says 12:00:00, everyone else's watches will be saying it is actually a few minutes earlier than that, and it will indeed be "sun noon" The same thing, of course, applies if you are not on the standard meridian for your time zone, but you have already taken account of this with the calculation in the preceding paragraph.
3. **Use the method of equal altitudes** This requires a reliably sunny day, and an accurately level board with a true vertical nail or stick. In one variation, concentric circles are drawn around the base of the vertical stick. The position of the tip of the shadow is noted whenever it just touches each of the circles in the morning hours and in the evening hours. If one is lucky there will be two marks on the same circle. Join them with a line. Bisect this line, and draw a line from the bisection point to the base of the stick - this will be a true North- South line.

   An alternative is to mark out points on the track of the tip of the shadow first, and then to connect them with a line. Then draw a circle to give the greatest possible distance between the two intersection points, and as before bisect the line, and draw a line from the bisection point to the base of the stick - this will be a true North-South line.

Checking the angle of the gnomon

Since horizontal sundials are often mass-produced, they have to be made for just one latitude. Many are made in Birmingham, where the latitude is around 52½ deg.N, so the angle between the gnomon and the dial plate is also 52½ Quite often, people bring back a sundial when they have been on holiday, so the angle may be very different. For example, a sundial made for the south of Spain will have an angle around 37 deg. and will not tell the correct time if it is set up with the dial plate horizontal in Southern England where the latitude is 51 deg. Fortunately, this can be compensated for.

First, measure the angle of the gnomon with a protractor.

Second, you can if you wish cross-check this measurement and check that the hour lines have been laid out correctly, by "back-calculating the gnomon angle from the angles of the hour lines. (The book by Waugh gives an example of this calculation on p.48, and also a table showing the correct angles of the hour lines for each degree of latitude. For example, the angle of the 9am and 3pm hour lines from the noon line is 26º24 at 30ºN, 29º50 at 35ºN, 32º44 at 40ºN, 35º16 at 45ºN, 37º27 at 50ºN, and 39º20 at 55ºN.)

Compensating for an incorrect gnomon angle

Third, provide a wedge to bring the gnomon parallel to the earth's axis. For example, the holiday sundial brought back from Spain (lat 37ºN) to be set up in Southern England (lat 51ºN) would have to be wedged up by 14º, so that the gnomon is at 51º to the horizontal. You can either measure this angle with a protractor, or you can calculate the height of the wedge by multiplying the length of the dial plate by the sine of the correction angle. In this case, the wedge required for a square sundial with a side of 10 cm would be 2.4 cm.

Sundials on the Internet

For a full overview click here

Frequently Asked Questions

We welcome queries on sundials - if we cannot answer them ourselves, we can usually suggest someone else who can. We've grouped together some of the queries we have received and the answers we gave then - maybe some of them may be relevant to your question too.

Q42 - 26 Jan 2001 - I just want to ask you the size of the biggest sundial in the world

> *The big sundials I know about are:*
> *Pajala in northern Sweden - there is I think a link from Sundials on the Internet - use the search facility on the home page*
> *Jaipur in India - ditto and I think there is a web page*
> *There was also a plan to construct a very large sundial in the easternmost point of New Zealand but I dont know if it got built*

Q41 - 5 Jan 2001 - HELP - My 8yo has a project to do a sundial. The problem is ,in the northwest Puget Sound area it rains alot and it is difficult to do one without the sun. Any suggestios?

> *Under Nicholson's law, the areas of the world with most sun have fewest sundials, eg Arizona, Mexico, Southern Spain, Greece) and the areas with the highest rain/snowfall have most (eg England, French and Swiss Alps, northern Spain)*

Q40 - 13 Dec 2000 - Hi, I'm a 16th C re-enactor and would love to get my boyfriend an authentic timepiece (untill he aquires the money for a subdermal watch implant !??) I can't seem to find out if either equinoctial sundials, or 'peasents' ring' sundials were in England in the 1500s, as I understand it shepherds' sundials were. I'd be grateful for any help you could offer.

> *Cylinder dials go back a long way - there is one mentioned by Chaucer and quoted in the book by Waugh. Mrs. Gatty's book says they go back to the 13th cent. (probably also based on Chaucer).*
> *As far as I can remember they got really common in the 18th century, when modern notions of time were beginning to creep in, but the technology for measuring it was (?mercifully) much less sophisticated than it is today.*
> *The people who could give you more information are at the Museum of the History of Science in Oxford.*

Q39 - 14 Oct 2000 - 30 09 several of your items on the FAQ page ask about human sundials for schools. I refer you to the Needham Science Center in Needham, Massachusetts, USA. They can provide (for a small fee of $5.00) appropriate measurements for the layout of a sundial in the schoolyard where the children act as the gnomon. Their address is: http://www.i_need_science@mail.needham.mec.edu

Q38 - Please can you tell me where I can get some information? Everything I find is for the northern hemisphere!

> *Yes, it's true, but there are only two important differences, that the gnomon points at the south celestial pole, and that the hour numbers go round the dial in the opposite direction to the Northern hemisphere. But everything else is exactly the same. For example, the gnomon's angle and the angles of the hour lines are related to the latitude in exactly the same way as in the northern hemisphere. Some computer programmes will print out for the southern hemisphere as well as the northern* A very good book on sundials, written specifically for the Southern Hemisphere, is available.

Q38 - 3 September - I have seen every sundial website there is, but I want to know what materials I need to make a horizantle sundial. My school is building a sundial in the front of our school. This is a project that is very important to our school besides our aviary, green house, butterfly garden, and waterfall. We all would really apprecaite it if you would send us some information.Thanks from the kids at West Hernando Middle School

> *Lovley to hear from you, but the answer is to look round the website first! We try to answer all Emails but usually cannot do so immediately, so it is worth having a good look for what you want (in this case, our projects page)*

Q37 - 10 Dec How do you set up an equatorial dial

> *Setting up an equatorial dial is essentially the same as setting up a horizontal dial (see our setup.htm page, with the one additional step that you need first to set the angle between the gnomon and the horizontal at the same angle as the latitude of the place you are.*

Q36 - 01 Aug I am stuck on a question for a quiz, is there any chance you could tell me what the indicator which casts a shadow on a sundial is called?

The gnomon. Strictly, the gnomon is the indicator and the edge of it which casts the shadow is the style.

Q35 - 29 July Can you please tell me the name for the art of making sundials?

A35 - The art is gnomonics and the people who do it are gnomonists according the dictionary, but it is a mouthful to say, so many people prefer dialing and dialists.

Q34a - 30 July - Are the E.O.T timing figures the same for the southern hemisphere. Thanks in advance.
Q34b - 26 July - I have made a sundial but it does not appear to be particularly accurate. Do I need to make any adjustment to the equation of time because I live in the Southern Hemisphere?

A34 - No - the sun is so far from the earth that the Equation of Time corrections are, for all practical purposes, exactly the same wherever you are on earth. The correction does change slightly on any given date from one year to another because of leap years, so the values given in books are usually the average of the four year cycle. Computer programmes such as the NASS Dialist programme give accurate values for every second of every day for a century or more!

Q33 - 29 July 1999 I will be teaching a carpentry class starting in September. We are studying the Colonial America. I am interested in finding plans and instructions on making a sundial that would be similar to one that would have been used by the early colonies of America. Can you please direct me to a source that could help me? Thank you for your time. Cris

A33 - The early colonists would have brought over with them some sundials, mainly horizontal ones, being made in Europe at the time. There are a number of these in museums in North America, see, for example, the Ottawa sundial trail. They would also have brought knowledge of vertical sundials, and there are a number of examples of these too, for example on the Sisters of Charity Convent in Ottawa and also in Quebec and other colonial centres.

Q32 - 7 July 1999 My question is similar to Question 24 in the FAQ. I am interested in creating a human sundial as part of a schoolground naturalization project in Calgary, Canada (latitude 52). I realize I cannot make a horizontal sundial with a vertical gnomon (person) because it will be inaccurate over the seasons. Your web page made reference to analemmatic sundials being used on lawns in a similar way such that the human gnomon would stand in a slightly different posiion each month to make the correction. Could you tell me where I could get the information on how to make such a sundial? Olympic Heights Elementary School Calgary, Canada P.S. Great Website!

A32 - The books by both Rohr and Waugh have ten pages or so on how to construct an analemmatic dial. You can order both of these straight off our books page. The easy way is to buy a kit of instructions from Modern Sunclocks who will work it all out for your exact location for a quite modest fee Hope this helps
PS Thanks for your kind PS!

Q31 - 23 May I was wondering whether anybody would be able to tell me where the largest Sundial in Australia is? If you could help me as soon as possible I woulf\d be most grateful. My e-mail address is: grimus@eisa.net.au

A31 - Sorry, we just don't know but we would like to, and could even start a largest sundials page! This would include the one at Jaipur in India and at Pajala in Finland.

Q30 - 1 June 1999- we live in Stamford, Connecticut USA and have been debating the difference between northern and southern latitudes sundials. Are the 15 degree hour markers equal but opposite in the southern hemisphere? Clockwise v. counterclockwise and can you explain the answer

Q29 - 22 May 1999 I received a sundial as a gift. I see that the numbers go LOWER as you go clockwise around the dial. Does that mean it was designed for use in the southern hemisphere? Don't know why they would sell that in New York if it's true. But your project on how to construct a horizontal sundial shows the numbers going in the clockwise direction. If the sun goes from east to west by way of the south, as in the northern hemisphere, does it not follow that the shadow cast by anything, a tree, a person, etc., will progress in a clockwise direction as the day progresses? What am I missing?

A29 - All the sundial books we know concentrate on the northern hemisphere. The only thing different about the southern hemisphere is that the gnomon points to the southern celestial pole rather than the northern one. The direction of the rotation of the earth is in the same direction in both hemispheres. So you are quite right that a horizontal sundial with the numbers increasing in an anti-clockwise direction will have been designed for the southern hemisphere. In the northern hemisphere, the numbers on a horizontal sundial increase in a clockwise direction (just like a clock!) A very good book on sundials, written specifically for the Southern Hemisphere, is available.

Q28 - 19 May 1999 What is the art of making sundials called?

A28 - According to the Oxford English dictionary, the art is called gnomonics and the person skilled in the art is called a gnomonist. However they are both such moutfuls that most people try and avoid using them! (Incidentally, the word gnomon was first recorded in the 1600s, and was also used to describe a carpenter's square as well as the shadow-edge of a sundial)

Q27 - 14 May 1999 I received a sundial as a gift. It's a horizontal type. The numbers descend as you go around clockwise. I am no expert on sundials but how can that be? Time goes backward as the sun progresses thorough its path. Any suggestions or help? Thanks.

Q26 - 10 May - I teach 8th grade science at Sage Ridge School in Reno, Nevada. I am interested in creating a sundial using an analemma. I am interested in knowing how to calculate the curvature of the analemma for this latitude. I would like to have students create one of these sundials out of plywood next year. Thank you. David Roberts

> *A26 - The theory of central projection analemmatic sundials is explained in a comprehensive paper originally publised in the NASS Compendium by Yvon Masse, and available at http://www.union-fin.fr/usr/ymasse/cpaprc.htm. If you just want the answers, [Modern Sunclocks](#) will provide a set of plans for an anelemmatic dial for your precise location.*

Q25 - 1 May Dear Friends, what a fantastic website. One Q though: why does the gnomon have to be at one's latitude's angle? In Q19 you explain the HOW but not the WHY. Why does a vertical gnomon turn incorrect after a few years? Thanks for your help. Heiner Thiessen

> *A25 - Think first of the day of the equinox. The sun's apparent path from earth is exactly above the equator, and rotating at 15 deg. an hour with respect to the earth's axis. If you make an equatorial dial with the gnomon parallel to the earth's axis and the dial plate parallel to the equator, the shadow will move round the dial plate at exactly 15 degrees an hour. Now move forward to the summer solstice. The sun's path is now 23.5 degrees above the equator. But the plane of its orbit is still parallel to the equator, so the shadow will still move round it at 15 degrees an hour. But now consider both cases when the gonom is at, say, 45 deg to the earth's axis. The shadow will move round this gnomon at a variable number of degrees an hour, not at a constant 15 degrees every hour. The number of degrees in any particular hour will be different at the solstice (and indeed at every other day of the year) from what it was at the solstice. So any mark you make on a dial plate to indicate the "clock" hour will not be true after even a few days. I hope this helps. If you want a practical demonstration, put a vertical pole in the ground, and mark where the shadow is at any time other than noon - then mark the same time at intervals over the next few weeks. You will see it for yourself. (You will find a fuller explanation on [equation.htm](#) under the Inclination of the Ecliptic.*

Q24 - 30 April - I am a Landscape Architect in Omaha, Nebraska. I have designed a human sundial to be installed in a public park but am having problems finding the correct settings. Can you help me find someone to do that?

Q23 - 26 April 1999 I am a sculptor working on a proposal to build a 26 foot high marble and stainless steel column which would function as a sundial. I am not sure what the best method for laying out the hour marks is. I would appreciate any information that you could give me.

> *A23 - Very tall sundials have problems all their own, partly because the gnomon may not be straight due to self-weight, and partiy because the shadow gets fuzzy if it is a long way away from the hour lines. So you need to do a bit of experimenting. You can see a picture of one I did at Lincoln linked from my entry on ..../personal.htm This was only 5 m. high. You also need to understand quite a bit about the theory of sundials, and for this you need 2 or 3 of the books listed on ..../books.htm You can get most of them through amazon.com*

Q22 -14 April 1999 Can you tell me, can I construct and arrange a vertical sundial facing due north the same way as a sundial facing due south as illustrated within these pages. I live in the southen hemisphere and I wish to make a vertical sundial but our aspect faces due north. Any assistance will be welcome

> *A22 - I always get slightly muddled about the southern hemisphere, but the essence of it is that the gnomon has to be parallel with the earths axis. In the northern hemisphere, that means it points at the pole star. In the southern, it points at the southern celestial pole, and the sun appears to go round it at 15 deg per hour just as everywhere else in the world*

Q21. 15 Dec 1998. I have read your ["How to set up a horizontal sundial"](#) page with interest. Surely, if one's sundial's gnomen is correct for one's latitude and the clock time correction for one's actual longitude (with respect to the time zone longitude) has been calculated, it is a simple matter to let the sundial do it for you. Simply set the sundial so that it shows the local sun time, taking into account the equation of time. There is no need to rely on noon. This could be done in the morning and checked at intervals during the day. I all is OK the sundial's noon line should point to the celestial pole.

> *A21 - Yes, you are quite correct. Why we do not recommend doing it this way is that most horizontal dials are not sufficiently accurate to do it this way, because the gnomon does not have a square edge, the lines are too wide, and/or the gnomon not quite straight. It is also quite rare to find a "garden-centre" sundial which is correctly set for its latitude. So we thought it preferable to set the thing out right to start with, and let the minor inaccuracies sort themselves out.*

Q20. 3 Dec 1998 I live in Israel which is approximately 32 degrees north. I have made a sundial according to my latitude. What I would like to know is whether the graphs for correcting the discrepancy of a sundial are the same all the world over, or change from place to place. (I have a copy of a graph from Enland - would it be valid here?) Also, how do I adjust for differences in longitude within the same time zone? I hope you can help me or guide me to the right source on the web. Thanks in advance, Jonathan

> *A20 - Thanks for your message. The Equation of Time is universal. The distance to the Sun is so much greater than any distances on earth. If you want your sundial to show the time at your prime meridian, you work out the time difference at 60 minutes of time equals 15 degrees of rotation. So, Lowestoft is at 1 deg 20 East, so the correction is 5 mins 20 secs. The sun reaches Greenwich after it reaches Lowestoft , so if I want the Lowestoft dial to read Greenwich time, I must calculate the hour lines for 12.05.20, 1.05.20, 2.05.20 and so on. I hope this will help you. If it does, let me know, and I will post it on our FAQ page to help others.*

Q19. I have a couple questions about the gnomon on a sundial. How long should it be, and is it's angle calcualted from the latitude, or is it taken directly from latitude (my lat is 33.6, should the angle be 33.6 degrees)?

> *A19 - The gnomon always has to point at the celestial pole. if you are at the North (or South) pole, it therefore points straight up if you are at the equator it is horizontal. as you move north (or south) from the equator, the gnomon angle lifts up from the horizontal and the latitude also increases. So, If it is a horizontal sundial, the angle between the gnomon and the horizontal is equal to the latitude If it is a vertical dial, the angle between the gnomon and the vertical is equal to the co-latitude (or 90 degrees less the latitude)*
> *As to how long it should be, you can calculate it, because the sun's orbit dips 23.5 deg below the equator in winter and 23.5 above it in summer. You want to make sure that the shadow falls all the way across the dial plate when the sun is highest - on midsummer day. Get your maths teacher to help you out with how to calculate it if you cant work it out for yourself.* Hope this helps

Q18 - 16 Oct 1998 - I am looking for information on setting up an armillary sundial. I have taken it apart and restored it. On setting it up I need the longitudal and latitudal figures. I can't find the information of the internet. Please help me.

> A18 - Please refer to our page on "Setting up a horizontal sundial". Setting up an armillary is essentially the same - the axis (gnomon) has to point to the celestial pole, which means that the angle it makes with the horizontal has to be equal to the latitude of the place, and the projection of the gnomon on the horizontal has to be pointing to true north, ie along the local meridian.

Q17. Dear Mr Sundial, I have a sundial with a gnomon set at 52 degrees, which is obviously an incorrect setting for is location which is 39 degrees 35 minutes South, and 174 degrees 16 minutes East. Could you please advise me of the correct setting given that New Zealand Standard time is G.M.T. plus 12 hours. Thanking you in anticipation. Could you also enclose your "snail mail" address so I can send you a 1999 New Zealand calendar in appreciation. Frank Lacy,

> A17. Thanks for your message, You too should refer to ....../setup.htm. For horizontal sundials, setting in the southern hemisphere is essentially the same as setting in the northern hemisphere, except that the gnomon is pointing to the south celestial pole. So you need to wedge up the sundial in such a way that it thinks it is at 52 deg. South. Your sundial is certainly manufactured for a place exactly on a standard meridian, and you cannot adjust for this (see next Q). You just have to remember to add or subtract the appropriate amount (4 mins for every degree you are away from your standard meridian). If you want to convert exactly to "clock time", you will also have to add or subtract the Equation of Time (see ....../equation.htm). I would certainly appreciate a calendar. Thank you. Would you also like to write a sundial trail for your neighbourhood (see ..../sunlist.htm)

Q16. we live in Langhorne, Pennsylvania, and we are affected by the daylight savings time. we put a sundial in our backyard, and my father and I had several long talks regarding adjusting or not adjusting the sun dial for the daylight savings time. please put us out of our misery, by answering this strange question.
thank you, heather and kenneth pyle

> A16. Please refer to www.sundials.co.uk/setup.htm for a full answer. The short answer is that it's best to set it for your local noon, and then to remember when you read it that you need to adjust it by XX minutes to get the time at your standard meridian, and a further hour if it's in the summer.
> The reason for this is that the angular difference between successive hours is not uniform. So rotating the dial will lead to inaccuracies. This may not matter too much if the gnomon of your sundial doesnt have a square edge, or if the hour lines are engraved too wide as many mass-produced dials are.
> You should also check what latitude the sundial you have is designed for, and if necessary make the adjustments in ..../setup.htm

Q15. I have recently moved to NSW Australia and whilst touring the local area spotted a sign at 'Singleton', which states 'Worlds Largest Sundial', having visited the 'Observatory' at Jaipur, India a few years earlier who had the same claim, I realised that one of them must be wrong. Both were of a similar design, but certainly the one in India was considerably larger. Perhaps you would like to list them, but as to which is the 'Worlds largest', I will leave to you!
I would like to try and get details of the size of the one in Jaipur, and if it is larger I will show this to the local tourist information centre! Any ideas where I might find this information? Do you know which is the Worlds largest sundial, perhaps neither of those I have mentioned. I am finding the general 'Sundial' information fascinating.
Thank you Sue Spence

> A15. The large instrument - a mammoth structure - is called Brihat Samarat Yantra and the main part is a right angle triangle with a base of 44 metres and a gnomon angle of 27 degrees, so the height is 27 meters. The semicircular quadrants have a radius of 15 meters. There is a link to it on the pix.htm page. There is another big one at Pajala in Sweden written up in the penultimate issue of the British Sundial Society Bulletin no 97.3. It has a diameter of 39 metres, so I guess that is not the biggest! (Paul Fischer has kindly given us its URL: http://www.pajala.se/narliv/ftgreg/elcs/elcs.htm and there is a description of it at http://www.pajala.se/welcome/tourism/soltorg.html

Q14. I am a member of the British Sundial Society and have built dials but I am still a beginer and one question remains in my mind that I can not seem to find the answer for. There seems to be a bit of a clue in question 1 in the F.A.Q. document but it is still not clear to me.

If the angle of the earth changes from Summer to Winter then why is the axis of the earth always quoted as pointing to the pole star?

> A14. The answer to your question is in what the angle is changing relative to. The angle of the earth's axis relative to the far distant stars doesnt change at all as the earth goes round the sun. But the angle relative to the sun does. In midsummer the axis is tilted 23.5 degrees towards the Sun, and in midwinter, it is tilted the same amount away from the sun.

Q13. Dear Society, What I would like to know is how Sundials work throughout the seasons. I mean the noon shadow falls in one place in Summer and a totally other place in Winter. Could some one explain this very rudimentary fact to me? I have just purchased my first sundial and would like to set it up correctly. Thank you so much for your help. Susan

> A13. Dear Susan Thanks for your message. Try looking at setup.htm on www.sundials.co.uk Essentially, at a given time of day in winter, the sun is lower in the sky and at a different angle relative to south compared with the same time of day in the summer. The slope on the gnomon, which is equal to the latitude, compensates for this, so that the shadow, taken from the lower part of the gnomon in winter and a higher part in summer, falls in the same place at the same hour. Let me know if this helps you. If so, I will put it up on the FAQ to help others.

Q12. Do any of your visitors ever tell you if they got useful information from it?

A12.Yes, occasionally. It's obviously only a very small fraction of those who visit Sundials on the Internet, and it's a great pleasure to get E-mails like this example:

Q11. I think this page is really great. When I got the project of making a sundial I didn't know where to start until I found your web site explaining how to make a sundial. I found that it was really easy to make and I hope now to get a good make for my project.
Thank-you Jennifer (one very happy person!)

> A11.Thanks a million. It's so nice to get a letter like yours - it makes the whole thing worth while. So I'm another very happy person! Webmaster - Sundials on the Interent

Q10a. We are doing a schools project on sundials and would like some help

Q10b. we are doing an assignment for school and wish to construct a sundial our latitude is 38deg 23' how do we plot the hour lines ?

Q10c. I'm a student at a high school and want to know alot about sundials. This information is needed for a science final and would be greatly appreciated if you could send it immediately.

> A10. There are details of a suitable project on www.sundials.co.uk/projects.htm if you have to get started immediately.
> If you have more time, we would suggest obtaining "Make a Sundial" from the British Sundial Society which has a number of projects. It was produced specifically for schools, but is equally suitable for anyone seeking to gain understanding of sundials and experience in making simple models before venturing on to larger projects. It can be ordered directly from them

Q9. I want to give my daughter some help on a project on the history of sundials, but can't find anything in my public library

> A9. Sundials - History Theory and Practice by Rene RJ Rohr has a very good section on the history of sundials.

Q8. My son is doing a science fair project on sundials. We are unable to locate a list of most famous sundials, and their location so that we can pinpoinnt them on a world map. Any help would be appreciated.

> A8. There is no comprehensive or easy way of finding out this kind of information. Some of the books give lists of sundials in particular areas. Our own pages on favourite sundials in North America, in the United Kingdom, in France, and in the Netherlands will also be helpful. And there are links to pictures of other sundials on the Internet on pix.htm. We are building these lists up gradually - if you find them helpful, please help us by adding any information you have!

Q7a. I am keen to make a sundial but know very little about it.

Q7b. I don't know if you can help me, but I want to construct a vertical sundial similar to some I saw in the U.K. I am particularly interested in a sundial that tracks the four seasons. Any construction details, geometry, and advice (pictures of vertical sundial faces?) would be greatly appreciated. My house faces south and I have the perfect location for such a sundial. Can you help?

> A7. If you want a few small practical projects to do before you get involved with your first big individual project, your best course is to get "Make a Sundial" (see question 1 above). This will give you a good basic grounding. Or you could start off with the projects on ...../projects.htm
>
> If you want to dive straight in to a big project, the books I have found most useful are Sundials - Their Theory and Construction, by Albert E Waugh and the book by Rene RJ Rohr mentioned above.

Q6. I acquired a Shepherd's watch but don't know exactly how to use it. CAn you be of any help? Thanks, Ann

> A6. There us a very good sundial mailing list which is the best way of getting quick and definitive answers to detailed technical questions like this. You can find out how to post a question (and how to subscribe to the list if you want) on www.sundials.co.uk/mailist.htm. Please start your enquiry along the lines "I found out about the mailing list from the FAQ page on Sundials on the Internet"

Q5. Are there any internet sites on the theory and/or constuction of sundials? if so, where? How does their constuction differ from the northern to southern hemispheres?

> A5. Try the sites listed on equation.htm. But you will probably find you are better off with one of the books listed above or on books.htmA very good book on sundials, written specifically for the Southern Hemisphere, is available.

Q4. I am a student in Singapore and I would require instructions to make a sundial for latitudes of 0 degrees, please email me immediately.

> A4. Most of the literature about sundials is written by people in medium or high latitudes. There, the gnomon (which has to point to the celestial pole) makes a large angle (some 50 deg in England) with the horizontal. At low latitudes, the gnomon makes a very small angle with the horizontal, and on the Equator, the gnomon has to be parallel with the dial plate. If you go to the botanic gardens in Singapore, they have a really nice sundial there and you could copy that using simple materials. Essentially you have a flat plate projecting p cm. from a horizontal surface with the hour lines. The hour lines are placed at y= p x tan h where h is the hour angle which is 15 deg for 11 am and 1 pm, 30 deg for 10 am and 2pm etc It could last a lot longer than 30 days.
>
> *He replied: I have made the sundial and it is quite accurate. Another victory for Sundials on the Internet!*

Q3. Where and Which is to largest sundial on this planet? Where is the oldest sundial still in tact? Curious is the cat!

> A3. I should think the one at Jaipur India is probably the largest. This is another of the questions worth posting on the sundial mailing list See question 5. above

Q2. Please could you send me details about where I can buy a sundial. I know this is a bit cheeky, but I am having great problems finding a stockist. I would be very grateful if you could help me in this matter.

> A2. The easiest place to buy a sundial is at a garden centre, or from a mail order catalogue like the one from the Science Museum in London. But you should read How to set up a horizontal sundial first so that you know how to check the gnomon angle, and how to correct for it if it is not right for your location. The accuracy of these dials is often very poor because the gnomon is not straight or the hour lines are wrongly marked out. For a more accurate sundial, you should go to one of the sundial makers listed on our sundial makers and designers page

Q1. I am a reference librarian at the Flagstaff, Arizona Public Library. A patron has requested information about the Dial of Almaraz. This is supposedly a 15th Century European sundial (in Almaraz, Spain?) which uses a room and a window or a portion of a building as the mechanism of the sundial. We have consulted many different sources, but have been unable to locate any references.

> A1. See question 6. above

For a full overview of Sundials on the Internet click here
This site designed and maintained by Inter*net*works Ltd of Epsom, England
first posted 1996 last revision
Comments/ suggestions/ problems, please get in touch with the Webmaster

Sun Clocks

Telling Time With Shadows

The Franklin Institute Sundials

Learn About Sundials

Vocabulary List

Interactive Activities

Annotated Links

Book List

Lesson Plans & Other Activities

Bibliography

Journey In Time

Sun Clocks

Lesson Plans & Activities

Astronomy with a Stick

The National Science Teacher's Association has published an online resource on Daytime Astronomy for Elementary and Middle School Students. The activities have been arranged into three interchangeable units. Unit I requires sunny weather to make observations, although some of the calculations are done later in the classroom. The unit 2 graphing activities and unit 3 modeling activities can be done throughout the year and on overcast or rainy days.

The Cosmic Gnomon's Sundial Page

A well thought out page where you will find the lesson plan for a Geometry enrichment lesson that utilizes sundial research on the internet, links to other sundial sites, some pictures, a book list, and an opportunity to provide feedback.

Project Primary-Physics

Ohio Wesleyan University's Dr. Barbara Andereck has compiled a collection of activities which are appropriate for children in grades K-3, but may be easily adapted to other grade levels. They include: Introduction to Shadows, Shadows and the Earth: A Class Activity, Shadows and the Earth and Moon, Measuring Shadows, and Sundials.

"Eyes on the Sky, Feet on the Ground" - Smithsonian Institution

Chapter One of this electronic book pertains to the phenomenon of shadows (how they are made), then uses measurements of shadows to track the motion of the sun across the sky. A companion activity done in the classroom uses an earth-sun model to reproduce the same pattern of shadows the students observed during the day. An outdoor model uses a small clear dome for the sky on which the students record the sun's path. Building and using a sundial is the last activity illustrating the sun's motion.

The Event Inventor - "Sun Time"

Fun activity using student's hands and the sun to measure time.

The Event Inventor - Sundial Wristwatch

Instructions for building and using a sundial wristwatch. Sundials faces are provided for you to print and use.

You Can - Sundials

Beakman & Jax answer the question: "What is a Sundial?" with an interactive activity. Shockwave Plug-In required.

Make a Sundial

Make a sundial using a toilet plunger! From the Curriculum Guide for The PSU-Greenbush Astrophysical Observatory by Dr. Tim Slater, Pittsburg State University.

FI Collection | Learn About Sundials | Vocabulary List
Interactive Activities | Web Resources | Book List
Lesson Plans & Other Activities

Journey In Time

Sun Clocks

Children's Books About the Sun

Arrow to the Sun

by Gerald McDermott. Harper Collins, 1989.

Cock-a-doodle Dudley

by Bill Peet. Houghton Mifflin, 1990.

Dawn

by Uri Shulevitz. Farrar, 1974.

Day the Sun Disappeared

by John Hamberger. Norton, 1964.

How Grandmother Spider Stole the Sun: Keepers of the Earth, Native American Stories

by Joseph Bruchac. Fulcrum, Inc., Colorado. 1989.

How the Sun was Brought Back to Sky

by Mirra Ginsburg. Scribners, 1961.

Sun Up

by Alvin Tressalt. Lothrup, 1991.

Sun's Up

by Teryl Evvremer. Crown, 1987.

Sun Up, Sun Down

by Gail Gibbons. Harcourt, 1983.

The Day the Sun Danced

by Edith Hurd. Harper, 1965.

The Earth and Sky A First Discovery Book

Scholastic Inc.

The Sun Dancer: World Myths and Legends II - Central America

Simon and Schuster, Inc.

The Sun's Day

by Modrdicai Gerstein. Harper Collins, 1989.

Wake Up, Sun

by David Lee Harrison. Random, 1986.

Wake Up, Vladimir

by Felicia Bond. Crowell, 1997.

Who Gets Out of Bed?

by Nancy Carlstrom. Little, 1992.

Why the Sun and the Moon Live in the Sky

by Elphinstone Dayrell. Scholastic, 1968.

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Internet Links

North American Sundial Society

The Link section of the North American Sundial Society's website. Well organized sections include: Featured Sites, General, History, Portable Dials, Public Dials, Monumental Dials, Analemmatic Dials, By Locale, Collections, Artisans, Education, Trigonometry, The Equation of Time, Sundial Generators and Calculators, Moon Dials, Meridans, Miscellany, Societies and Software.The North American Sundial Society is an association of people from a wide variety of disciplines who are interested in the study, development, history, and preservation of sundials and the art of dialing throughout the continent.

Sundials on the Internet

One of the most resourceful sundial sites on the internet. It links to numerous sundial topics, including sites in languages other than English. This site is sponsored by both the North American Sundial Society and the British Sundial Society.

Telling Time Without a Clock - Scandinavian Daymarks

Industrialized societies need accurate regular time measurement to function. Does everyone on Earth live in such a society? No, in some parts of the world people still live much as they did thousands of years ago. Only a few hundred years ago telling time exactly wasn't so important. But it was still helpful to get a rough idea of what time it was. This is an interesting article about telling time with daymarks and the sun.

Types of Sundials

Sundials are classified into a number of different types, mainly by the plane in which the dial lies. This page includes descriptions and examples of many different types.

[Sundials]

An online informational leaflet from the Royal Observatory Greenwich which contains a great deal of good information about Sundials.

[Time and the Sun]

An informative article from the Curriculum Guide for The PSU-Greenbush Astrophysical Observatory by Dr. Tim Slater, Pittsburg State University.

[Pictures of Sundials]

This section from "Sundials on the Internet" contains links to more pictures of sundials around the world than you will have time to look at in a day! There are some beautiful and fascinating sundials included here for you to view.

Sun Clocks

Interactive Sundial Activities

Sundial Memory Game	This is an interactive "Concentration" type game. Click on one of the cards to turn it over. Try to find the second card with the picture that matches the first. If they match, the cards are removed to reveal part of the background image. Keep going until you find the hidden picture! *Primary (Gr. K-3)*
Sundial Crossword Puzzle	For crossword puzzle fans here is an interactive puzzle using words from the Sundial Vocabulary List. Complete the crossword by clicking on the boxes and typing the correct letters. *Junior/Intermediate level (Gr. 5-8)*
Sundial Word Jumble	Here is a game that randomly scrambles the letters of words. See if you can guess the Sundial Vocabulary. Look at the letters and think as hard as you can! You might want to get a piece of paper and pencil to write the letters down and move them around on. *Upper Primary/Junior/Intermediate level (Grades 4-8)*
Sundial Hang Man Game	Everybody loves to play Hang Man! Try your luck at this version which uses words found in the "Learn About Sundials" section of this website. *Upper Primary/Junior/Intermediate level (Grades 3-8)*

Journey In Time

Sun Clocks

Sundial Vocabulary List

angle

The shape or space formed by two lines meeting at one point.

axis

A real or imaginary line about which an object turns or seems to turn.

clogs

Heavy shoes or sandals with a wooden sole.

equator

An imaginary circle on the earth halfway between the North and South Poles marking the dividing line between the Northern and Southern Hemispheres.

gnomon

The pointer (stick) on a sundial, which by its shadow, shows the hour of the day. It is usually set parallel to the earth's axis.

hemisphere

1. Half of a sphere or globe. 2. One of the halves into which the earth is divided.

hieroglyphics

Ancient Egyptian style of writing based on picture symbols.

horizon

The line where the sky and the ground seem to meet.

hour

A period of time equal to 60 minutes.

obelisk

A tall four-sided pillar of stone that narrows to a pyramid shape on top.

peasant

In Europe or Asia, a small farmer or farm laborer.

rotation

A turning or moving about a central point.

shadow

A dark area made when rays of light are blocked by a person or thing.

sundial

A device that consists of a plate with numbers and a pointer that casts a shadow. It shows the time of day by the movement of the shadow across the numbers.

timepiece

Any instrument used to measure time; a watch or a clock.

uniform

The same throughout.

vertical

In a straight up and down position.

Journey In Time

Sun Clocks

Sundials at the Franklin Institute

Click on photo for larger view

"Noon Cannon"

--French, 19th century
At noon, heat from the sun ignites the fuse, setting off the cannon.

Click on photo for larger view

"Portable Equatorial Sundial"

--French, 19th century
To tell time accurately, sundials must be leveled, pointed north, and the angle of the post set for the proper latitude.

Click on photo for larger view

"Portable Sundial"

-- Paris, 18th century
Made by Jacque Lemair

Click on photo for larger view

"Portable Sundial"

--Kanghsi Dynasty, China
circa 1700

FI Collection | Learn About Sundials | Vocabulary List
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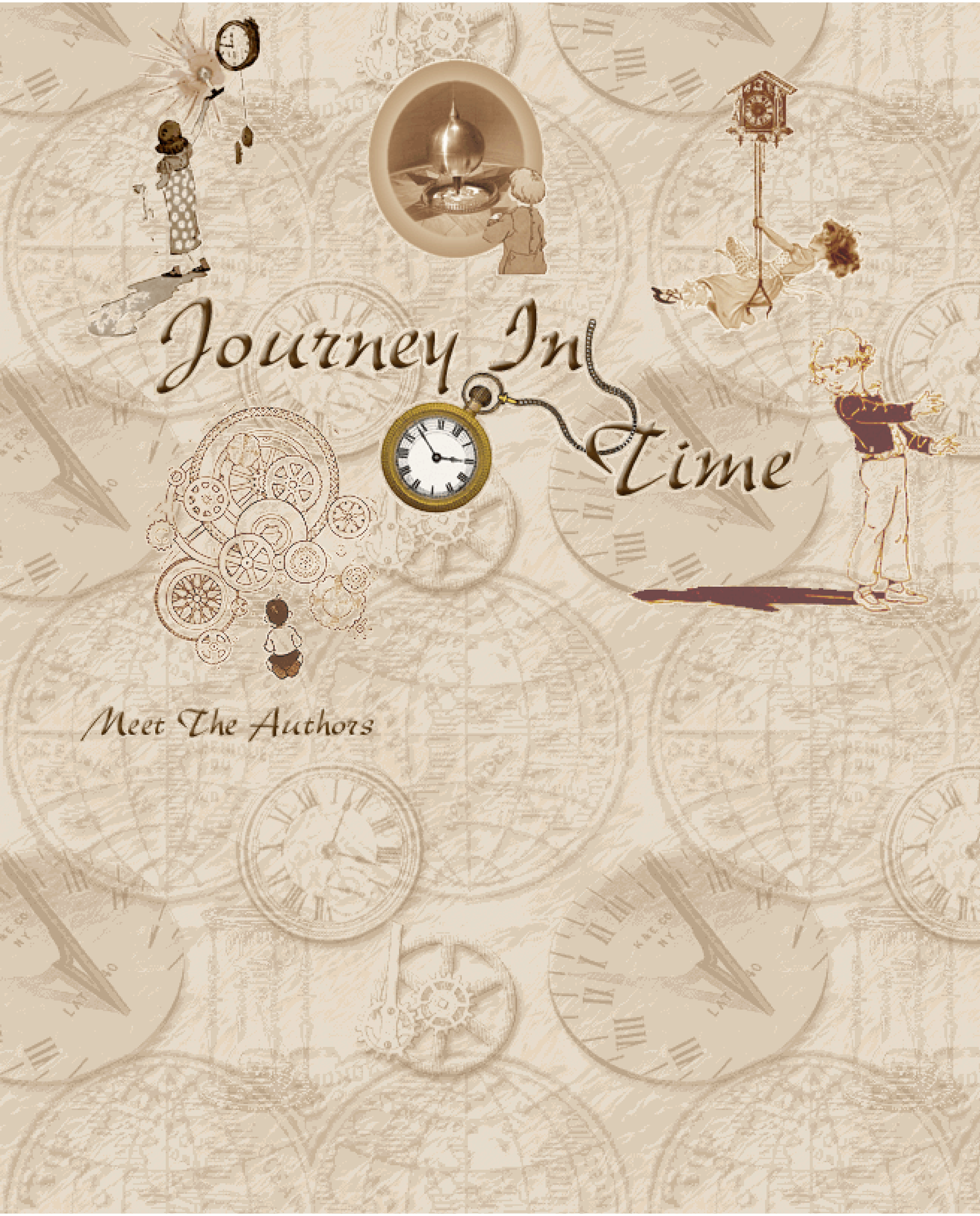
Journey In Time


Journey In Time
Meet The Authors

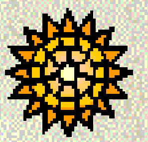
Cosmic Gnomon Home Page | Sundial Home Page | Feedback

COSMIC GNOMON

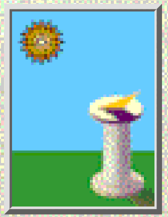
SUNDIALS
Lesson
Pictures
Links Books

Welcome to Cosmic Gnomon's Sundial Web Page.
Here you will find the lesson plan for a Geometry enrichment lesson that utilizes sundial research on the internet, links to other sundial sites, some pictures, a book list, and an opportunity to provide feedback.

Sundials and the Internet -- This is the lesson plan (with handouts) for a high school Geometry enrichment lesson which introduces students to sundials as they utilize the research benefits of the internet. Using simple geometric concepts, students then construct and set up their own working sundial.



Web Links -- This is a partial (and by no means inclusive) list of some interesting internet sundial sites.



Sundial Pictures -- Here are some interesting pictures of sundials. Sundial pictures (photos, scanned images, drawings, etc.) you would like to have displayed on this site, would be gratefully considered and, of course, full credit given if displayed. Students' sundial constructions are especially welcome.

Books -- These books were found in local libraries. Most give some history on sundials and describe the variety of dial types and designs. Many have excellent photographs and illustrations of sundials and provide detailed instructions on dial construction using geometric and/or trigonometric approaches.

Feedback -- Please take the time to let us know what you think of our site. If you are a teacher and used the "Sundials and the Internet" lesson with your students, please let us know about any lesson improvements you found that would benefit other instructors.

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Cosmic Gnomon Home Page | Sundial Home Page

This web page was last updated on 23 Apr 2003.

Additional questions or comments on this web site can be addressed to the webmaster:
cg@cosmicgnomon.com

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Sun Time 

Materials needed:

First Activity: **Your hands**

Second Activity: **Pencil, pen or a straight stick of similar length**

What to do:

site:

Out in the sunshine.

preliminary preparation:

Plan for a mostly sunny day. Each activity will take 5 minutes or less.

First Activity -- Know when sunrise or sunset will take place and schedule one of the activities for a few hours after sunrise OR a few hours before sunset.

Second Activity -- Works best when conducted between 7 and 9 am and/or between 3 and 5 pm. Try to do this activity where you can see the rising or setting sun and a distant horizon.

Be sure you have read my WARNING first.

Activities:

(#1) Time from sunrise or sunset:

1) First remind the children that they should NEVER LOOK DIRECTLY AT THE SUN!!You don't need to experience pain to receive PERMANENT DAMAGE to your retina, and the damage is CUMULATIVE! If possible, stand in the shadow of a tree trunk or at the edge of the shadow of a building and use the Sun's glare to estimate its location.

2) Make fists with your hands. With arms outstretched (elbows straight), place one hand over the other, starting at the horizon to see how many "fist-widths" it takes to step your way to the bottom of the Sun. Each fist-width is about TEN DEGREES (across your knuckles).

3) Since the sun (and all celestial bodies) moves across the sky at 15 degrees per hour, adjust the known sunrise or sunset time to the current time, based on how many fist-widths the sun is above the horizon. (1 1/2 fist-widths per hour). There is no need to adjust for Daylight Savings Time, since the time being figured here is relative to sunrise/sunset times, which have already been adjusted.

OPTIONAL: After sunset, find the North Star and measure how many hand-widths it is above the horizon. It is the same number of degrees above the horizon as the (north) latitude of your location. This is how early sailors and travelers estimated their latitude (how far north or south they were) when trekking over unknown seas and through uncharted wilderness! (Click here to learn how to find the North Star)

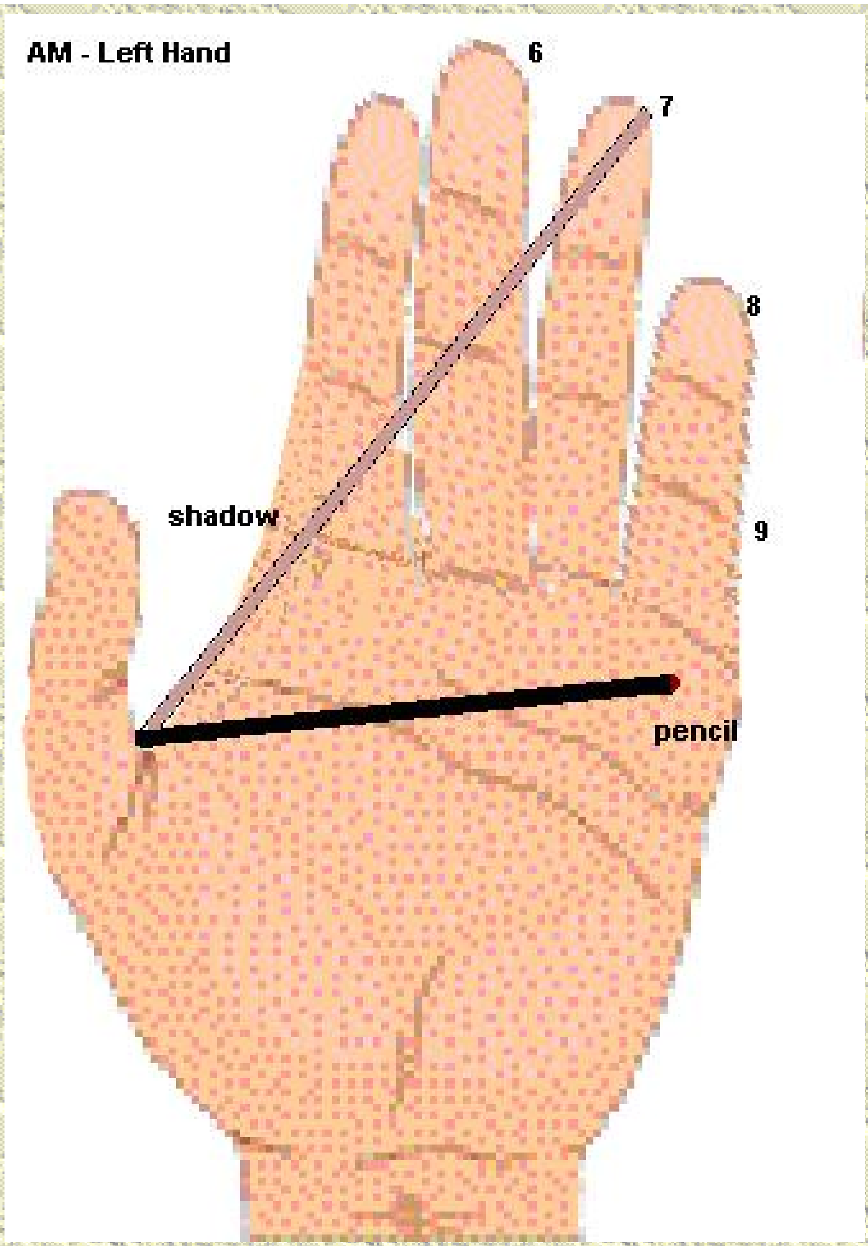
(#2) Time from shadow on your hand:

1) Hold a pencil (or ??) with your thumb while your hand is pointing horizontally. The angle of the pencil should be as close as possible to your latitude. (Pencil point pointing approximately at the North Star)

2) Read the approximate time (see diagram below).

Kye's Skies Sun Exploration #2 - Sun Time:

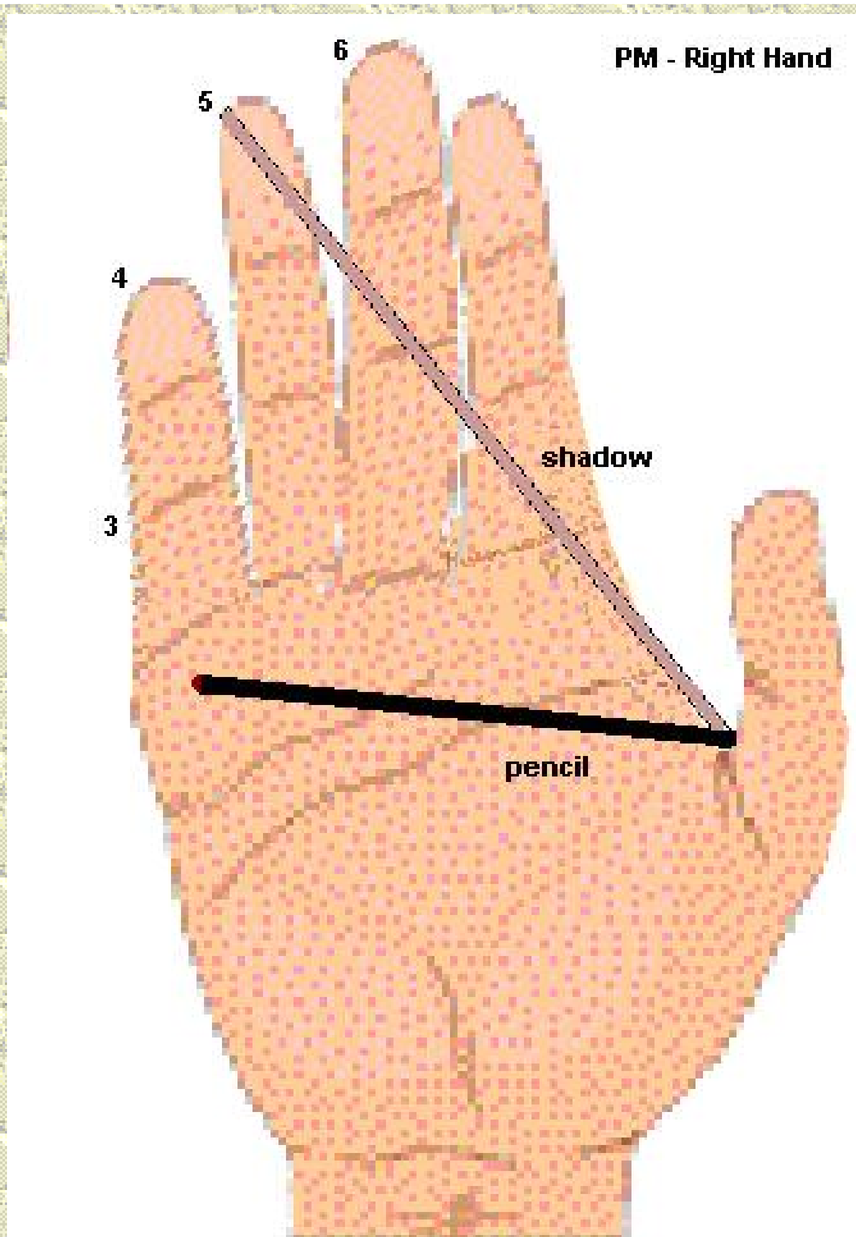
(Morning - Hand pointing WEST, pencil pointing NORTH)



The shadows tells you the time!

Kye's Skies Sun Exploration #2 - Sun Time

(Afternoon - Hand pointing EAST, pencil pointing NORTH)



Remember to adjust for Daylight Savings Time (a/k/a Summer Time)

(ADD ONE HOUR)

(* More on my copyright policy HERE ***)**

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The Event Inventor

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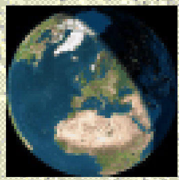
Sun Watches



Sundial Wristwatch

Materials needed:

Ease print Sun Watch pattern **or** **Wristwatch in COLOR**
Scissors and scotch tape
Printer paper - stiff paper like card stock or vellum is best
OPTIONAL: Compass to estimate north

Prepare ahead:

Choose a site: **Outside on a fairly flat, level surface in a sunny area.**

preliminary preparation:
Plan for a sunny day. This activity will take about 15 to 20 minutes to construct the watch and about 5 minutes to learn to use it. Know what direction north is or do the Directions from a Stick activity the day before. (Note: Buildings and roads are often constructed with a north/south orientation.)

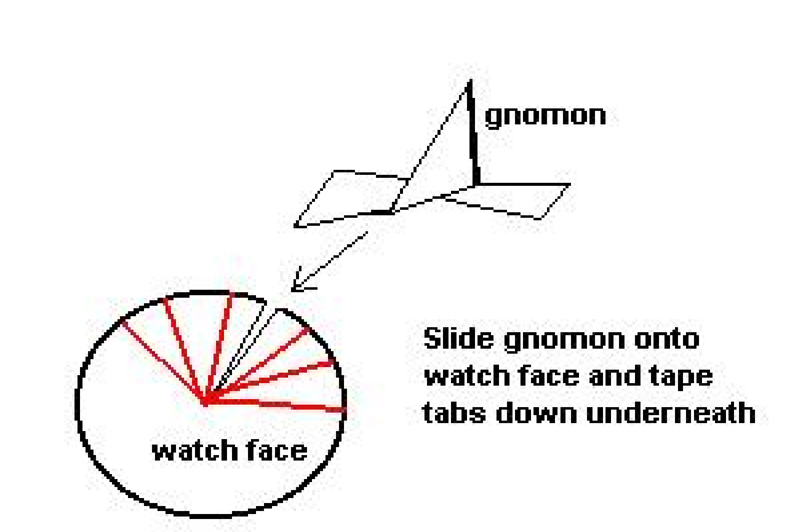
What to do:

1) Cut out a watch face and gnomon for the latitude nearest your own and a wristband piece 2 or 3 cm wide (about 1 inch) and 1.5 times the circumference of your wrist.

2) Cut into the watch face and gnomon along the green lines

3) Fold the gnomon along the dashed line.

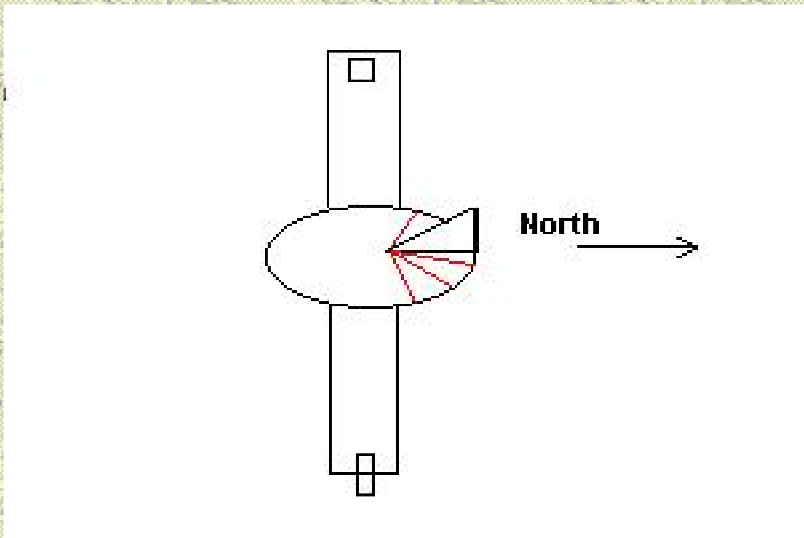
4) Slide the gnomon onto the face's slit, folding the two underneath pieces to opposite sides. Make sure the side of the gnomon that is going STRAIGHT UP&DOWN (vertical) is by the outer edge of the watch face.



5) Tape down the flaps under the watch face, trimming the extra from the flaps.

6) Tape the watch to the wristband with the vertical edge of the gnomon pointing toward the short side of the wrist band (see diagram).

7) Put your sundial watch on your wrist and tape the ends together.



To Use your Sundial Watch:

With the watch on your LEFT ARM, go outside and face WEST, holding your arm with the watch level in front of you so that the vertical edge of the gnomon is pointing NORTH. (If you don't have a compass handy you can usually estimate north since many buildings are oriented to north/south.)

Read the approximate time by the number the shadow falls nearest to.

Another Event Inventor activity closely related to this one is:

- **Determining your LATITUDE by sighting the altitude of the North Star (the angle you are using on your sun watch).**
- **Determining your LONGITUDE by finding Local Solar Noon Time.**

Remember to adjust for Daylight Savings Time (a/k/a Summer Time)

(SUBTRACT ONE HOUR)

Return to Sun Projects Page

Sundials

Shockwave plug-in required to play this game.

DOWNLOAD NOW!

Question:
Dear Beakman,
How does a sundial work?

Answer:
The idea of 12 noon used to be a local thing. That *noon* was different from town to town. That's because it's noon when the sun is at its highest point in the sky and that does not occur at the same instant for all towns.

Sundials worked great for telling local time until the idea of Standard Time was invented. Standard Time was needed to keep the trains running on time because trains traveled from town to town. Train schedules is why we have time zones and Standard Time.

You Can use the game below to move the sun. *You Can* also build a real sundial in your yard or in a park nearby.

Click the sun and drag it across the sky. Or use the buttons.

When you're done, click the **SO WHAT** button below.

SO WHAT?

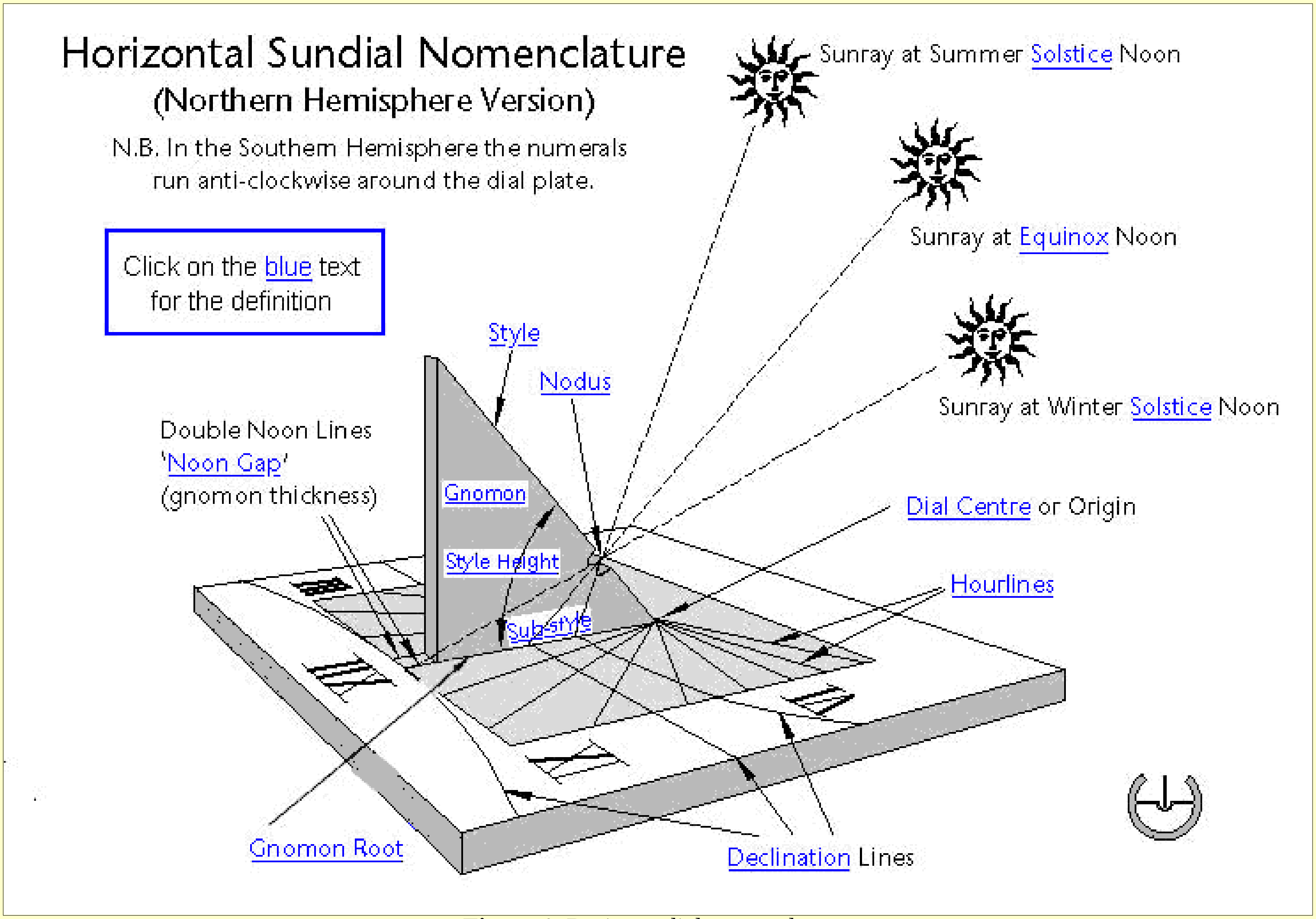


Figure 1. Basic sundial nomenclature.

A

aberration (of light): the effect by which the apparent direction of distant astronomical bodies is altered by the velocity of the Earth and the finite speed of light. Discovered by James Bradley, it has a value of 20.47 arc-sec and is thus totally insignificant to dialling.

accuracy (of a dial): a measure of how closely the time indicators (lines or points) of a dial indicate the true time. Contrast with resolution. See also precision.

Act of 1751: {1752} refers to an act of the British parliament in that year which finally adopted the Gregorian calendar and set the beginning of the (English) year to 1 January, rather than 25 March. As a result, there can be some confusion about the year, prior to 1752, for dates between January and March. Scotland's New Year's Day had already been set to 1 January since 1600. Dates in the Julian calendar are usually denoted "Old Style", with those in the Gregorian "New Style.
British dials made before 1752 and which have EoT or sunrise/sunset tables show dates 11 days earlier than the current ones, e.g. the vernal equinox is on 10 March instead of 21 March, and the EoT will be shown as zero on 5 April, 3 June, 23 August and 15

December. Note that the Act was passed in 1751 but did not come into operation until the following year, hence the alternative dates sometimes seen.

acute angle: an angle of less than 90º.

age of the moon: see phase of the moon.

almanac: an annual calendar of months and days, with astronomical and other data. They usually include an ephemeris of the Sun and some other celestial bodies, the equation of time, the Sun's declination etc. Almanacs are sometimes inscribed on, or accompany, C16-18 dials.
The annual Nautical Almanac, produced by the Royal Greenwich Observatory, derives from the version first published by Astronomer Royal Nevil Maskelyne in 1767.

almucantar: (pron. al-moo-can-tar) a circle of equal altitude on the celestial sphere. It is a small circle on the celestial sphere, parallel to the horizon.

alidade: the revolving arm of an astrolabe through which sightings of the stars are made. Sometimes used on sundials where a pinhole at one end of the ~ forms an image of the Sun on a plate at the other end carrying an analemma.

altazimuth: {alt-azimuth} a mounting system for an astronomical instrument that allows it to be set in altitude and azimuth. The term is also used to describe the horizon co-ordinate system which uses these two parameters.

altitude (of the sun): {elevation} **[*a*, ALT]** the angular distance of the (centre of) the sun's disk above the observer's horizon (negative values indicate that the Sun is below the horizon). It is measured along the principal plane to the sun's centre, and is the complement to the zenith distance. It is part of the horizon co-ordinate system. See Equations. Note that aviators and others use the term altitude to measure a height (distance) above the ground.

anaphoric (clock): a clock with a dial face like an astrolabe, showing seasonal hours.

ante meridiem (a.m.): before noon.

analemma: (pron. ana-lem-a) in modern usage it is a graphical plot with the Equation of Time on one axis and the sun's declination on the other. In appearance, a tall thin figure of eight. The dates of various points around the curve are often shown. The shadow of a point falling onto an arbitrary plane at the same clock time each day will trace out an analemma over the course of a year. Normally seen on the noon line of a dial, but can be on any hour line. The exact appearance of the analemma will depend on the plane upon which it is projected.

Figure 2. The components of the analemma

The word analemma has had several other meanings in the history of astronomy and dialling. In the first century BC, the Roman engineer Vitruvius used the word to refer to a graphical construction, equivalent to today's orthographic projection. In the second century AD Ptolemy used analemma to mean an instrument acting as a nomograph for defining the angles of a dial. The use of a modern analemma on a dial dates to around 1640, and the first treatment in English was by Samuel Foster in 1654.

angle: (units of measurement) may be decimal degrees; degrees, arc-minutes and arc-seconds; radians (2π radians = 360º); or (seldom, military equipment) mils (6400 mils = 360º); or (very rare) grade (1/100th of a right angle). Preferred notations are: [dd.ddº or ddº mm' ss"]. Note that trigonometric functions in computer spreadsheets (e.g. Excel™) are always defined in radians. The mathematical convention is that positive angles are measured counter-clockwise, usually with the zero angle position in the 3 o'clock direction or along the x-axis (see cartesian co-ordinates). In dialling, it is more common to measure angles counter-clockwise from the noon line, although some authors measure from the sub-style line.

Antarctic Circle: the parallel of latitude at 66° 34' S. Note that this defines the northern limit of the region around the S pole having at least one day a year with no night.

antisolar point: the point on the celestial sphere directly opposite the sun's position.

aperture: a small transparent hole in an opaque surface, designed to let a small beam of sunlight through to fall on a dial plate or alidade e.g. for noon dials, ring dials and heliochronometers.

aphelion: (pron. ap-heel-eon) the point where the Earth's orbit takes it furthest from the sun. It occurs during the first week of July.

apogee: (pron. apo-gee) the point in the Moon's (or other satellite's) orbit when it is furthest from the Earth.

arc: a curve which is part of the circumference of a circle.

arc-minutes {or **minutes of arc**}: an angular measure equal to 1/60th of a degree. Preferred notation [' or arcmin].

arc-seconds {or **seconds of arc**}: an angular measure equal to 1/60th of an arc-minute. Preferred notation [" or arcsec].

Arctic Circle: parallel of latitude at 66° 34' N. Note that this defines the southern limit of the region around the N pole having at least one day a year with no night.

Aries (first point of): see equinoxes.

armillary sphere: a skeleton model of the celestial sphere with rings representing the equator, tropics etc. Often finely made in brass, but versions in wood with paper scales were common in 19th century France. It is also the basis of a form of dial - see armillary, dial (types of).

ascendant: rising towards the zenith. Note: astrologers have a different definition.

astro compass: see solar compass.

astroid: (pron. as-troy-d) a mathematical curve which is formed by the envelope of a series of straight lines, and has the equation: $x^{2/3} + y^{2/3} = 1$. In dialling, it is the shape of a vertical gnomon used in the latitude-independent astroid dial. The astroid curve is also one branch of the shape which is traced out by a point on the circumference of a circle as it rolls inside a circle of four times the radius.

astrolabe: an early astronomical instrument in the form of a heavy disk (the mater) which was suspended vertically and had an angular scale marked around it (the limb). A coplanar klimata and an alidade rotated about its centre. A fretted rete gave the positions of the brightest fixed stars. The various components were held on the central pivot (the pin or axis) by a small wedge or horse; sometimes dog.

> The **planispheric ~** represents the celestial sphere by a two-dimensional stereographic projection, showing the position of the sun and major stars at different times and dates, as well as different latitudes. A separate plate is required for each latitude. It was probably a Greek invention of the 2nd century BC, but it was developed extensively by the Islamic cultures from the 9th century AD. It fell out of use in the late 17th century in the west.
>
> The **universal ~** uses modified projections of the celestial sphere so that they are latitude-independent. The Gemma Frisius type (developed in the west in the early 16th century) retains the stereographic projection but moves the centre to the First

point of Aries. The Rojas type (by J. de Rojas of Sarmiento, 1550) uses an orthographic projection with a projection point at infinity. The La Hire type (late 17th century) moved the projection point in an attempt to make it easier to read.

The **mariner's ~** is a much-simplified instrument designed to measure the sun's altitude, using an open frame and weighted at the bottom to make it more stable onboard ship; it is a precursor to the sextant.

See Appendix X for further astrolabe terminology.

astronomical triangle: the spherical triangle on the celestial sphere whose vertices are the observer's zenith, the elevated celestial pole, and the position of the Sun (or other celestial body).

atmospheric refraction: see refraction.

autumnal {or **fall**} **equinox**: see equinoxes.

axis (of the Earth's rotation) or **polar axis**: the line running through the true North and South poles about which the Earth rotates.

azimuth (of the sun): **[A, AZ]** the angle of the sun, measured in the horizontal plane and from true south. Angles to the west are positive, those to the east, negative. Thus due west is 90°, north is ±180°, east –90°. It is part of the horizon co-ordinate system. See Equations. Note that navigators (and some astronomers, but not Meeus) measure azimuth or bearings clockwise from the north.

B

back-staff: an old instrument for measuring the altitude of the Sun while facing away from it. The **Davis quadrant**, designed by the English captain John Davis, is actually a form of back-staff.

bay (or bay en imy wenut): literally a "palm rib of the observer of the hours". It was an ancient Egyptian instrument or sighting device, used in conjunction with a merkhet to observe and time transits.

Beltane {Beltaine}: an ancient Celtic festival held on the 1st of May, when bonfires were lit. It is one of the cross-quarter days

bissextile: a leap-year (from bis sextus dies, or doubled 24 February).

blue moon: there are at least two possible meanings. It can mean a second full moon in a given calendar month. It seems that this "meaning" was accidentally invented by Sky and Telescope magazine in 1946, but it has passed into wide usage. Alternatively, it may mean that the Moon actually has a blue coloration, due to smoke or other aerosols in the atmosphere. Both phenomena are rare (the second more so), hence the expression "once in a blue moon".

brachiolus: (pron. brak-e-o-lus) from the Latin for "little arm" it is a movable arm which acts as a suspension point for a cord on a card dial.

break of day: see daybreak.

British Summer Time [BST]: see time (types of).

C

Candlemas: the festival of the purification of the Virgin Mary, on 2nd February. It also corresponds to the Celtic festival of Imbolic, and is a cross-quarter day.

calendar: a system for counting days and defining the date.

Campbell-Stokes: see sunshine recorder.

Cancer: see tropics.

canting out: see wedging out.

Capricorn: see tropics.

cardinal point (of the compass): North, South, East or West [N, S, E or W]. These points are the intersections of the celestial meridian (N, S) and the prime vertical (E, W) with the horizon. Note that the Latin terms are Septentrio, Meridies, Oriens and Occidens, so that a compass rose on a mediaeval dial simply identifying "S" is ambi guous.

cartesian co-ordinates: see co-ordinates .

celestial equator: the intersection of the extended plane of the Earth's equator with the celestial sphere.

celestial latitude: see ecliptic latitude.

celestial longitude: see ecliptic longitude.

celestial pole: the points on the celestial sphere where it meets the Earth's axis. The stars appear to rotate around these poles.

celestial sphere: an imaginary sphere, arbitrarily large and co-centred with the Earth, on which all the stars appear to be fixed.

centre (of a dial): the point where all the hour lines, and a polar-pointing style, meet. This point does not always exist (e.g. on polar dial and direct E or W dials, the lines meet at infinity). In simple horizontal or vertical dials, this point coincides with the root of a (thin) gnomon. In the case of a thick gnomon having two styles, there are two centres to the dial. The centre is often, but not necessarily, the origin of the co-ordinate system used to describe the dial. See Figure 1.

chapter ring: the ring on a dial face carrying the hour numerals. The term is more widely used for clocks, but it also finds use, for example, on dials with several separate rings for different locations.

chilindrum: see Dial (types of); cylinder ~.

civil time: see Time (types of) civil~.

clinometer: an instrument for measuring the inclination or slope of a surface. Also called an inclinometer.

cloisonné: a term sometimes used to describe the technique of making metal dials by deeply etching the lines and numerals and then filling them with coloured material. It derives from the jewellery method of separating enamels into shallow compartments with metal edges.

co-latitude: equals 90° – latitude.

compass bowl: a bowl sunk into the dial plate of a (portable) horizontal dial to house a magnetic compass.

compass rose: a drawing of the compass directions, showing as a bare minimum the cardinal points, but more usually eight, sixteen or thirty-two points.

compendium: normally used to describe a collection of scientific instruments in one case. Also, **Compendium**: the journal of the NASS.

conic section: any of the range of geometric curves produced by the intersection of plane with a cone (i.e. circles, ellipses, parabolas and hyperbolas).

co-ordinates: a system of measurements used to describe any point in two or three dimensions.

Co-ordinate Systems:

Cartesian ~ [x,y,z] in which the axes are mutually perpendicular, are normally used for positions of points within a dial. For simple horizontal dials the preferred axes have x increasing to the E of the dial plane, y increasing to the N of the dial plane and z (in 3-D only) increasing. perpendicularly to the dial plane (upwards)**.** For vertical and other plane dials, x increases to the left, y increases downwards, and z perpendicular to the plane in the direction towards the observer. The origin of the system must be defined explicitly. Note that these definitions produce a conventional right-handed co-ordinate system, and are also those used by the Zonwvlak programs.

ecliptic ~: {celestial ~} **[β , λ_e]** or **[ELAT, ELON]** the system of ecliptic (or celestial) latitude and longitude, defined with respect to the ecliptic and the celestial poles. Ecliptic co-ordinates predominated in Western astronomy until the Renaissance but, with the advent of national nautical almanacs, the equatorial system, more suited to observation and navigation, gained ascendancy.

> **Figure 3.** Celestial co-ordinates seen by an observer in mid-northern latitudes.

equatorial ~: **[α, δ]** or **[RA, DEC]** is the most common astronomical co-ordinate system and is defined by the celestial equator and poles. The right ascension and declination are directly analogous to terrestrial latitude and longitude.

> **Figure 4.** The equatorial system of celestial co-ordinates, showing the right ascension (RA) and declination (dec) of a star.

galactic ~: is used for studying the structure of the galaxy. It is unlikely to be encountered in dialling.

geographic ~: (or terrestrial ~) **[ϕ, λ]** or **[Lat, LON]** the standard method of determining any location on the Earth's globe, using latitude and longitude.

horizon ~ system: {or altazimuth system} **[*a*,A]** or **[ALT,AZ]** the simplest celestial co-ordinate system, it is based on altitude and azimuth. It is fundamental in navigation as well as in terrestrial surveying. However, for specifying the position of the Sun or other celestial bodies, other co-ordinate systems fixed with respect to the celestial sphere are far more suitable.

Ordnance Survey co-ordinates: (also referred to as the British National Grid, BNG) the system of Eastings and Northings used to define locations in the UK. They are cartesian co-ordinates with a basic grid consisting of 100km squares, each of which has a unique two-letter code (e.g. SZ). See Appendix XI for a map of the grid squares. The full OS grid reference comprises these two letters followed by a three-digit easting and a three digit northing, eg SZeeennn. This gives a resolution of 100m in both directions. Higher resolution ("6-figure" or BNG) references usually replace the letter code with their numerical values, eg eeeeee nnnnnn, giving a 1m resolution. Here, the first two digits of the easting (northing) are the distance in 10 km increments east (north) of the datum point at the bottom left of the map. Note that the OS maps on which the co-ordinates are based use the transverse Mercator projection, with a projection origin at 49º N; 2° W.

polar ~ :[*r*, θ] an angle-based co-ordinate systemal sometimes used for defining points on a dial plane, where *r* is the distance from the origin and θ is measured anti-clockwise from the S. Note: navigators also make use of polar co-ordinates and usually define them as (θ, *r*).

Ptolemaic co-ordinates [hec, hor]*:* an angular co-ordinate system loosely based on the geometry of Ptolemy.

terrestrial : see geographic ~.

End of Co-ordinate systems

cross: for a discussion of the cross sometimes seen on the noon line of a dial, see noon cross and cross patty.

cross-quarter days: days which are (approximately) midway between the Quarter days, hence dividing the year into eight parts. They are occasionally used instead of the zodiac signs for declination lines on dials, and have become adopted as modern celebrations or holidays. See Appendix XII for their names and dates.

cross patty {c. pattée or c. formée}: an heraldic term for a form of square cross shape (✠) sometimes seen instead of XII on the noon line of dials. It is perhaps the most common of the noon crosses.

cross-staff: a simple instrument for determining t he altitude of a celestial body. A cross piece or transom is moved along a staff, calibrated with a cotangent scale, and sighted by eye against the body and the horizon. Old illustrations often show a ~ with three transoms fitted but, in use, only one would be used at a time. Also called a **fore-staff** or **Jacob's staff**.

culmination (of the sun): to lie on the meridian or, in more general language, to reach its highest point. Equivalent to the superior transit. From the Latin "culmen", meaning summit.

cursor: a part of a mathematical instrument which slides backwards and forwards over a scale.

cusp: (mathematical) a sharp point where two curves meet e.g. the "horns" of the Moon (strictly, where the second derivative of a curve changes sign).

(astrological) the initial point of an astrological house or sign.

cycloid: (pron. si-cloy-d) a geometric curve which is traced out by a point on the circumference of a circular disk rolling (without slipping) along a straight line.

D

daeg mael: one of the Anglo-Saxon tides, it may also have been the word for a dial in the early Anglo-Saxon period.

dagsmork: an Icelandic term ('daymarks') referring to landmarks in the countryside which, when viewed from a fixed location, indicated the direction of the Sun at fixed times of the day.

date: a single day in a chosen calendar system. Note that the agreed international date system (and British Standard 4795) specify "year, month, day" - for example 1951 August 10. Common UK usage is the reverse of this - beware the illogical American usage of month, day, year, especially in all-numeric forms.

Date Line see International Date Line.

dawn: the first light of day, taken as the onset of morning twilight.

day: the period for one rotation of the Earth. **Solar** ~ : measured between successive transits of the sun**: Mean solar** ~ :measured between successive transits of the fictitious mean sun. Equal to 24 hours, it is the usual meaning of ~ unless it is further qualified**. Sidereal ~** : measured between successive transits of the First point of Aries (or, in everyday language, any 'fixed' star). A sidereal day is 23 hours 56 minutes 4.1seconds. Beware the possible confusion between day and daytime.

daybreak (or **break of day**): an old term for first light, usually taken as the onset of astronomical twilight.

daytime: that period of a day between sunrise and sunset.

Daylight Saving Time: see time (types of).

declination (of a wall) {sometimes called the **declining angle** or the **deviation**, to avoid confusion with the *sun's* declination}: **[*d*, DEC]** the angle, measured in a horizontal plane, that a wall's perpendicular makes with due south (i.e. a wall facing S has $d = 0°$). Walls declining westward have positive declinations, those eastward, negative. Beware – this is not a universal convention and some authors define the angle with respect to the nearest cardinal point of the compass.

declination (of the sun): **[δ, DELTA, DEC]** the angular distance of the Sun above or below the celestial equator. Its value follows an annual sine wave like curve, varying between 0º at the equinoxes and ±23.4º (approx.) at the solstices. It has positive values when the Sun is above the celestial equator (summer in the Northern hemisphere) and negative when below. The same system is used as part of the equatorial co-ordinate system (together with right ascension) to locate other celestial bodies. See Figure 1 and Equations.

declination lines: lines on a dial showing the sun's declination on a particular date. They are read by observing the shadow of a nodus.

degree: [**º** or deg] an angle equal to 1/360 of a complete circle.

descendant: falling from the zenith. Note: astrologers have a different definition.

diagonal scale: a device for interpolating between scale divisions, pre-dating the vernier scale. It is constructed by drawing diagonals between individual divisions across a wide band, with a series of equi-spaced arcs parallel to the main scale crossing them. It is read by noting the position of the fiducial line with one of these arcs. Most usually found on astronomical instruments, a similar design was used by Sir Christopher Wren for indicating the minutes on his famous vertical dial on All Souls' College, Oxford.

dial: a Middle English word, apparently deriving from the Latin 'dies' though the medieval Latin 'dialis', used for what is now called a sundial. It later became used for many types of indicators, hence the necessity (from 1599) for the qualifying 'sun' prefix. The word ~ in modern English has now become common again as a shortened version of sundial. Hence **dialling** {dialing}, the art and science of designing and constructing dials; **diallist** {dialist}, one who designs or makes dials.

Dial types:

Ahaz (Dial of Ahaz): supposed refraction dial, from the Bible story (Kings 20 v8-11) which may allude to a dial showing time running backwards.

altitude ~: {or elevation ~} any dial which uses the sun's altitude, rather than its azimuth, for indicating the time. Usually does not need to be aligned N-S. Examples are ring dials, flag dials, and shepherds' dials. Altitude dials were also often incorporated in quadrants and folding rules.

analemmatic ~: (pron. ana-lem-mat-ic) dials consisting of hour points, (rather than lines) laid round an ellipse, and a movable gnomon perpendicular to the dial plane. It may be on any plane, but the most usual form is horizontal. In the horizontal version of the dial, gnomon position lies on the straight N-S minor axis, at a point determined by the sun's declination (i.e., the date). Most usually found set in the ground in parks, where the observer acts as the gnomon. Note that some of these dials show an analemma drawn about the gnomon positioning line. This is a method of indicating the EoT for the appropriate date, but it must be remembered that the gnomon is not positioned on the analemma. The analemmatic dial may be regarded as a projection of the universal equatorial ring dial. Analemmatic dials were once common paired with a horizontal ~ in a self-orienting portable compendium.

analemmic ~: this term has sometimes been used to describe dials which have an analemma-shaped gnomon, or analemmas on the hour lines, enabling them to read mean time. Note, the dials have no direct link to analemmatic ones.

Anglo-Saxon ~ {sometimes just **Saxon ~**}: a sundial from the Anglo-Saxon period (c 650 – 1050 AD); designed to show unequal hours, or the basic tides, with a horizontal gnomon. Similar to the mass dials which superseded it, a Saxon ~ shows much higher levels of craftsmanship and is often finely decorated. Also, it is invariably engraved in a separate (circular or rectangular) stone, not into a pre-existing wall. Saxon dials are often taken to be the precursors to the later scientific dials. In the early part of the period the semicircle was divided by five lines into four segments. During the latter part of the period it was subdivided into eight or twelve segments and the dial sometimes carried an inscription in Old English. Throughout the period the principal lines had a cross bar near the perimeter giving the appearance of Latin crosses. See Appendix II for the basic time periods shown on the dial.

antiboreum: an ancient form of dial in which a partial-sphere is hollowed into a stone, and a ray of sunlight enters the partial-sphere through a south-facing pinhole through the stone.

armillary: (pron. ar-mil-ar-y) (or armillary dial; some authors also use the term armillary sphere) a form of equinoctial sundial which comprises, as a minimum, two circular bands plus a rod through the poles representing the Earth's axis and acting as the gnomon. One band represents the equator (carrying the hour scale) and the other the local meridian. Usually, other great circles are added representing the Prime meridian and the ecliptic plane, sometimes together with small circles for the tropics and arctic circles. These add artistically, but detract from its clarity as a dial. The gnomon sometimes carries a nodus at the centre of the sphere; this may be used for indicating the date.

astroid ~: a ~ which uses the sun's declination, altitude and azimuth to give the hour angle. It is latitude-independent, and is named after the geometric shape which forms its gnomon.

auxiliary ~: a small equatorial dial used as a mechanical aid to constructing dials on other planes (particularly vertical decliners) by co-mounting on a common gnomon and projecting the hour lines. Often used with a trigon.

azimuthal ~ (or **azimuth ~**): any dial which uses the sun's azimuth for indicating the time. It usually needs to be aligned N-S, and has a vertical style (if it has no dependence on altitude).

Berossos ~: another term for a hemispherium, named after its inventor Berossus Chaldaeus, a Babylonian astronomer who flourished on the Greek island of Cos around 270 B.C.

bifilar ~: invented in 1922 by Hugo Michnik in its horizontal form, although it can be on any plane**.** The time is indicated by the intersection on the dial plate, of the shadows of two wires (or other lines in space) stretched above and parallel to it. The wires often run E-W and N-S, with their (different) heights above the plane being a function of the location of the dial. It may have equiangular hour markings, and hence can be delineated to show many kinds of hours.

Bloud ~ : a portable, *magnetic* azimuth ~ made mostly in Dieppe by makers such as Charles Bloud.

book ~ {**open book ~**}: a modification of the polar ~, with the dial plate consisting of two planes set in a vee, with their intersection line lying parallel to the Earth's axis. A polar gnomon can be placed bisecting the angle of the two planes. Alternatively it may be arranged so that the outer edge of each plane acts as the gnomon for the other. The term book ~ can also be applied to diptych dials which are designed to look like a book when closed.

Butterfield ~: a pocket sundial by, or in the style of, Michael Butterfield (Paris, 17th century). Typically it consists of an octagonal silver horizontal dial with a gnomon of adjustable angle, often with a bird's head pointer, with several rings of hour lines for cities of different latitudes. A magnetic compass is fitted in the same case.

cannon ~: see noon gun.

Capuchin ~ {or **Capucine** ~}: a latitude-specific card dial, related to the Regiomontanus dial. So-called because the outline of the hour-lines is said to resemble a hooded Capuchin monk.

card ~: a class of portable dials built on a single plane, e.g. a card which is suspended in the vertical plane. They usually have a sun sighting device along one edge, and a cord with a bead which hangs vertically below a movable suspension point.

ceiling ~{also known as a **mirror ~** or **reflected ~**}: a dial marked on a ceiling where the time and date are indicated by a beam of sunlight reflected from a small horizontal mirror placed on a windowsill.

chalice ~ (or **cup, bowl** etc.): a form of refraction ~ where the hourlines are drawn on the inside of a drinking vessel. Early examples, often in precious metals are rare and valuable.

Chinese ~: a wide range of dials have been used in China, from the vertical gnomon of the mythical astronomer Xi, through equiangular ~ with sun-pointers and 100-segment time scales from the 1st - 2nd centuries BC, equatorial dials for equal hours in the Ming dynasty (1368 to 1664), to conventional horizontal dials in the 19th century.

compass ~: a portable horizontal dial with an accompanying compass to allow it to be correctly oriented. The compass is often below the pierced dial plate, and the gnomon is hinged for packing. Beware: the term compass dial is often used to mean a magnetic dial.

complementary ~: a (hypothetical) horizontal ~ used as an aid to designing a vertical declining and/or reclining dial. Its gnomon and hour lines are calculated not for the site of the proposed (real) dial, but for the location where the Earth's surface is parallel to the dial plate of the proposed dial. For a simple direct south dial, the complementary dial would be located at the co-latitude.

cone ~: a term used to describe several entirely different types of dial.(a) a class of dials where the dial plate is an inverted, truncated cone, giving dials similar to a scaphe dial or a hemicyclium, or (b) a class of modern dials which use a cone lying on its side as the gnomon. Many varieties, including sidereal, exist.

cross ~: (or cruciform ~ or crucifix ~) a dial in the form of a cross, usually of stone, with the "front" surface of the cross parallel to the equatorial plane, and the top pointing south. The side surfaces of the cross can each form a dial plane, with its gnomon being a corresponding edge of the cross itself. Usually found as churchyard memorials. Rare. Portable cross dials have the long arm parallel to the polar axis and the short arm E-W.

cube ~: a (set of) dials on the surfaces of a cube. There may be up to 6 dials, but more often 5 e.g. direct N, S, E, and W, together with a horizontal on the top surface. Alternatively, it is possible to set the cube so that its top surface is parallel to the equatorial plane, i.e. the base makes an angle equal to the co-latitude with the horizontal. Both portable (usually adjustable) and monumental versions are known.

cycloid (polar) ~: a variation of the standard polar dial in which the gnomon has a cycloid shape, with the result that the hour lines are equally spaced.

cylinder ~ (also known as a **shepherd's ~** or **pillar** ~): a portable, altitude dial in which hour lines for different dates are delineated around the surface of a cylinder, which is allowed to hang or stand vertically. A horizontal gnomon projects radially from the top of the cylinder, and is adjusted to the appropriate date around its periphery. Sometimes two gnomon are supplied; a long one for winter and a short one for summer. The dial is held with the gnomon facing the Sun so that the shadow falls vertically. Latitude specific. This was the **chilindrum** of Chaucer's monk.

declining ~: a vertical dial which does not face any of the cardinal points of the compass. The sub-style will be displaced from the noon line, although the latter will still lie vertically below the dial centre.

diametral ~ : one of the equatorial projection dials, first described by Samuel Foster of Gresham College in the 17th century, it is a horizontal dial with a moveable style and hour points which lie along a straight line lying E-W.

diffraction ~: a dial invented in 1999 by M. Catamo & C. Lucarini. It has no gnomon, but the dial plate consists of a circular diffraction pattern, which forms a bright, multicoloured diametrical line pointing at the Sun when viewed perpendicularly to the centre of the dial plate. Horizontal, altitude and equinoctial versions are possible. The dial plate is usually made from a CD (compact disc), hence "**CD dial**".

digital ~: an ingenious 20th century dial. The "gnomon" consists of a rectangular sandwich of shadow masks set parallel to the polar axis. This gnomon casts a shadow in which digits representing the time are sunlit. Patented, and requires great precision in manufacture.

diptych ~: (pron. dip-tich or dip-tic) a portable (pocket) dial in which a vertical and horizontal dial are hinged together, and a common cord gnomon running between them also ensures that they open to a right angle. Latitude specific. This term is, confusingly, sometimes also used to describe a monumental open book dial.

direct ~: a vertical dial which directly faces one of the cardinal points of the compass e.g. direct S.

double horizontal ~ : a horizontal dial with (usually) a combined polar pointing gnomon and a vertical one showing the time/date on a stereographic projection of the sky onto the horizontal plate. Capable of self orientating, although normally fixed in position. Usually attributed to William Oughtred in the early 17th century, early hand-engraved versions are very fine.

Egyptian ~: a range of sundials from ancient Egypt (portable and fixed) exists, the earliest being from the time of Tuthmosis III (1479-1425 BC). The portable devices appear as a long, thin 3-D letter "L", laid with the long shaft horizontal along the sun's azimuth, with the upturned foot casting a shadow onto the shaft. It is very similar to the merkhet but has a dedicated hour scale

equant ~: (pron. ek-want) a modified horizontal ~ in which the hour-lines are replaced by hour points. These points are arranged round a geometric curve chosen so that the points are equally spaced, allowing the use of a vernier scale and more accurate interpolation of times. Not related to Ptolemy's equant point.

equatorial ~: a dial in which the dial plate is set parallel to the equatorial plane and the polar-pointing gnomon is perpendicular to it. The dial has hour lines equally spaced at 15º intervals around the gnomon, and hence the dial plate may be rotated to account for EoT, longitude and BST/DST corrections. Sunlight falls on the underside of the dial plate from the autumnal equinox until the vernal equinox. For this period, the gnomon must project below the dial plate, which is delineated on both sides. An alternative form replaces the dial plate by a narrow hour ring (or half-ring) allowing the scale, inscribed on its inner circumference, to be read throughout the year. With this form, special analemma-shaped gnomons can be used to show mean time. Note: some authorities insist that this dial should be called an equinoctial ~.

equiangular ~: a term used for dial types where the hour points are placed at equal angles (15º) around a circle (or part of). If the dial plane is not parallel to the equatorial plane, the mounting of the gnomon, (which does not need to be polar) must be movable to accommodate this.

equatorial projection ~: a class of dials obtained by projecting a universal equatorial ring dial onto any plane. Members of the class include analemmatic, diametral, Foster-Lambert and Parent dials.

equinoctial ~: (pron. ec-we-noc-te-al) another (historical) name for an equatorial ~, preferred by some authors.

flag ~: an altitude ~, formed by "unwrapping" the scale of a shepherd's ~ into a flat plane which can be shaped like a flag or pennant and is positioned perpendicular to the sun.

Foster-Lambert ~: a form of equatorial projection dial, with the projection arranged to produce a circular ring of equiangular hour points. A good example is the large reclining dial (now back at Herstmonceux Castle after a period at Cambridge) designed in 1975 by Gordon Taylor for the Royal Greenwich Observatory.

geographical ~: a dial in which the dial plate shows a map of the world, with curved hour lines allowing the time at any location to be indicated.

globe ~ (or **spherical** ~): a class of dial in which the "*dial plate*" is a globe or sphere, usually set with its axis parallel to the Earth's polar axis and often with the observer's position at the top. The gnomon is in the form of a thin semi-circular vane which can swivel around the globe about its axis. In use, the vane is rotated until the shadow is minimised and the time read from an equiangular scale around the equator. It indicates the meridian of longitude where it is currently noon. An alternative type of globe dial (a terrella) simply uses the globe itself to form the shadow, and the time is indicated by the terminator. Transparent globe ~ are also possible (the Wenger ~). where the shadow of a movable point on the surface is made to fall on the centre of the globe.

Graeco-Roman ~: a general class of dial from about the 3rd century BC (Greek) to the 4th century AD (Roman). Made of stone, they include the hemispherium, the hemicyclium, and some conical dials.

great decliner: usually indicates a declining dial which nearly, but not quite, faces E or W. The centre of the dial falls off the dial plate and, as a consequence, it does not show a noon line.

hâfir dial: an Islamic dial with unequal hours, vertical gnomon and equiangular date scale of 12 segments.

halazûn dial: an Islamic dial with unequal hours, vertical gnomon and a date scale of 6 segments (each representing two signs of the zodiac).

hat ~: an altitude dial comprising a circular disk mounted concentrically on top of a vertical cylinder. The dial is read by the maximum vertical length of the disk's shadow on the outside of the cylinder.

heliochronometer: a precision sundial which incorporates some means to allow it to read civil (or mean) time. This is usually achieved by incorporating an EoT cam (as in the Pilkington and Gibbs heliochronometers), or by projecting a spot of light onto an analemma. Note: some authors use this term to describe any precision sundial.

hemispherium: an ancient dial with the dial surface formed by a hemisphere hollowed into a horizontal (or occasionally vertical) stone face. The gnomon is a vertical spike (length equal to the radius of the sphere) set in the bottom of the hemisphere. It is essentially a horizontal altitude dial, with a shaped dial plate which prevents sunrise and sunset being at infinite distances.

hemicyclium: similar to the hemispherium, but with the south-facing part of the hemisphere cut away, and with the gnomon now projecting horizontally from the N edge.

horizontal ~: the common or garden sundial with a horizontal dial plate and polar-pointing gnomon. Latitude specific.

inclining ~: usually applied to portable dials in which a horizontal dial, designed for a high latitude, typically 60º , may be inclined by raising its southern edge (in the N hemisphere) so that it may be used at locations with lower latitudes. The opposite arrangement is also sometimes found. The term is also sometimes confusingly used for near-vertical dials where the top leans away from the observer.

Islamic ~: a ~ with unequal hours and showing the Islamic prayer times.

Lambert ~: see Foster-Lambert ~.

Little Ship of Venice {or **Navicula**}. A portable dial in the shape of a Venetian ship with a central mast. Based on the Regiomontanus dial, the few early examples are valuable.

magnetic ~ {or **magnetic compass ~**} : a small portable ~ in which a complete horizontal ~ is mounted on a compass card, and hence is self-orienting. In principle, the magnetic variation of the place and date where it will be used can be accommodated by rotating the dial from the magnetic N-S line of the compass. Beware: this type of dial is sometimes described as just a compass dial.

magnetic azimuth ~: a portable ~, usually in diptych form. There is no string gnomon but instead the lid is lined up to fall exactly on the base, the time being read from the compass needle on a chapter ring. The chapter ring position is moved in a N-S direction from a calendar volvelle on the under side.

mass ~ (or **mass clock**. Also known as a **scratch ~**): a rather basic dial from the medieval period scratched or engraved into the south-facing stonework of a church or similar building, often near the main door or the priest's door. Although later than Anglo-Saxon dials, they are generally less well executed. Usually circular or semicircular in form, with a hole in the centre to accommodate a horizontal gnomon rod (invariably missing). Delineated, probably empirically, to show some form of unequal hours, there is a huge variety of design types. Some are event markers rather than true sundials.

mechanical universal equinoctial ~ (sometimes **minute ~**): a ~ that uses gearing to show accurate time on a clock face, i.e. a solar clock.

mirror ~: a ~ having no gnomon, but using a small, appropriately angled mirror to reflect a small spot of sunlight onto the dial face. The dial may be on a vertical wall facing N or within a building. See also ceiling dial or reflecting dial (separate definitions).

monofilar ~: a ~ in which time is marked by the point where the shadow of a thread (or other thin gnomon) held between the dial face and the Sun intersects a set of date lines.

moon ~: a sundial calibrated in some way so that it can tell the time by moonlight. No change to the basic dial is required, but a correction factor for the time is required which accounts for the age or phase of the Moon. Never very accurate because of the complex nature of the Moon's orbit, they generally require a nearly full Moon to be able to be read clearly. Purpose-built moon dials have either spiral hour lines or a table of moon phases (as in the famous Queens' College, Cambridge, dial).

multiple ~: simply more than one dial physically incorporated into the same dial structure.

multiple gnomon ~: a ~ in which there is a separate shadow casting element (gnomon) for each hour line. The elements can be points, lines or planes.

navicula de Venitiis: see Dial Types (Little Ship of Venice)

noon (or meridian) dial or line: a dial which has only one hour line, for noon. It has a nodus rather than a full gnomon. This may be in the form of a small ball on the end of a shaft or, more usually, an aperture in a plate or window opening into a building. Very long, accurately-levelled meridian lines (running N-S) built into cathedrals were intended for the accurate determination of the equinoxes, solstices and other solar parameters. A **noon dial** (as opposed to noon line) is usually taken to mean a complete noon analemma, possibly including dates.

noon gun: a small cannon mounted such that focussed sunlight from an appropriately angled lens falls on the touch-hole and fires the gun at noon. A novelty rather than an accurate time indicator.

noon mark: a stone, or line marked on a stone, set to receive the noon shadow of a building or other feature. The term is, however, often used interchangeably with a noon ~.

Nuremberg ~: a loose collective term used for the diptych dials made around Nuremberg, Germany, during the 16th and 17th centuries. The majority were made of ivory, featured a compass bowl in the lower leaf and had a string gnomon.

Oughtred ~: another name for a double horizontal dial.

Parent ~: a form of analemmatic ~, with the dial plane parallel to the Earth's axis so that the ellipse of hour points becomes a segment. First designed by Parent in 1701.

pelekinon ~: a form of ~ attributed to the Greeks around 100 BC. In appearance, the dial resembles a butterfly or double-headed axe, and was delineated to show unequal hours.

pillar ~: see cylinder ~. Sometimes also confusingly used to describe monumental dials mounted on tall pillars.

poke ~: an old term for a pocket or portable dial.

polar ~: a ~ in which the dial plate is set along the E-W direction and reclines so that it is parallel to the polar axis. The standard polar-pointing gnomon is thus also parallel to the dial plate. Simple to construct, but the hour lines disappear to infinity when the Sun is in the plane of the dial. For a south-facing polar dial, the theoretical limits at the summer solstice are 6am to 6pm.

polarised light ~: a gnomon-less dial which detects the orientation of the polarised skylight. Its polariser/analyser system is best arranged to view a region of the sky near the N celestial pole (S in the southern hemisphere), allowing the hour lines to follow a standard 15° per hour scale. Although not particularly accurate, it has the advantage that it does not require direct sunlight to work as long as there is clear sky towards the N celestial pole. Thought to have been invented by Sir Charles Wheatstone in 1848.

polyhedron ~: a multiple dial in the form of a solid polyhedron, with a separate dial on each face. Usually each dial is some form of decliner/recliner, but may include scaphe and polar dials as well. Particularly common as the monumental Scottish stone lectern and obelisk dials.

portable ~: simply a dial meant to be moved from place to place, either as a pocket dial or simply being transportable. In most forms, some means of orienting the dial is included, and they are often either universal or capable of being read at a number of fixed latitudes.

prism ~: a term occasionally used to describe a multiple dial with two or three dial faces set on the sides of a triangular prism.

proclining ~: a term sometimes used to describe a dial which is approximately upright but which leans forward towards the observer. A dial which leans forward by 10º will have an inclination of +100º. They are sometimes also called inclining dials, although that term is best reserved for dials derived from a horizontal ~.

reclining ~ : strictly, an approximately vertical dial which leans backwards away from the observer. However, often used as a catch-all term for any non-vertical dial. The angle is defined from the horizontal towards the observer, so a dial which leans backwards by 10º from the vertical has an inclination +80º.

reflecting ~: these dials have no gnomon, but reflect sunlight by means of a semi-cylindrical mirror, set with the axis of the mirror parallel to the *polar* axis. The mirror reflects the light to form a caustic curve amongst the hour points. For the special case of the mirror having a cycloid shape, the hour points are equally spaced. Note that the term reflecting dial may also be used for ceiling dials.

refraction ~: dials which use a clear liquid in a solid cup to compress the hour lines. Sometimes drawn on the inside of a drinking cup - a chalice dial - (see Dial of Ahaz) or on the bottom of a fountain basin or swimming pool. A second form uses a cylindrical lens to focus sunlight onto a curved dial plate.

Regiomontanus ~: a universal form of card dial, usually with the suspension point of the cord movable in two dimensions in the card plane. It is the basis for many other variants of dial.

ring ~ : a portable, altitude dial in the form of a ring, with a small aperture in its circumference. The ring is suspended in a vertical place such that the aperture faces the sun. The time is then indicated on a time/date scale on the inside of the dial. The suspension point may be adjustable on the circumference to allow for latitude changes. Not very accurate, due to their usually small size and the fact that a very compressed date scale is needed to prevent the ring becoming too wide. These dials were known by Vitruvius in the first century BC. Beware: this term is also sometimes loosely used to described a universal equinoctial ring dial.

Saxon ~: see Anglo-Saxon ~.

scaphe ~: (pron. sk-af-e) {skafe, scaphion} a dial in which the dial plate is a shallow dish in any plane (usually a horizontal or, rarer, vertical one). The name comes from the Greek word for boat, and the dial itself is thought to have developed from the hemispherium. Normally with a vertical gnomon.

scientific ~: a term usually taken to mean a dial which is designed to show equal hours, or at least in which the effect of latitude been mathematically accounted for. Thus any dial with a polar-pointing gnomon is scientific, but, for example a mass dial is not. Mostly, they date from the 16th century onwards.

scratch ~: see mass dials.

self-orienting ~ : any dial which, when correctly adjusted for he latitude and/or date, can be used to find the direction of south. Sometimes also called "self-southing".

shadow plane ~: a class of dial in which the gnomon is movable and is set by the observer so that it, and its shadow, lie in the sun's hour plane. The gnomon may be a plane, line or point. The dial plate can, if required, be any surface. A globe dial with a movable vane is an example of a shadow plane ~.

shepherd's ~: see cylinder dial for the usual meaning. A second type of shepherd's dial is a set of marks cut in the turf, so that the shepherd's crook could be used as a vertical gnomon – see Shakespeare's Henry VI part 3, act 2, scene 5.

sidereal ~: (pron. sy-deer-e-al) a ~ designed to show sidereal time by means of introducing a variable offset to the time shown by the solar shadow on an equiangular dial. The dials are rare, with no known public dial in the UK(?)

solar clock (or solar chronometer): an instrument in which a sighting of the sun, through a movable telescope or open sights, is made to display the time on a clock face by a set of gears. A famous example by Sir Charles Wheatstone is in the Science Museum. Note: this term is often used as a synonym for heliochronometer, but is best reserved for the definition given here.

spherical ~: see globe dial.

spoon ~: a rare form of scaphe ~ delineated in the bowl of a spoon.

stained glass ~: a (generally vertical) dial in which the dial face is of stained glass, and is viewed from the back, i.e. through the glass from inside the building. The gnomon remains on the outside of the building, and frequently causes cracking of the glass if supported directly from it. Typically, they were incorporated into church windows in the 17th century, although most are now in museums and there are some notable modern examples.

standing ring ~: a form of universal equinoctial ring dial mounted on a stand, usually including a compass.

Star of David ~: a monumental dial similar in concept to the cross dial, except that the six-pointed star with 60º angles gives opportunities for numerous dials.

sun clock: see solar chronometer, dial (types of).

tidal ~: a dial delineated to give the times of the marine tides. Based on some form of equiangular dial (e.g. an equatorial dial). It bears the compass points in a circle with the names of various ports written against them. The 'establishment' of a port is given as a compass point and, together with the hour markers, indicate the interval of time between the passage of the Moon over the meridian of the port and its high tide. Not to be confused with dials showing the Anglo-Saxon tides.

universal ~: any portable dial with a means of allowing it to work at, or be adjusted for, any latitude. Note: sometimes the range of usage is limited to one hemisphere. The term is also sometimes applied, with qualifications, to dials which operate over a more limited range of latitudes, e.g. dials with, say, 30º-60ºN scales.

universal equatorial ring ~ (or - equinoctial -): a portable dial which looks similar to a folding version of an armillary dial, but with a movable suspension point to provide latitude adjustment. A stylised version of the hour ring and gnomon forms the BSS logo. In some versions, an aperture gnomon mounted on the central axis is used, the position of the aperture being adjusted to suit the sun's declination. This form is self-orienting. Large well-made versions are accurate and valuable.

vertical ~: any dial in which the dial plate is vertical.

window ~: (or projecting ~) a ~ in which the hour lines are marked on a window in such a way that their shadows fall across a single reading point inside the room. The lines, as drawn on the window, form an inverted, mirror-imaged vertical dial. This form is related to stained glass and mirror (or ceiling) ~.

- End of Dial types -

dialling scales: ruler-like (or rule-like) scales designed to help in the geometrical layout of dial. Their non-linear scales are effectively analogue computers for solving dialling equations. Standard scales, following George Serle's original version of 1657, and themselves developed from Samuel Foster's 1638 work, have separate scales for : hours, latitude (prime) and latitude (meridian).

dial plane: the plane in which the dial plate, and the hour indicators, lie.

dial plate (or ~ face): the physical plate on which the hour lines and furniture lie. It (usually) supports the gnomon.

diffraction grating: a plate with a set of closely spaced slits (usually parallel and equi-distant) which disperses incoming light into its constituent wavelengths (i.e. colours). The surface of a CD acts as a circular reflection diffraction grating.

dioptra {dioptera}: a form of alidade, used as the index of a volvelle (and also sometimes of a quadrant or an astrolabe), rotating against an angle scale.

dip (of the horizon): the angle of the observed horizon (due to the curve of the Earth's surface and the height of the observer, but neglecting refraction) below the true or astronomical horizon. It is given by:

dip (arc-minutes) = 1.811 x $\sqrt{\text{height (metres)}}$.

dip (magnetic): the angle that the Earth's magnetic field makes with the horizontal. It varies with geographical location and (slowly) with the date. See Appendix IX for values. It is measured with an inclinometer.

dipleidoscope: (pron. dip-ly-do-skop) from the Greek words for "double image viewer". Devised by James Bloxham and patented by Edward Dent in 1843. It is an instrument for observing the transit of the Sun to an accuracy of a few seconds. Essentially, it comprises a hollow equilateral prism, with the front, semi-reflecting face facing south and parallel to the polar axis. At noon, the reflection of the Sun from this surface exactly coincides with a second image doubly reflected from the other two faces.

diptych: literally, two leaves or pages. See dial types, diptych .

diurnal: daily, or occupying one day. Can also mean of the daytime (as opposed to nocturnal: of the nighttime).

domifying circles: (from the Latin Domus Coelestris - celestial house.) Circles on the celestial sphere which show the hourly position of the Sun in the six Regiomontanus (astrological) houses that are above the horizon. On a vertical south dial, they are represented by straight lines emanating from the intersection of the noon line and the horizon line (i.e. the horizontal line on the dial plate perpendicular to the nodus). The domifying lines are angled similarly to the hour lines, but are numbered in the reverse direction as DOM. VII (horizontal, E),DOM.VIII, DOM.IX, DOM.X (along the noon line), DOM.XI, DOM.XII and DOM.I (horizontal, W). On a horizontal dial, these lines all lie parallel to the noon line. See Appendix V.

Dominical cycle: a letter-cycle originating in the Roman period, when each day of the year was allocated the letters A,B,C,D,E,F and G in a repeating sequence. In a given year, every weekday (e.g. Monday) has the same letter, and the cycle repeats with the 28-year Julian leapyear cycle. The Dominical letter (for Sundays) is often found on portable dials, and is used with the Golden Number to find Easter.

dusk: the evening twilight period.

E

earthshine: the illumination resulting from sunlight reflected from the Earth, particularly when providing low-level illumination of the "dark" portion of the Moon.

East: the point on the horizon 90º (measured clockwise) from the North. The Sun appears to rise from the East point on the equinoxes.

Easter: the requirement to set the date of this Christian festival drove much of the early astronomy and calendar reforms. The standard astronomical algorithm for the date is now "the first Sunday after the full moon (paschal moon) that occurs upon, or next after, the vernal equinox". However, because the rules were set by the Christian clergy before the dates of the equinoxes could be defined accurately, the vernal equinox for this calculation is always taken as 21 March. See Meeus or Duncan in Sources for a full algorithm. The extreme dates of Easter are 22 March and 25 April

eccentricity (of the Earth's orbit): **[e_c, EC]** a measure of the relative sizes of the major and minor axes of the Earth's elliptical orbit. e_c = 0.01671... in the year 2000 and is slowly decreasing. e_c = 0 would imply a circular orbit. The earliest accurate value was found by John Flamsteed, the first Astronomer Royal, in about 1700 (most of his results were only published after his death in 1707).

eclipse (of the Moon or the Sun): the phenomenon which occurs when the Earth (or at least the observer's location), Sun and Moon lie on a straight line. If the Moon lies in the ecliptic plane between the Sun and the Earth, a solar eclipse occurs (either full, partial or annular, depending on the relative distances). If the Earth lies between the Sun and the Moon (i.e. at a full moon) a lunar eclipse is seen.

ecliptic (plane): (pron. e-clip-tic) the plane that the Earth's orbit traces during a year. The orbits of the Moon and the planets are also close to this plane. It is the plane in which eclipses occur since, by definition, the Sun is always on the ecliptic. It is a great circle on the celestial sphere.

ecliptic latitude: {celestial latitude} **[δ, ELAT]** is the position of a body on the celestial sphere, measured along the great circle from the ecliptic. Positive to the north, negative to the south, range –90º to +90º. It is part of the ecliptic co-ordinate system.

ecliptic longitude: {celestial longitude} **[λ, λ_e, ELON]** is the position of a body on the celestial sphere measured around the ecliptic from the vernal equinox positive to the east. Range 0º to 360º. It is part of the ecliptic co-ordinate system.

elevation: see altitude.

ellipse: a conic section and the path the Earth follows during a year (neglecting only the small perturbations caused by the moon and the other planets). It is defined by two foci, and by a major and a minor axis. A circle is a special case of an ellipse with the two foci coincident, and the major and minor axes equalling the diameter. The elongation of an ellipse is characterised by its eccentricity. Also, the outline shape of an analemmatic dial.

ellipsoid: a closed geometric surface obtained by rotating an ellipse around its major or minor axis.

elongation (of the Moon): the angle of the Moon relative to the Sun, as viewed from an observer on the Earth. The term may also be applied to the planets. An elongation of

180º implies a full Moon.

epact (number): the number of days past the full moon on the 1st January of any year in a 19-year metonic cycle (the period before the Sun and the Moon are again in the same relative positions in the constellations). Epact tables are found on old dials, particularly portable ones, in conjunction with lunar volvelles and calendars. In conjunction with an almanac, they can be used to predict the date of Easter.

ephemeris: (pron. ef-em-er-is) a table of predicted positions of celestial objects as a function of time. Astronomical almanacs invariably include an ephemeris for the Sun.

ephemeris second: an obsolete definition of a second used between 1955 and 1965, based on the Earth's speed of rotation. Now replaced – see second (of time).

epicycle: a small circle whose centre moves around the circumference of a larger one. It was proposed as the shape of the orbit of some of the planets by Ptolemy.

epoch: a particular fixed instant used as a reference point on a time scale for astronomical calculations, e.g. J2000.0 or noon 1 Jan 2000 (2451545.0 JD). The word epoch also occurs on some dials, for example, in tables for calculating Easter.

Equation of Time: **[E, EoT]** the time difference between Local Apparent Time (apparent solar time) and mean solar time at the same location. Its value varies between extremes of about +14 minutes in February and –16 minutes in October. It arises because of the elliptical orbit of the Earth, and the tilt of the Earth's axis to the ecliptic. The preferred usage by diallists is:

mean solar time = apparent solar time + EoT

but this sign convention is by no means universal and the opposite sign is used in modern almanacs. Irrespective of the sign convention adopted, sundials will always appear slow compared to mean time in February, and fast in October/November. See Equations.

Figure 5. The Equation of Time and its components.

EoT varies continuously, but is usually tabulated for noon each day at a particular location. Hence values for America (e.g. as printed in the NASS Compendium) can be a few seconds different from those in Europe. The noon EoT on a particular day varies slightly over the leap year cycles (4, 100, 400 years), and more significantly over millennia.

The first published tabulation of the EoT was by Christiaan Huygens in 1665, but the knowledge of its existence probably goes back to Ptolemy. The first Astronomer Royal, John Flamsteed (1646-1719) produced the first English tables in 1672.

EoT can also be expressed as an equivalent hour angle

equant point [E_a,EOTA]: a point in Ptolemy's model of the solar system around which the Sun and the planets rotate.

equator: the great circle of the Earth (or other celestial body) which is equidistant from the poles. It has, by definition, a latitude of 0º.

equatorial mount: a mount for an instrument (e.g. a telescope) which has one axis parallel to the polar axis and another at 90º to this (the declination axis). The diurnal motion of a celestial body can be followed by rotation about the polar axis alone. A polar-pointing gnomon could act as the axle for such a mount.

equatorial plane: the plane through the Earth defined by the equator.

equinoctial plane: the plane of the equator extended to the celestial sphere, i.e. defined by the celestial equator.

equinoctial line (on a dial): is the line followed by the shadow of a nodus on the equinoxes. For a plane dial, it is a straight line perpendicular to the sub-style.

equinoxes: (vernal or spring ~, autumnal or fall ~) literally "equal nights" i.e. equal amounts of daylight and night-time. Astronomically, the points where the plane of the ecliptic cuts the celestial equator, or the moments when the Sun is at these positions. The vernal ~, around 20-21 March, is also called the **First point of Aries** and represents the zero of ecliptic longitude and right ascension. Thus the Sun has an ecliptic longitude of 0º or 180º at the ~. Day numbers of the Earth's orbit are usually counted from this point. The autumnal equinox is around 22-23 September, and has a right ascension of 12h. The Sun's declination at the equinoxes is 0º. See Figure 1.

establishment (of a port): the interval between the time of the moon passing the meridian and high tide at the port. It is indicated on some equiangular dials which can indicate the times of the tides (tidal dials).

F

fiducial line (or ~ edge): (pron. fid-oo-shal) the edge of an index plate or pointer against which a scale is read.

filem: an old term for a plumbline, particularly on a card dial, to show the vertical.

First point of Aries: see the definition for equinoxes. Note that, because of the precession of the equinoxes, this point currently lies in the constellation of Pisces.

fleur-de-lis {fleur-de-lys}: an heraldic symbol of a stylised Madonna Lily, composed of three petals bound together near their bases. Often used on dials to denote the half-hour lines.

furniture: all features on a dial plate other than the hour lines and their numerals are referred to as dial ~. This may include declination lines, compass rose, EoT graphs or tables, mottoes etc. Other common furniture includes: date, maker's and/or benefactor's name, coats of arms, and latitude and (rarer) longitude. See Figure 1.

G

Geographic Position (GP): the point on the Earth's surface directly beneath a celestial body (i.e. where a line to the body from the centre of the Earth intersects the surface).

geoid: the Earth's shape, formed by the mean sea level and its supposed extension under the land masses. It cannot sensibly be represented mathematically, and is often approximated by one of many ellipsoids. Those most likely to be encountered are the Airy 1836 ellipsoid, used to define Ordnance Survey maps, and the WGS 84 ellipsoid, used in the GPS system.

globe: a spherical chart of the Earth. Note that although the Earth's geoid is actually a flattened ellipsoid (i.e. slightly melon-shaped with an equatorial radius of 6378 km, and a polar radius of 6357 km) the spherical representation is used for all dialling activities with the exception, for example, of the model used by the GPS system.

gnomon: (pron. no-mon) the physical structure of a sundial which casts the shadow (from the Greek for "indicator"). The gnomon today is most-often polar pointing (sometimes described as an "axial gnomon"), although it may also be horizontal or vertical. The special properties of a polar pointing gnomon were known to the Moorish astronomer Abdul Hassan Ali in the first half of the 13th century, but its first use may be earlier. The distinction between gnomon and style made (and encouraged in this

Glossary) in modern dialling literature is not the one used in early works, and the two words are still sometimes used interchangably. Originally (in English from 1546), gnomon meant a vertical pillar or rod which cast a time-indicating shadow. See Figure 1.

Hence **gnomonics**: the science of sundialling and **gnomonist** (seldom used): a person who practices gnomonics.

Golden Number: a number sequence (1-19) used to describe the year number in the metonic cycle. It was used, together with the Dominical letters, to find Easter, and is often found on portable dials.

grade (or **grada** or **gons** (obsolete)): [grad] a unit of angular measurement, equal to 1/100th of a right angle, or π /200 radians. Used particularly in France in the 18th and 19th centuries.

great circle: a circle on the surface of a sphere whose diameter is equal to the diameter of that sphere. Thus the circle has the same centre as the sphere. The shortest route between two points on the surface of a (solid) sphere lies on the circumference of the great circle connecting them.

GPS (Global Positioning System): a system of polar-orbiting satellites, run by the US Dept. of Defense, which allows hand-held radio receivers to provide accurate 3-D location information anywhere on (or near) the Earth's surface. It also provides a highly accurate clock, based on UTC. The system uses the WGS84 co-ordinate system and description of the Earth's geoid.

grazing incidence: a term used to describe illumination in which the rays are parallel to the receiving surface. The shadow of a point above the surface falls at infinity.

green flash: an atmospheric phenomenon occasionally observed during the final phase of sunset, when the upper limb of the Sun shows as a green flash due to the complex wavelength-dependence of atmospheric refraction.

Greenwich Mean Time (GMT): see GMT, *time (types of)*

Greenwich Meridian: the line of longitude (or half a great circle) passing through the centre of the Airy transit circle at the old Royal Greenwich Observatory in London, and which defines the origin of Longitude (º = 0º). It is now designated the Prime Meridian. Note: prior to 1884, there was no single fixed prime meridian, and hence early sundials sometimes refer to different origins, notably Paris.

Gregorian calendar: the calendar first introduced by Pope Gregory XIII in 1582 AD and now the accepted calendar throughout the vast majority of the world. It introduced the modern system of leap years which results in an error of only 3 days in 10,000 years. Note that adoption of this calendar throughout Europe took an extended period. Its introduction in Britain in 1752 produced a step change of 11 days which can be seen in the difference between EoT tables on dials earlier than this and those on later ones.

H

halcyon days: (pron. hal-ce-on) originally, 14 days about the winter solstice. Now taken as simply calm, peaceful.

Hallomas (Halloween in USA): All Saints' day on 1st of November. It is one of the cross-quarter days.

hectemoros angle: **[*hec*]** (pron. hec-tem-or-os) the angle from the western horizon to the sun's position, measured around the *hectemoros* circle. Part of the ptolemaic co-ordinate system, and related to the seasonal hours.

hectemoros circle: the great circle that passes through the E-W points on the horizon and through the sun's position.

heliacal rising: (pron. he-le-ac-l) the instant of the earliest visibility of a star in the East at dawn. The heliacal rising of the star Sirius was used by the ancient Egyptians to predict the coming of the annual Nile flood. Since their year had 365 days, this occurrence had a variable date.

height (of a style): see style height.

heliocentric: an adjective to describe a model of the solar system which places a stationary Sun in the centre, with the planets revolving around it.

heliograph: has two distinct meanings: (i) a device for transmitting morse signals over extended distances by using an accurately aligned mirror to send flashes of sunlight to the receiving station. For long messages, the ~ has a mechanism for tracking the sun's motion. (ii) an astronomical instrument for studying sunspots, as built by George Airy at Kew in 1873.

heliometer: a telescope which produces two images of the Sun which can be manipulated to determine its angular size accurately. Invented in 1754 by John Dollond of London, it is also used to measure angular distances between stars.

heliostat: a scientific instrument which holds an image of the Sun stationary, allowing extended observation (e.g. for solar spectrometry).

hemisphere (northern ~ and southern ~): one half of the Earth's globe, either north of or south of the equator. Note that a sundial at a particular latitude in one hemisphere must be reversed for use at the reciprocal latitude in the other hemisphere.

horarius circle: (pron. hor-ar-e-us) the great circle that passes through the N-S points on the horizon and through the sun's position.

horarius angle: **[*hor*]** the angle from the southern horizon to the sun's position, measured around the *horarius* circle. One of the ptolemaic co-ordinates.

horizon: the line of intersection between the sky and the Earth. For normal astronomical purposes, the observer's horizon is taken to be the great circle on the celestial sphere on which every point is 90º from the observer's zenith. The **observed horizon** (accounting for the curve of the earth and the height of the observer above its surface, but excluding refraction) is below the astronomical horizon by an angle called the dip. This can have a significant affect on the times of sunrise/sunset.

horologia: the collective Latin name for dials, water-clocks and sand-glasses, used in the Middle Ages.

horologium: a name used to describe medieval manuscripts listing shadow lengths, deriving from the Latin name for timepieces. Modern versions have also been produced. In modern astronomy, it is also the name of a faint southern constellation ("the Clock").

hour: usually means 1/24th of a mean solar day, unless otherwise stated. Scientifically, it is defined as 3600 standard seconds. See Hour (types of) for other definitions. The word derives from the Latin "hora", which was synonomous with prayer.

hour angle: **[*h*, HA]** the angle corresponding to the sun's position around its daily (apparent) orbit. Measured westward from local noon, it increases at a rate of 15º per hour. Thus 3pm (Local Apparent Time) is 45º and 9 am is –45º.

hour circle: a great circle on the celestial sphere that passes through the celestial poles. It is orthogonal to the celestial equator.

hour line: the line on a dial plate indicating the shadow position at a particular time (includes fractional as well as whole hours). See Figure 1.

hour line angle: **[*X*, HLA]** the angle that an hour line on a dial plate makes with the noon line. The angle increases with time (i.e. positive for the p.m. hours). Thus, for a horizontal dial, the angle increases clockwise (hence the origin of the term) whereas for a vertical south-facing dial, it increases counter-clockwise . Beware, this convention is not used by all authors, and some define the angle with respect to the sub-style line.

hour point: a point on the dial plane indicating the crossing of the gnomon's shadow at a particular time. Hour points replace hour lines on dials where the shadow edge does not pass through the dial centre.

hour plane: the plane which, at any instant, contains the sun, the observer and the N celestial pole. The style and the appropriate hour line lie in the hour plane.

Hours (types of):

antique ~: same as unequal hours or seasonal hours.

Babylonian ~: number of hours elapsed since sunrise, with 24 equal hours per day. The origin of the term is unclear, but may be related to the fact that the ancient Babylonians originated the base-60 counting system for angles etc. They are sometimes written as "horae ab ortu solis" or H. AB ORT." on dials. See Equations for conversion from equal hours to Babylonian hours.

biblical ~: same as unequal hours or seasonal hours.

Bohemian ~ : same as Babylonian ~.

Canonical ~: the seven times of the day (as opposed to time periods) used to define the services or divine offices in the medieval church. These offices were based on the sixth century Rule of St. Benedict. See Appendix IV for details.

An alternative definition of the term canonical hours, sometimes applied to lines on early Italian dials, is the system of putting equi-angular hour lines around the base of a horizontal gnomon on a vertical south dial.

common ~: the standard 2 x 12 equal hour system, also called German or French ~. In Latin "horae communes", they are often labelled "kleine uhr" (small hours) on Nuremberg dials.

decimal ~: an hour system with ten equal hours per day (as sometimes used by the Chinese and ancient Egyptians, and during the French Revolution).

equal ~: any hour system where the length of an hour is independent of the date, and the same during daytime and night-time.

French ~: an early name for the equal hour system with 2 x 12 hours per day, beginning at midday and midnight. Sometimes written "Oltramontane".

French revolution ~: the equal hours according to French Revolution time.

Great ~: a term for any of the unequal hour systems. Often labelled "grosse uhr" on Nuremberg dials.

Greek ~: same as Babylonian ~.

Italian ~: {sometimes Italic ~} the number of hours that have elapsed since the most recent sunset (hour 0), with 24 equal hours per day. They were used in many European countries during the period 1200 to 1800. They are sometimes written "horae ab occasu solis" or "H. AB OCC." on dials. The two terms (Italian and Italic) are often used synonymously in modern works but there is some evidence in older works that Italian hours were counted from 30 minutes after sunset. See Equations for conversion from equal hours to Italian hours.

modern ~: the equal hours as used in modern time systems. They may occasionally be referred to as common, European, French, German or vulgar hours.

Nuremberg ~: a hybrid equal hour system. The daylight hours were measured using the Babylonian ~ system, starting with 1 at sunrise, while the night hours started with 1 at sunset and used the Italian ~ system. In Latin, "horae norimbergenses".

octaval ~: a time system with the period of daylight divided into eight hours. Probably introduced by the Romans, circa 250AD. See Appendix III for the names of the daylight periods.

planetary ~: a planetary hour is the time needed for 15º of the celestial equator to rise above the horizon, counting from sunrise. As there is always 180º of the celestial equator above the horizon, there are 12 planetary hours from sunrise to sunset but they are unequal not only from day to day but also from hour to hour. Note: this definition is based on the writings of Sacrobosco, but some authors use planetary hours simply as another form of seasonal hours, with the hours associated with the "planets". See Appendix VIII for the symbols of the planets and this association. The Zonwvlak program uses the definition of the German scholar Joseph Drecker (1925) who defines a planetary hour as the time for 15º of the ecliptic to rise above the horizon (counting from sunrise) and are hence very irregular.

seasonal ~: a form of unequal hours, usually with 12 daytime and 12 night-time hours. Named from the fact that the length of an hour varies with the seasons.

temporal ~ or **temporary ~**: an unequal hour system with 12 hours from sunrise to sunset, and 12 hours (of a different duration) from sunset to sunrise.

unequal ~: an hour system where the duration of an hour depends on the date and is different from day-time to night (except at the equinoxes). The number of hours during day-time is usually 12, but may be 8 and just possibly 10 (e.g. on some mass dials). Counting of the daytime hours begins at sunrise.

Welsch ~: i.e. foreign. Same as Italian ~.

End of Hours (types of)

house: (astrological) a segment of the celestial sphere. Several methods of dividing the sphere into segments exist, the most common of which produce the signs of the zodiac, and the Regiomontanus houses.

hyperbola: a conic section, its most common use in dialling is the shape of the declination lines on a dial.

I

Imbolic: an ancient Celtic festival held on the 2st of February, celebrating fertility. It is one of the cross- quarter days

inclination: **[*i*, I]** the angle between the back of the dial plane and the horizontal for inclining or reclining dials. Equivalently, it is the angle between the zenith and the positive z co-ordinate of the dial. i = 0º implies a horizontal dial. For an inclining dial, 0 < i < ϕ (the latitude of the place). For a reclining dial leaning away from the observer, i < 90º; whilst i > 90º implies a proclining dial leaning forward towards the observer. Beware: this convention is not followed by all authors.

inclinometer (or **clinometer**): an instrument for measuring the inclination or slope of a surface. Two types are common: simple devices with a plumb-line hanging across a protractor, or precision ones where a sensitive spirit level is moved to the horizontal position against an accurate scale. Note: the term inclinometer is also used to describe an instrument - also called a **dip circle -** for measuring the vertical component of the Earth's magnetic field.

index: besides its normal meaning of an alphabetical list, an ~ is a pointer on a scientific instrument, indicating a point on a graduated scale. The **index arm** of a sextant is the movable arm carrying the index mirror and the fiducial line.

inferior: refers to an event on the celestial sphere below the horizon. Opposite of superior.

inhiraf: the angle which the qibla line makes with the north ray of the meridian at any location.

International Date Line: the line from the N to S poles, approximately following the 180º line of longitude, through which the date alters by one day (positively if travelling from W to E). Variations from the 180º meridian are made to avoid political and geographic boundaries.

Islamic prayer lines: the lines on Islamic dials where the shadow of the nodus falls at the times when Muslims must pray. The times of the three most common lines are determined by a linear relationship to the noon shadow length of a vertical gnomon:

zuhr: noon shadow + 0.25 x gnomon height

asr-awwal: noon shadow + gnomon height

asr-tânî: noon shadow + 2 x gnomon height

isogonals: lines of equal magnetic deviation plotted on some navigational charts.

J

Jaipur: (pron. Ji-poor) a famous early 18th century solar astronomical centre in India, constructed by the Maharaja Jai Singh around 1724. It includes many monumental sundials, including a famous equatorial one with a gnomon 27 metres high.

Julian calendar: the calendar system introduced by Emperor Julius Caesar and devised by the Greek philosopher (and court astronomer of Egypt) Sosigenes. Widely used from 45BC to 1582AD. By this date, it was in error (compared to the Earth's orbit) by 10 days due to the imperfect use of leap years (i.e. it assumed the length of a year was 365.25 days).

Julian Day {sometimes **Julian Ephemeris Day**}: **[JD]** the astronomer's scale of date and time. Used in dialling, for example, for the accurate calculation of the EoT and sun's declination. Measured continuously in decimal days since noon GMT 1 Jan, 4713BC. By tradition, since midnight is difficult to define without an accurate clock, the JD begins at Greenwich Mean noon, that is, 12:00 UT. As an example, 9:36 GMT on 26 April 1977 is JD2,443,259.9. See Sources: Meeus for a full algorithm for converting modern date/time to JD. The Julian Day count was defined by John Herschel in 1849, based on the 4713 BC epoch used in 1583 by Joseph Scaliger (France). It is commonly stated (probably erroneously) that Scaliger named the system after his father.

K

kamál: an early Arabic navigational instrument for determining the Sun's altitude by means of a transom and a knotted cord.

Kepler's Laws (of planetary motion): three laws which describe the motion of the planets around the Sun, after Johannes Kepler (1571-1630). They are:

1. Planets travel in elliptical (rather than circular or epicyclic) orbits, with the Sun at one of the foci.
2. The line joining the Sun and the planet sweeps out equal areas of space in equal time intervals (so that the planet moves faster when it is nearer the Sun, and establishing the Sun as the main controller of the planets)
3. The link between the size of the planet's orbit and its period of rotation is described mathematically.

klimata: (pron. clim-arta) part of an astrolabe, it is a disk rotating on the mater with the north celestial pole in the centre and showing almucantar lines for the design location. After the Ancient Greek meaning "angle of the Sun's rays", and hence the modern word "climate".

L

Lambert's circles: circles of construction used when drawing sets of nested ellipses to represent analemmatic dials for different latitudes, these dials using a common scale for the (vertical) gnomon position. Such sets of dials are particularly useful for a solar compass, e.g. the Cole sun compass used in N. Africa during the Second World War. After the mathematician Lambert (b. 1728, Alsace).

Lammas (or Lammas Day): one of the cross-quarter days. It is on 1st August, and was formerly observed as the harvest festival.

latitude (geographical, of a place): **[ϕ , PHI, Lat]** Note: avoid LAT, since it implies local apparent time. It is the angular position of a place north or south of the equator. Positive values in the Northern hemisphere, negative in the South (i.e., the South Pole has ϕ = -90º). Part of the geographic co-ordinate system, the term comes from the Greek "latus" (breadth).

leap second: an extra second inserted into UTC at the end of some years between 24:00:00 Dec 31 and 00:00:00 Jan 1 to ensure that UTC remains in step with the Earth's diurnal rotation. It may also be added at the end of June. The addition is not predictable as it depends on many factors, such as the increased atmospheric drag on the Earth in El Niño years. The actual addition is performed by the Bureau International des Poids et

Mesures near Paris. Leap seconds are gradually becoming more common as the rate of the Earth's rotation slows due to energy dissipation by the tides.

leap year: years in which an extra day (February 29) is introduced so that the (Gregorian) calendar keeps step with the Earth's orbit. The rule for leap years is that a year is a leap year if and only if the year number: is divisible by 4, except years divisible by 100 which are not leap years unless they are also divisible by 400. This corresponds to the length of the year being 365.2425 mean solar days. This can be compared to the 365.25 days in the earlier Julian calendar. (The Julian leap year doubled February 24.) The leap year system causes the EoT (and Sun's declination) on a particular day of the year to exhibit a small periodic variation.

lemniscate (curve): the term used in Latin countries for the analemma. From lemniscus, meaning ribbon. In English, the ~ is a mathematical curve which is similar to a spiral and is sometimes used in road design; it also looks similar to one lobe of the analemma.

libration (of the Moon): the periodic oscillation of the Moon from 'side to side' (and 'up and down') which allows an observer on the Earth to see somewhat more than half its surface.

limation: (rare) a term used by Flamsteed to mean the correction of a calculation or observation, having originally (1612) had the meaning 'filing or polishing'.

limb: part of an astrolabe, it is the circular ring with a scale of hours and degrees. Its first recorded English use was in 1593.

limb (of the Sun): the outer circumferential region of the Sun (or other celestial body). The term **limb darkening** indicates that the disk of the Sun does not have uniform brightness but is dimmer around the "edges" due to increased optical absorbtion by the photosphere.

local apparent time: **[L.A.T.]** solar time see LAT (types of). Hence **local apparent noon**, at the Sun's superior transit.

local hour angle (or just **hour angle**): **[*h*, HA]** Local Apparent Time expressed as the angular position of the Sun in its daily track. Measured from noon, it increases by 15º per hour with increasing time (i.e., morning hours are negative). Beware, this convention is not universal.

lodestone: a naturally occurring oxide of iron, mounted with two iron poles in a non-magnetic frame. Used for magnetising compass needles, small ones were made specially for portable dials.

longest day: a term in common parlance, defined as the day of the year with the greatest (astronomical) sunrise to sunset period. It is normally used synonymously with the summer solstice although, strictly, it can vary by a day depending on the exact time of the solstice and the relationship between the rate of change of the EoT and that of the local sunset/sunrise.

longitude (or geographic ~ to distinguish it from the ecliptic ~): **[λ , λ_t, LON]** the angular location of a place on the Earth's surface measured east or west of the Prime meridian though Greenwich. Longitudes W are positive, E are negative. Part of the geographic co-ordinate system, the term comes from the Greek "longus" (length). See also Prime Meridian.

Longitude Act: a 1715 act of the British parliament which established a Board of Longitude to manage a prize of £20,000 for a practical method of finding longitude at sea.

longitude correction: the correction required to local apparent time to translate it to the

L.A.T. for the central meridian of that time zone. The correction is +4.0 minutes for every 1º longitude W of the time zone meridian (and –4.0 minutes for E). Sometimes, this correction is built into the hour lines by calculating the local hour angle for times at the zone meridian.

lunar angle: the difference between the right ascensions of the Sun and the Moon. On a standard sundial used as a moon dial, the L.A.T. equals the time shown by the lunar shadow plus the lunar angle expressed in hours.

lunation: the time interval between successive New Moons. The mean interval is 29 days 12 hours 44 minutes 3 seconds (the synodic month) but, because of the perturbing action of the sun, the difference between the shortest and longest lunations in the 20th century is 5 hours 19 minutes.

M

Mach bands: (pron. mak) subjective light and dark bands which an observer sees when looking at a black-white edge. They are produced by the brain's visual processing (i.e. they are not real) and have the effect of sharpening up edges. First described by the German physicist Ernst Mach (1838-1916).

magnetic variation {**magnetic declination, magnetic deviation**}: Note, the use of the term magnetic declination is best avoided because of confusion with the other types of declination. It is the angle between the true N pole and the magnetic N pole. At present in the UK, the magnetic pole is very approximately 3º W of true north, and decreasing by about 12' annually. See Appendix IX for more detailed and historical values. There can be large local variations to the general values, some of which can be found mapped on navigational charts. The use of a magnetic compass for aligning a permanent dial is not recommended, even if due corrections are made, as the presence of steel or magnetic rocks will cause very local variations.

manaeus: (pron. man-ay-us) the circle of months which formed part of the ancient orthographic spherical projection used by late Middle age diallists. It establishes the sun's declination.

maquette: a sculptor's small preliminary model. The term is used to describe small mock-ups of three-dimensional dials.

Martinmas: St Martin's day, on 11th November. It is one of the cross-quarter days.

mass dial: see Dial types (mass dial).

mater: the heavy disk which forms the base of an astrolabe.

mean solar day: the time between successive transits of the fictitious mean Sun (i.e. an imaginary sun which appears to circle around the celestial equator at a constant rate equal to the average rate of the Earth's real rotation). The basis of civil time keeping.

mean time: see Time (types of).

mean local time (or **local mean time**) : see Time (types of).

Mercator projection: the most common projection used to produce a 2-D map of the globe. Developed by Gerardus Mercator in Belgium, 1586. It has straight meridians and parallels of latitude that intersect them at right angles. Scale is true at the equator or at two standard parallels equidistant from the equator. The **Transverse Mercator** projection is obtained by projecting the sphere onto an enclosing cylinder tangent to a central meridian. This is the projection used for Ordnance Survey maps of the UK.

merkhet: a transit instrument from ancient Egypt, consisting of a horizontal "L" shaped stone with a plumb-bob supported from the short vertical arm. It was used in conjunction with a bay.

meridian: the great circle (or, more usually, half of a great circle) passing through the N and S poles. The same as a line of longitude. The term is sometimes used to mean the meridian line passing through the observer's location, or its representation on the dial face.

meridional: south-facing (e.g. a direct-south dial). In more general usage, it generally means of, or from, the south.

meridian line: see Dial Types (noon line) for the lines inscribed in the floors of Renaissance cathedrals, etc.

metonic cycle: a cycle of 19 years (or 235 lunar months) over which the Sun and the Moon return to the same relative positions amongst the constellations. It was discovered by the Greek astronomer Meton c.433 BC and determines the epact number and the Golden Number. Actually, the moon runs 1½ hours slow over this period, or one day over 312.7 years. This fact has to be included in the calculations for Easter.

midnight: strictly, the time when the Sun achieves its most negative altitude (or, equivalently, when its azimuth is ±180º). More loosely defined as half-way between sunset and sunrise or, with even less accuracy, 12 hours after local noon.

midsummer, midwinter (~ day): the same as summer or winter solstice. Note that **Midsummer** (with capital M) is a legal term for the Quarter Day on June 24.

mil: unit of angular measurement used in some military equipment, e.g. rangefinders, theodolites. 6400 mils = 360º. Beware possible confusion with use as a linear measurement of 1/1000 inch used by engineers (particularly in the USA).

mileways: an obsolete term for an hour angle of 5º, equivalent to 20 minutes of time. So called because this is the approximate time that it takes to walk one mile.

minute of arc: see arc minute.

minute (of time): is now defined as 60 seconds. Historically, the definition was 1/60th hour, where the hour was derived from the rotational period of the Earth.

month: an interval of time related to one revolution of the Moon around the Earth (a "moonth"). The calendar month derives from the **synodic month** (full-moon to full-moon) which averages 29.53 days. The **anomalistic month** (perigee to perigee) averages 27.53 days.

Moon: the natural satellite of the Earth. It has a mean distance from the Earth of 384.4 x 10^3 km and a semi-diameter at mean distance of 15' 33". The inclination of its orbit to the ecliptic is 5º 8' 43". Note: "moon", without an initial capital letter, is sometimes used to refer to moons of planets other than the Earth.

moondial: see Dials (types of).

moonlight: rays of light which reach the observer directly from the Moon, having originally been sunlight reflected by the Moon's surface. There is usually sufficient light to cast a shadow only between the 1st and 3rd quarters of the Moon. Since the angular size of the Moon is approximately the same as that of the sun, the ratio of umbra to penumbra of a moon shadow is also the same as for a sun shadow.

motto: a sentence, phrase or verse inscribed on a dial expressing an appropriate sentiment. Mottoes started appearing on dials in the late 16th century but were particularly popular in the 19th century.

N

nadir: the point on the celestial sphere that is diametrically opposite the observer's zenith.

nautical mile: a distance (6080 feet or 1853 metres) determined as 1 arc-minute of longitude at the equator.

night (or **night-time**): the period of darkness between sunset and sunrise.

nocturnal: (noun) a fixed or, more usually, portable instrument used to tell time by the apparent revolution of the stars on the celestial sphere. The stars most often used on these instruments are either the "guards" of the Little Bear (Ursa Minor) or the "pointers" of the Great Bear or Plough (Ursa Major). These are known as the Little Dipper and Big Dipper, respectively, in the USA. Most nocturnals have inscriptions "GB" and "LB" on their scales. The term ~ can also be used as an adjective, meaning "of the night".

nodus: a point which casts a shadow to indicate the time and/or date on a dial face. It may take the form of a small sphere or a notch on a polar-pointing gnomon, or it may be the tip of a gnomon with an arbitrary (usually horizontal or vertical) orientation. See Figure 1.

nodus height: **[N, NH]** the height (distance) of a nodus perpendicular to the dial plane. It is also the same as a vertical style height.

nomogram (sometimes **nomograph):** a system of graphs showing relationships between three or more variables. From the Greek "nomos" (law).

nonius: a device similar to a vernier for interpolating readings on an angular scale, but using a large number of concentric scales rather than a single movable one. Named after the 16th century Portuguese mathematician Pedro Nõnes.

noon: the time of the sun's transit each day. Equivalently, the time that the Sun reaches its largest altitude for that day. Note that noon is specific to the observer's location, unlike 12:00 o'clock with which it is often confused.

The word ~ originates from the Latin 'nonus' or ninth, indicating the ninth hour of the day counting from sunrise. By 1420 it meant the hour or ecclesiastical office of Nones, so noon gradually became associated with the beginning of this office.

noon cross: a cross shape often seen instead of XII on the noon line of dials. It can have many forms, many of which look like an Iron or Maltese cross. The nearest heraldic term is the cross patty.

noon gap (or **gnomon gap** or **split noon**): the gap in the hour scale of a dial to account for the finite thickness of the gnomon. It is positioned on the dial plate where the Sun is in the same plane as the gnomon, i.e. at noon for horizontal or direct S dials. A gnomon gap is occasionally seen on the sub-style of a declining dial. See Figure 1.

noon line (on a dial): simply the hour line corresponding to noon, it is the most important line from which the others are usually calculated. It is the line which most often carries an analemma.

noon marker: a single mark or stone in the ground (or on a wall) set to show noon when crossed by the shadow of a convenient vertical; for example, a stick or edge of a wall. Sometimes also called a shepherd's dial.

North: the intersection of the local meridian with the horizon, in the direction of the north celestial pole.

North Pole: the point on the Earth's surface and its axis with a latitude of +90º . It lies in the direction of the **North celestial pole**, from which the Earth is seen to rotate anti-clockwise.

numerals: The numerals on dials are usually either **Arabic** (the usual 0-9 used in English) or, especially on older dials, **Roman** numerals (I, II,..XII etc.). Note that it is common to find IIII in place of the later IV on some dials. A convention sometimes used on dials with more than one hour ring is to use Roman numerals for Local Apparent Time, and Arabic ones for civil time (often BST etc.). Many other forms of numerals (e.g. Chinese, Turkish) are used world-wide.

nutation: a small periodic (principal time constant of 18 years 220 days) oscillation of the rotational axis of the Earth about its mean position. Discovered by James Bradley (1693-1762), the third Astronomer Royal, in 1748. The disturbance of the idealised orbit of the Earth (as a two-body system) is due to the gravitational attraction of the Moon and, to a lesser extent, the other planets. Nutation introduces small changes, typically 7 arcseconds annually, to the precession of the equinoxes.

O

obelisk: a tall tapering shaft of stone, usually monolithic with a square or rectangular section ending with a pyramidal apex. Prominent in Ancient Egypt as a solar symbol, often at the entrance to tombs or as a cult object in shrines to the sun.

obliquity (of the ecliptic): {sometimes the **slant**} **[ε , EPS]** is the angle between the Earth's equatorial plane and the ecliptic. The current mean value of the obliquity (i.e. ignoring its nutation) is 23º 26' 21", decreasing by 23" over the next 50 years. Note that this figure sets the position of the tropics.

obtuse angle: an angle of greater than 90º and less than 180º.

occidental: west-facing (e.g. a direct-west dial). In more general usage, it generally means of, or from, the west.

orbit (of the Earth): the path of the Earth around the sun. For dialling purposes, this is taken as elliptical, with a very small eccentricity, i.e., it ignores the small perturbations due to the effects of the Moon and other planets.

origin: the (0,0) point (or (0,0,0) in three dimensions) of a co-ordinate system used to describe a dial plane. It is usual to place this point at the centre of the dial (if it exists), but it is sometimes placed at the sub-nodus point.

oriental: east-facing (e.g. a direct-east dial). In more general usage, it generally means of, or from, the east.

orrery (pron. or-rer-re): (sometimes called a **planetarium**): a physical model of the solar system, used for demonstration purposes. Named after Charles Boyle, 4th Earl of Orrery, who had an early example built by John Rowley in 1712. Sometimes powered by clockwork to provide the correct relative orbital periods of the planets. Early examples are very valuable. See also tellurian.

orthography: the art of drawing anything without perspective, as though viewed from infinity. In dialling, the sphere so drawn consists of circles, straight lines and ellipses. Hence orthographic (or orthogonal) projection, which is used in the universal astrolabe.

ortho-style: a style which is perpendicular to the dial plate. It was used in many ancient dials.

P

parabola: a mathematical term for the conic section obtained by cutting a cone with a plane parallel to its generator (or "edge"). A **parabolic** surface, obtained by rotating a parabola about its own axis, is much used for mirrors as it has the property of focusing parallel rays of light to a point focus.

parallactic angle: **[η]** the angle of the polar triangle between the directions to the pole and to the zenith at the celestial object. Hence it is the angle between the vertical and the hour circle, of use in calculating the effects of astronomical refraction.

parallax: the effect whereby the apparent position or direction of an object changes with the observation point. See solar parallax for its affect on solar parameters. The effect can affect the accuracy of reading scales.

paschal moon: (pron. pas-kal) the first full moon following the Spring equinox. Important for the determination of Easter.

patina: Coloured, metallic compounds (usually oxides and sulphides) which form on metal surfaces left exposed to the atmosphere. The actual colour depends principally on the metal, but also on the impurities in the atmosphere resulting from pollution or proximity to the sea. Typically, copper-containing alloys develop a greenish colour.

pedestal: the supporting structure for a dial, particularly horizontals. Usually of stone, it may comprise several different pieces and brings the dial to a convenient viewing position. See Appendix VII for more details of architectural terms.

pelorus: an instrument for finding the solar azimuth, consisting of a magnetic compass and an alidade, with some means (e.g. mirrors, prisms, shades) of viewing the Sun and the compass needle.

penumbra: the area of partial shadow surrounding the central umbra. It is due to the finite size of the sun. An observer standing in the penumbra would observe only part of the sun's disk.

perigee: (pron. pe-ri-gee) the point in the Moon's (or other satellite's) orbit when it comes closest to the Earth.

perihelion: (pron. perry-he-le-on) the point in the Earth's orbit when it comes closest to the sun. It occurs during the first week of January.

perpetual calendar: a device, usually in the form of a circular plate with one or two rotating engraved disks, for finding the day of the week for any date (over a wide range of years). They are often combined with portable dials as part of a compendium. More sophisticated versions have extra tables for Saint's Days and similar data.

phase (or age) of the Moon: the approximately monthly variation of the angular separation of the Sun and the Moon, leading to the sequence of new, waxing, full and waning moons. The **age** (as seen, for example, in tables associated with moon dials) is measured in days since the last new moon. Astronomically, the phase of the Moon is defined as the angle between the Sun and the Moon measured from the Earth (the lunar angle). The mean length of the synodic (i.e., lunar) month is 29.53059 days (usually approximated to 29½ days in the lunar mechanisms of clocks).

photosphere: the outer envelope of the Sun which produces the visible light by which it is seen.

pinnules: sighting pinholes (usually in pairs) in an alignment device, e.g. an alidade.

planet: astronomically, a celestial body in orbit around a star. The five planets of the solar system known to the ancients were Mercury, Venus, Mars, Jupiter and Saturn. In addition, they often counted the Sun and the Moon as planets; for example, in the planetary hours system. See Appendix VIII for symbols.

planetarium: see orrery.

planisphere: a map of part of the celestial sphere, formed by a stereographic projection of the sphere onto a flat plane and showing (or adjustable for) the positions of the stars at a particular time and location.

plinth: the base part of a pedestal, normally resting on the ground. Note that some authors use ~ to refer to the whole of the pedestal. See Appendix VII for more details of architectural terms.

plumb-line: a freely suspended line with a weight (or plumb-bob) at its lower end, used for defining the vertical.

plummet: the form of plumb-line incorporated in a portable dial and used for levelling it. It usually consisting of a solid elongated cylinder suspended, by a joint with free movement in the horizontal axes, above a datum point.

pobble: the bead on the plumb-line of a card dial.

polar axis: see axis.

polar co-ordinates: see co-ordinates.

polar distance: the distance (as an angle) of the Sun from the elevated celestial pole; the complement of the declination.

polarised light: light in which the electromagnetic waves have a single plane of vibration in a direction perpendicular to the direction of propagation. Polarising filters allow the transmission of light rays with only a selected plane of polarisation. Discovered by Christiaan Huygens (1635-1703). Sunlight is randomly polarised, but skylight is partially plane polarised, with the direction of polarisation at any point in the sky being perpendicular to the plane containing the point, the Sun and the observer. The proportion of the skylight which is polarised is a maximum in the principal plane and at 90º to the sun. The proportion is always less than 75%, and substantially less in slightly hazy conditions.

Polaris (or Pole Star): actually α Ursae Minoris, it is the star which appears quite close to the N celestial pole and is frequently used for finding north by navigators. It currently appears to rotate daily around a circle of radius 1º, so it requires some knowledge if it is to be used for aligning a sundial. The size of this circle varies over the centuries with the precession of the equinoxes.

polar plane: any plane which is parallel to the Earth's axis.

polar triangle: the spherical triangle on the celestial sphere whose vertices are at the pole, the zenith, and a celestial body, with respective angles of the hour angle, the azimuth, and the parallactic angle. The arcs joining these are the co-latitude, the north polar distance (90º - δ) and the zenith distance. The polar triangle is fundamental to the operation of most types of sundial, whose function it is to derive the hour angle, and hence the time, given any three of the other quantities.

poles (N and S of the Earth): the locations on the Earth's sphere with latitudes of +90º (N) and –90º (S).

polos: an old term for a polar-pointing style.

post meridiem (p.m.): the portion of the day between noon and midnight.

precession (of the equinoxes): the slow westward progression of the equinoxes on the ecliptic. It is caused by the drift of the Earth's axis in space, as in a precessing spinning top. The position of Polaris turns around the pole of the celestial pole once in about

26,000 years. As a consequence, the vernal equinox regresses by about 50 arcseconds per year along the ecliptic. It is caused predominantly by the gravitational force of the Sun and the Moon on the Earth's equatorial bulge. Secondary effects, due to the other planets, give a rotation of the ecliptic plane of 47 arc-seconds per century.

The first measurement of precession was made by Hipparchus in 129 BC.

precision (of a dial): a combination of the resolution and accuracy of a dial, it gives a measure of how exactly (and correctly) it indicates any time.

Prime meridian: the meridian line defined as the origin for longitudes. Now synonymous with the Greenwich meridian, before 1884 various countries defined their own origin. The early Greeks used Rhodes or Alexandria. Ptolemy used the Fortunate Islands, assumed to be Ferro in the Canary Islands by scholars in the Renaissance. Nuremberg was common for dials made there, and in relatively modern times many maritime nations had their own locations; Paris in particular continued to be used even post-1884. Note that the 0º longitude line used by the GPS system is actually a mean value, periodically recalculated to allow for tectonic drift etc. and currently lies approximately 38 m (80 feet) east of the Greenwich line.

Prime vertical: the vertical circle perpendicular to the meridian. It passes through the E and W points.

Primum Mobile: (pron. pree-mum mo-be-lay) an old term for the supposed crystal sphere carrying the stars in their orbits around the earth.

principal plane {or vertical plane}: the plane obtained by varying the Sun's altitude whilst its azimuth is constant. Perpendicular to the almucantar.

prosthaphaeretical arc: a term introduced by Samuel Foster to describe an arc on the surface of the earth between the location of an inclining/declining dial and the position where it would be identical to a horizontal dial (i.e. the complementary dial). In astronomy, prosthaphaerisis is the adding of a small amount to an observed value.

Ptolemy's rulers: an interconnected set of three linear scales used to measure the angular positions of stars, used particularly by Regiomontanus and the Nuremberg group in the 1460s.

Q

Qibla line: sometimes found on Arabic dials, it is an azimuth line on the dial plate starting at the centre and pointing to Mecca.

quadrant: a term used for a large genus of astronomical and navigational instruments. In the form of a quarter-circle, it incorporates a sun or star sighting device along one of its radial edges and a plumb-bob hanging from the centre of the circle. The old **quadrans vetus** was originally an Islamic invention which provides seasonal hours but is only truly accurate for an observer on the equator. The **quadrans novus**, invented by Profatius in 1288) was more accurate, incorporating the circular scale of the astrolabe folded into a quadrant but it was difficult to read. The 1438 **horary quadrant** of von Gmunden was one of several attempts to improve on this. The **Gunter ~** (after Edward Gunter, Gresham College, 1623) is latitude dependent and employs a stereographic projection. The **navigational ~** is actually an octant (eighth of a circle) with two reflecting mirrors replacing the plumb-bob. For the **Davis ~,** see back-staff.

Quarter days: the first or last days of each quarter of the year on which rent or interest is due. These dates are occasionally used instead of the zodiac signs for declination lines on dials. See Appendix XII for their names and dates.

quincunx: five dots arranged as on dice. It sometimes appears on mass dials at noon or service times.

R

radian: [rad] the primary unit of angular measurement, it is the central angle subtended by an arc of a circle equal in length to its radius. 2π radians = 360º or 1 rad $\approx$ 57.3º.

ray: a single line or narrow beam of light.

reclination: a term sometimes used for the angle by which a reclining dial leans away from the observer (i.e. the complement of the inclination). It is more consistent, however, to translate this into the equivalent inclination.

rectificatory: an old term for a right-angled triangle where the other two angles are the latitude and co-latitude. Used particularly in the graphical construction of dials.

reflex angle: an angle of greater than 180º.

refraction: the "bending" of light at the interface of two materials of different refractive indices. It accounts for the focusing action of lenses. In dialling, use is made of ~ in dials which use a clear liquid in a solid cup to compress the hour lines, or which use a cylindrical lens to focus sunlight onto a curved dial plate**. Atmospheric refraction** (due to the curve of the Earth's surface and the variation of atmospheric density with height, in turn dependent on meteorological conditions) is the effect which makes the Sun (or other celestial body) look slightly higher in the sky than its true astronomical position. It is only significant when the Sun is within a few degrees of the horizon. At 0º altitude, the bending is equivalent to approximately 34 arc-minutes, so that it is possible to see the Sun when it has actually just sunk below the horizon. See Equations. This effect is not generally included in normal sundials but it must be allowed for when calculating solar parameters from observations using meridian lines.

The **refractive index [μ , MU]** of a medium (or its index of refraction), needed to calculate these effects, is defined as the ratio of the speed of light in a vacuum to its speed in the medium.

Regiomontanus houses: an astrological division of the celestial sphere into 12 segments or houses. The division is performed in equal segments around the celestial equator, rather than around the ecliptic as is done for the normal signs of the zodiac. The houses are numbered I to XII, beginning at the east point of the horizon and are, confusingly, associated with the standard zodiac signs with I corresponding to Aries. Only the last 6 of the signs appear above the horizon. They are shown as domifying circles on some old dials.

resolution (of a dial): the smallest time increment to which the scale on a dial can be read. Contrast with accuracy. See also precision.

rete: {or net or spider} (usually pron. ree-tee) part of an astrolabe, it is the fretted disc containing a number of star pointers, and which can be turned on the limb until the star's pointer crosses the altitude circle on the stereographic projection, allowing the time to be read off (assuming the date is known). The term ~ has sometimes (first reference in 1677) been used as a graduated scale fixed to an astronomical telescope.

reticule: fine lines or scales on an optical element in a sighting device (e.g. a telescope) to aid in alignment or measurement of an object.

revolve: (astronomical) to orbit around another body, e.g. the Earth revolves around the Sun. Contrast to rotate.

right ascension: [α, RA] a co-ordinate used by astronomers, as part of the equatorial co-ordinate system, (together with declination) to define the position of a celestial body.

It is the angular distance measured along the celestial equator (positive to the east) from the vernal equinox to the intersection of the celestial equator to with the hour circle through the point in question. Usually measured from 0 to 24 hours, but sometimes 0º to 360º.

root (of a gnomon): The fixing between the gnomon and the dial plate. See Figure 1

rotate: (astronomical) to spin on its own axis, e.g. the Earth rotates on its polar axis. Contrast to revolve..

S

Samhain: an ancient Celtic festival held on the 1st of November. It is one of the cross-quarter days.

saros cycle: a cycle of 18 years 11 days 8 hours (223 lunations) between repetitions of eclipses.

scales: see dialling scales.

sciagraphy: {**skiagraphy**} the art or science of shading and shadows. From sciaterics or scioterics - the name for gnomonics in ancient Greece.

seasons: the seasons are defined astronomically as follows:

Spring: from the vernal equinox to the summer solstice

Summer: from the summer solstice to the autumnal equinox

Autumn: from the autumnal equinox to the winter solstice

Winter: from the winter solstice to the vernal equinox

In popular parlance, the seasons of the northern hemisphere comprise the following months:

Spring March, April, May

Summer June, July, August

Autumn September, October, November

Winter December, January, February

The signs of the zodiac for the seasons are given in Appendix I.

second (of angle): see arc-second.

second (of time): the fundamental unit of time. The accepted scientific definition of the second is now 9,192,631,770 periods of radiation corresponding to the transition between the two hyperfine levels in the ground state of caesium 133. This definition was adopted in 1967, and replaced the earlier (since 1955) ephemeris second which was defined in terms of a fraction of the mean tropical year in 1900. The above frequency was chosen because it gives a close approximation to the number of seconds in a day (86,400). Fluctuations in the Earth's rotational rate since about 1969 have been such that the day is between 1 and 3 ms longer than this number of seconds. These variations are totally insignificant to even the best sundial. The word ~ derives from the Latin "secunda minuta" or second minute.

semidiameter (of the sun): **[s, S]** half the angular size of the Sun (or, more correctly, its photosphere). As the distance from the Earth to the Sun varies during its orbit, the semi-diameter varies from 15.76 arc-minutes in July to 16.29 arc-minutes in January. In dialling, it is usual to take the sun's full diameter as ½º .

septentrional: a term now rarely used for "of the north" and sometimes applied to north-facing dials.

shadow sharpener: any of the various devices for sharpening the edge of a shadow, allowing more accurate time readings to be made. Usually a physical addition to the gnomon or nodus, it casts a secondary shadow, with its own penumbra, in which the primary shadow can be located more accurately (although it may have less contrast). The term is sometimes also used to refer to a movable lens which produces an image of the shadow edge.

shadow square: a square (or rectangular) scale often found on quadrants and astrolabes which allows the tangent or cotangent of the altitude of a celestial body to be found.

shortest day: a term in common parlance, defined as the day of the year with the least (astronomical) sunrise to sunset period. It is normally used synonymously with the winter solstice although, strictly, it can vary by a day depending on the exact time of the solstice and the relationship between the rate of change of the EoT and that of the local sunset/sunrise.

sidereal time, sidereal day: see time (types of).

signs of the zodiac: see Zodiac.

Sirius: (the Dog star) the brightest star in the night sky, used by the Egyptians as a means of determining the beginning of the Nile floods. See heliacal rising.

skylight: light which reaches the observer from the general (blue) sky. It is sunlight which has undergone multiple scattering events with the molecules of the Earth's atmosphere (i.e. Rayleigh scattering) or with clouds or other aerosols in the atmosphere. High levels of skylight reduce the contrast of a shadow. It also tends to be polarised.

slant: see obliquity.

small circle: a circle on the surface of a sphere whose centre does not coincide with that of the sphere (and hence it must always have a smaller diameter).

solarium: Latin for sundial. Beware, it can also be interpreted as "sunning place".

solar compass: an instrument for direction finding which uses dialling principles. The most common are modified versions on an analemmatic dial with a vertical gnomon. Sometimes called an **astro-compass**, although these latter more properly use sightings of the fixed stars.

solar longitude: the ecliptic longitude of the Sun, it varies from 0º (at the vernal equinox) to 360º during the year. By Kepler's Second Law, the rate of change of the solar longitude is such that the Earth sweeps out equal areas on the ecliptic plane in equal times.

solar parallax: the difference between the Sun's altitude as observed from the Earth's surface and its true astronomical value from the centre of the Earth./

solar time: see time(types of).

solstices: (Summer ~, Winter ~) literally, "Sun stands still". In the Northern hemisphere, they represent the beginning of summer (on or around 21 June) and the beginning of winter (on or around 21 December). They are (usually) the same as the longest and shortest days, respectively. Astronomically, they are the occasions when the Sun's ecliptic longitude is 90º or 270º, respectively, and correspond to the extreme values of declination. See Figure 1.

South: one of the cardinal points of the compass, it is the direction opposite north, in the direction of the south celestial pole. It is also the direction of the Sun at local noon (in the northern hemisphere).

southing: another term for a southern transit.

South Pole: the location on the Earth's surface where it intersects the axis, and opposite the North Pole. It has a latitude of -90º.

spherical angle: the angle whose vertex is at the intersection of two great circles of the celestial sphere. Spherical trigonometry deals with spherical angles and triangles.

spherical triangle: the figure formed on the surface of a sphere by three intersecting great circles. The **fundamental** (or **nautical**) triangle is the special case of a spherical triangle on the celestial sphere with vertices at the zenith, North celestial pole and the Sun.

split noon: see noon gap.

standard time zone: **[TZ]** a geographical region which uses the same civil time. These are approximately regions between two lines of longitude, set 15º apart, and hence with 1 hour time difference between adjacent zones. The standard time for each zone is the mean solar time at the central or standard meridian for the zone. For the UK, which is in Zone 0, the standard meridian is the Prime Meridian at Greenwich, and the zone nominally extends from 7½º W to 7½º E. For political reasons, other time zones have their boundaries adjusted to follow country borders or other features. The zones were defined at the same international conference in 1884 that set Greenwich as the Prime meridian.

steradian: (pron. ster-ade-e-on) unit of solid angle. It is the central solid angle of a sphere subtended by a surface area equal to the square of its radius. The whole sphere supports an angle of 4π steradians around its centre.

stereography: (hence stereographic projection) a drawing method in which a sphere is projected from a point on its surface to a plane which is tangent to it. Its main property is that circles on the celestial sphere are projected as circles or straight lines on the plane. It is fundamental to the construction of planispheres and astrolabes as the rete is a stereographic projection. Its use is difficult in the construction of sundials due to the vast length of some of the radii required (although this can be overcome by calculating in cartesian coordinates and then converting). Its use was advocated by 17th century diallists.

string gnomon: a gnomon in the form of a flexible cord which is pulled tight when the dial, typically in diptych form, is opened.

style {stile}: the line in space which generates the shadow edge used to indicate the time on the dial plate. Note that a gnomon with finite thickness will have two styles (one along each of the upper edges) which will each be operational for parts of every day. If the gnomon is in the form of a long rod, the style will be the virtual line running along the centre of the rod and the dial is read by estimating the centre of the shadow. Note: this modern distinction between gnomon and style is not the one found in earlier literature where (from 1577) the word style was used to indicate a polar-pointing gnomon (a polos) or, more rarely, a nodus. Hence **stylar**: pertaining to the style or gnomon of a dial (first used 1688). See Figure 1.

style height: **[SH]** of a polar style is the angle that the style makes with the sub-style line. Note that this is an unusual use of the word "height", and **style angle** could be regarded as a better term. For a style which is perpendicular to the dial plane, style height is simply the distance from its top to the foot. See Figure 1.

sub-nodus (point): the point on the dial plane that lies perpendicularly below (or behind for a vertical dial) a nodus. The distance from this point to the nodus is sometimes called the **ortho-style distance**.

sub-style angle: **[SD]** the angle that the sub-style makes with the noon line, measured positively clockwise (towards the p.m. hours for a south-facing vertical dial).

sub-style (line): the line lying in the dial plane which is perpendicularly below (or behind for a vertical dial) the style. See Figure 1.

sub-style triangle: the right angled triangle formed with the polar style as the hypotenuse, with the other sides lying along the sub-style and the ortho-style distance.

summer solstice; see solstices.

Sun: the star at the centre of our solar system. The mean distance to the Earth (designated the Astronomical Unit or AU) is 149.6 x 10^6 km. It has a surface temperature of about 5800 º K. The solar spectral irradiance reaching the Earth's surface (at AM1 - air mass 1 - i.e. looking through a standard atmosphere with the Sun at the zenith) ranges from about 250 nm to 2000 nm, with the main peak at 490 nm. See semi-diameter for the apparent size of the Sun.

sun clock: see Dial types.

sun compass: see solar compass

sundial: an instrument for telling the time and/or date from the position of the Sun. More generally, it can give any function of the Sun's co-ordinates. See dial for the origins of the term, and Dial (types of) for types.

sunlight: light reaching the observer directly from the Sun. Contrast with skylight. Note that the Sun's rays reaching the Earth are always taken as parallel, but coming from an extended source (see semi-diameter).

sunrise, sunset: the first (last) appearance of the Sun above the horizon each day. This occurs when the sun's altitude reaches -0º 50'. Note that astronomers define the rising of an object as an altitude of 0º. The difference is due to the combined effects of the Sun's mean semi-diameter (16 arcmin) and atmospheric refraction (34 arcmin). See Equations for expressions to calculate sunrise and sunset.

sunshine recorder: a meteorological instrument for recording the hours in which the Sun shines. The most interesting type is the **Campbell-Stokes ~**, which uses a spherical lens to focus bright sunlight onto a paper chart, burning a track along it.

superior: refers to an event on the celestial sphere above the horizon. Opposite of inferior.

synodic: pertaining to the successive conjunctions of a planet (or moon) with the Sun.

T

tellurian: a demonstration model, similar to an orrery, but showing the Earth-Sun system, or the Earth-Sun-Moon system. This latter is sometimes referred to as a **lunarium**. Note: the tellurian is sometimes called a tellurium but this term is best avoided as it is the name of the 52nd element in the periodic table.

terminator: the edge of the shadow cast by a self-shadowing object, such as the edge of the illuminated part of the Moon.

terrella: from the Latin for "little globe". See globe dials.

tide(s): the divisions of a day used in the Anglo-Saxon period. The time from sunrise to sunset was divided into four tides or time periods. See Appendix II for the names of the tides. Lines showing the tides are found on Anglo-Saxon and some mass dials. Some dials also have lines denoting the half-tide. Note that this use of the word has no connection with the marine tides.

Time, (types of):

Apparent solar ~: the measure of time based on the diurnal motion of the true sun.

British Summer Time: **[BST]** civil time in the UK during the "summer", one hour ahead of GMT. Invented by William Willett and first introduced in 1916. A sundial showing BST in Petts Wood, near Chislehurst, Kent, is his memorial. BST usually begins on the last Sunday in March, and ends on the last Sunday in October. These dates are now co-ordinated with Summer Time in the rest of the EU.

civil ~: the legally-accepted time scale in a particular country or region. It is based on the standard time for that standard time zone, but may have fixed differences (eg BST). Measured in modern hours from the most recent midnight, with either a 24 hour or 2 x 12 hour format.

clock ~: simply the times shown by a clock, usually civil time. Hence the appendage "o'clock" to some times.

Daylight Saving Time: **[DST]** civil time during the summer in much of the USA (and some other countries) obtained by advancing clock time one hour from local standard time. Equivalent to BST in the UK.

dynamical ~: [or Terrestrial Dynamical Time, **TDT**] "scientific time" – it superseded ephemeris time in 1984, and is based on a uniform scale of time derived from atomic clocks (i.e. not subject to fluctuations in the Earth's rate of rotation). Now usually called **international atomic time (TAI).**

ephemeris ~: **[ET]** "scientific time" **-** used between 1960 and 1983, this uniform timescale was based on the ephemeris second, itself derived from the period of rotation of the Earth at a particular date. It was succeeded by dynamical time when the second was redefined in 1984.

French revolution ~: a decimal timescale (10 equal hours or decidays per day) devised in 1790 by the French Academy after the French Revolution. Each hour was divided into 100 millidays (of 86.4 seconds) and each milliday into 1000 microdays (0.0864 seconds each). The decimal timescale, which had been used previously in ancient Egypt and China, was never fully implemented and was quickly dropped, with the result that sundials so calibrated are extremely rare.

Greenwich Mean Time: **[GMT]** the basis for civil time standards worldwide, it is the time at Greenwich as given by the fictitious mean sun. It is derived from UT, but GMT is measured from midnight.

Local Apparent Time: **[L.A.T. -** the use of the full-stops is encouraged to avoid confusion with the common contraction of "latitude"**]** this is solar time, as derived from the real Sun at any particular location. It is the hour angle of the Sun + 12 hours. Some authors (non-UK) may refer to it a Local True Time.

local mean ~ {mean ~}: **[LMT]** this is solar time which has been corrected for the EoT but not for longitude, so it is still location specific. English towns used this form of time prior to the coming of national railways and the telegraph, e.g. Oxford time.

Mean Solar Time: the authoritative (by the National Physical Laboratory) definition is: a measure of time based conceptually on the diurnal motion of the fictitious mean Sun, under the assumption that the Earth's rate of rotation is constant.

railway ~: (or **London time**) a colloquial term used for Greenwich time as it began to replace local time with the introduction, in the mid-1800s, of railways and the resulting need for unified timetables.

sidereal ~: **[τ, SDT]** "astronomical or star time". This is timekeeping based on the sidereal day, and hence it runs ahead significantly with respect to solar-based time. **Local sidereal time** is equal to the hour angle of the first point of Aries and is, to a first approximation, sidereal time with a longitude correction.

solar ~: the same as Local Apparent Time.

Summer time: a generic term for BST, DST etc.

standard ~: **[ST]** is mean solar time at the central meridian of a given time zone.

universal ~ :**[UT or UTC]** this is the basis for terrestrial and civil timekeeping, and was adopted in January 1972. It is tied to the rotation of the Earth, and hence has to be periodically adjusted by the addition of leap seconds to account for the gradual slowing of the Earth, and the vagaries of its rotation. UT is by definition measured from the superior transit of the fictitious mean sun (i.e. mean noon at Greenwich), and hence is 12 hours behind GMT (although this difference only tends to be recognised by astronomical calculations). UT measurement is based on standard seconds. The version referred to as **UTC (Universal Time, Co-ordinated)** simply means the value averaged over a number of atomic clocks world-wide. In aviation, it is referred to as Z or zulu.

zonal solar time: sometimes used to denote solar time at a time zone meridian. Thus it is local apparent time with a longitude correction but without EoT. In the UK, it would be denoted **Greenwich Solar Time**.

- End of Time (types of) -

time zone: see standard time zone.

torquetum: (pron. tor-kwet-um) an early (known to be before 1326 AD) astronomical instrument capable of fixing star positions and producing conversions between equatorial and ecliptical co-ordinates. Some forms may have been used to help delineate dials, and torquetum-style dials for solar and sidereal time were made in the late 17th century. Most famously, it features amongst the instruments in Holbein's 1533 painting "The Ambassadors" (National Gallery).

transit: the meridian passage of a celestial body. For the sun, this occurs when it is directly south of the observer. It can also refer to the time of this occurrence. Transits may be either superior or inferior.

transom: a crosspiece of fixed length, as on a cross-staff. Sometimes called a **vane**.

triangle (fundamental or nautical): see spherical triangle.

triens: an extended quadrant, with a 120º arc. It can usually tell the time in both equal and unequal hours.

trigon: in dialling, a mechanical aid to drawing lines of declination on dial plates. It consists of an instrument which is fitted to, and can swivel around, the nodus on a polar-pointing gnomon, and can be set at an angle equal to the sun's declination angle to the gnomon. Often used with an associated auxiliary dial. Trigon is also an archaic term for a triangle. From the Greek "trigonon" or three-cornered.

triptych: (pron. trip-tich) literally "three leaves", it refers to a set or compendium of three instruments, including at least one dial. Other instruments often include a compass and perpetual calendar.

tropical year: see year.

tropics: geographical bands of the Earth's surface, extending from the equator to latitude 23º 26' N (tropic of **Cancer**) or to 23º 26' S (tropic of **Capricorn**). The terms are also used to refer to these specific latitudes. Note that they represent the extremes of the region where the Sun can reach the zenith when the sun's declination is at its extreme values.

twilight: the interval after sunset or before sunrise when the Sun illuminates the upper atmosphere and hence it is not completely dark. It is determined by the sun's altitude falling within a given range, as follows:

civil twilight: -0º 50' and -6º

nautical twilight: -6º and -12º

astronomical twilight: -12º and -18º

These values reflect the need for decreasing light levels for various activities.

U

umbra: the central, darkest portion of a shadow, i.e. the region which does not receive direct rays from any part of a distributed light source (e.g. the Sun).

umbra recta: Latin for "upright shadow", it is the label often found on the cotangent scale of altitudes < 45º on a shadow square.

umbra versa: Latin for "reverse shadow", it is the label often found on the tangent scale of altitudes > 45º on a shadow square.

Universal Time (UT): see time (types of).

V

vernal {spring} equinox: see equinoxes.

verdigris: (pron. ver-de-gree) the green patination found on weathered brass and copper.

vernier: a small moveable scale for obtaining fractional parts of the subdivisions of a fixed scale. Invented by Pierre Vernier in 1631 (published Brussels, 1638). For circular scales, a Type A vernier has a central zero. After about 1780, sextants commonly had a Type B vernier with the zero on the right of the scale. European instruments often have the very similar nonius.

vertical angle: the angle from the zenith to the horarius circle passing through the sun, measured along the prime vertical (the E-W vertical circle). It is one of the ptolematic co-ordinates.

vertical plane: see principal plane.

volvelle: (pron. vol-vel) an old device consisting of one or more movable circles surrounded by other graduated or figured circles. It is used for showing the rising and setting times of the Sun and Moon, the state of the (marine) tides etc. A ~ has sometimes been included around the rod-gnomon of equiangular dials.

W

wedging out: (or **canting out**) placing wedges between a dial plate and its mounting surface. (a) for a horizontal dial: to compensate for moving a dial to a different latitude from the one it was designed for, (b) for a vertical dial: to ensure that it faces a cardinal point of the compass (usually S).

West: the point on the horizon 90º (measured anti-clockwise) from the north point. The Sun appears to set at the west point at the equinoxes.

winter solstice: see solstices.

X

Y

year: the time that it takes the Earth to make one orbit of the sun. The **tropical year** is the interval in which the mean ecliptic longitude of the Sun increases by 360º. This is the version of the year used in normal calendars and has a length of 365.24219 days. Other versions of a year (e.g. the sidereal, anomalistic and Julian years) have differences of about a hundredth of a day to this figure.

Yule: an ancient Celtic festival held on or around the 21st of December, celebrating the winter solstice. It is one of the cross-quarter days, and has now become synonymous with Christmas.

Z

zenith: (astronomical) the point on the celestial sphere vertically above the observer. In everyday parlance, ~ usually implies the highest point. This gives rise to confusion as the mid-day Sun is often described as its ~, irrespective of the latitude.

zenith distance (or **zenith angle**): **[*z*]** the complement of the altitude i.e. (90º - *a*)

zodiac: an imaginary band, centred on the ecliptic, across the celestial sphere and about 16º wide, in which the Sun, Moon and the planets Mercury, Venus, Mars, Jupiter and Saturn are always located. The band is divided in 12 intervals of 30º , each named (the **Signs of the Zodiac**) after the constellation of stars which it contains. The sun's ecliptic longitude may be measured against this scale. The names (and/or signs) of the constellations are given in Appendix I and are often used in sundials, instead of the date, to specify declination lines etc. Because of the effects of precession over the period of 2,300 years since the constellations were first named, the signs of the zodiac have slipped by a whole sign, i.e. at the vernal equinox (defined as the first point of Aries), the Sun is actually in the constellation of Pisces.

Zonwvlak: a major suite of computer programs for calculating sundial lines. Written by Fer de Vries (Netherlands) it is available at www/iaehv.nl/users/ferdv. The name is short for zonnewijzer (sundial) vlak (plane).

The BSS Sundial Glossary

Several letters to the BSS Bulletin in 1999 suggested that a sundialling glossary would be useful in furthering the society's aims. It is hoped that this resulting glossary will fulfil two objectives. The first of these is to provide newcomers to dialling with a reference document which will explain the many strange terms or unusual usages of common words which they will come across in the dialling literature.

The second objective is to try to produce definitive meanings of the terms which diallists sometimes use rather loosely, and which can therefore lead to some confusion. Thus when several words have the same meaning, the preferred use is described here. Likewise, an attempt has been made to produce a standardised set of symbols for the most widely used terms in dialling equations.

Choices between different meanings have been made on the basis of adopting the most common modern usage found in the literature (particularly those items shown in the Sources section) as long as this does not produce confusion. Alternative usages, spellings or conventions which may be met, particularly in early dialling works, have been given where possible, but it is hoped that future authors will adopt the preferred definitions given here.

As English is used in countries other than the UK, there may be alternative definitions overseas. However, this glossary has been assembled with collaboration from the North American Sundial Society and, via the medium of the internet, diallists worldwide, so it is not expected that there will be major differences in terminology throughout the majority of the English-speaking world.The alphabetical section of the glossary consists of over 190kb, please watch the status bar of your browser and wait for the entire document to load.

John Davis - BSS Glossary Editor

UPDATES TO THE EDITOR

It is proposed to update this glossary periodically, so that it will develop along with the science of dialling. If you have any comments, corrections or additions, please inform the editor at john.davis@btinternet.com or at the address below.

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May 2000

SCOPE

The glossary contains mainly terms which are directly related to dials and dialling. Additionally, excursions into the fields of astronomy, horology, optics and solar sciences have been made where it seems useful. Some comments on the history of dialling are made, but there are no direct entries for famous diallists, except where something is named after them.

NOTATION

Words thus are links to entries in this glossary or other internal references.

Bold text indicates a definition.

~ indicates a repeat of the entry word.

Symbols in square brackets **[*x*, X]** give the preferred symbol and abbreviation. See section on **Symbols** for a full list.

Alternative spellings or terms to the preferred ones are shown in brackets thus: {dialing}.

Pronunciation of unusual words is shown with a simplified phonetic scheme thus: **gnomon** (pron. no-mon). If no pronunciation is given for an entry, it is pronounced as it is written (following normal Oxford Dictionary rules for English pronunciation).

A note on the Southern Hemisphere. This glossary has been written primarily for the Northern Hemisphere, since this is where the majority (but not all) of the BSS membership resides. Gnomons in the Southern Hemisphere generally point to the S celestial pole, and the hour numbers on a horizontal dial run anti-clockwise rather than clockwise. The notation and equations used in the glossary are consistent as long as the sign conventions are followed, but the reader must mentally change N to S in the text.

PRINTED VERSION

This Glossary is also published by the British Sundial Society as a printed book which is now available.

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WEB DESIGNER

Conversion of the printed version for this website has been a complex and demanding task, undertaken by BSS member Robert Terwilliger who is also the Webmaster for the North American Sundial Society.

Glossary: a list with explanations of abstruse, antiquated, dialectal or technical terms.

SYMBOLS

The following symbol set should be used in dialling equations wherever possible. In computer programs and spreadsheets, where Greek symbols cannot be used, the capitalised version should be used instead. The sign conventions and reference points for the various parameters are given in the main glossary.

Preferred symbol	Alternative symbols	Meaning	Dimensions
(a) Co-ordinates on the celestial sphere, etc.			
α	RA	Right Ascension of a celestial body	angle or time
δ	DELTA, DEC	declination of the Sun (or other celestial body)	angle
λ (or λ_e)	ELON	ecliptic longitude of a celestial body	angle
β	ELAT	ecliptic latitude of a celestial body	angle
ε	EPS	obliquity of the ecliptic	angle
e_c	EC	eccentricity of the Earth's orbit	dimensionless
s	S	Sun's semi-diameter	angle
(b) Observer's local co-ordinates			
λ (or λ_t)	LON	longitude (terrestrial) (positive west of Greenwich)	angle
ϕ	PHI, Lat	latitude of a place	angle
h	HA	hour angle (p.m. hours give positive angles)	angle
A	AZ	azimuth of the sun (clockwise from S)	angle

a	ALT	altitude of the sun	angle
z	ZD	zenith distance	angle
η	PA	parallactic angle	angle
(c) Sundial parameters			
d	DEC	declination of a wall (E negative, W positive)	angle
i	INC	inclination of the dial plate (horiz. to back of dial)	angle
v	V	angle between noon line and angle of greatest slope for a declining, inclining dial	angle
SH	SH	style height or angle from dial plane (note unusual use of "height")	angle
SD	SD	sub-style angle from noon line	angle
DL	DL	difference in longitude	angle
X	HLA	hour line angle from noon line (positive for pm)	angle
N	NH	nodus height above dial plate (or length of vertical style)	distance
(d) Time related			
E	EoT	Equation of Time (as a time)	time
E_a	EoTA	Equation of Time (as an equivalent hour angle)	angle
t	T	time (subscript shows which system)	time

LAT	LAT or L.A.T.	Local Apparent Time	time
LMT	LMT	Local Mean Time (LAT corrected for EoT)	time
ST	ST	Standard Time (LMT corrected for longitude)	time
TDT	TDT	Terrestrial Dynamic Time	time
TZ	TZ	Time Zone number (integer)	dimensionless
t_{sr}, t_{ss}	TSR, TSS	times of sunrise and sunset	time
JD	JD	the Julian Day number	days
$\mathcal{T}$	SDT	sidereal time	time
ST	ST	standard time	time
ET	ET	ephemeris time (obsolete)	time
UT or UTC	UT	Universal Time (Co-ordinated)	time
GMT	GMT	Greenwich Mean Time	time
DST	DST	Daylight Saving Time	time
BST	BST	British Summer Time	time
(e) Co-ordinate systems			
(x, y)	X, Y	cartesian co-ordinates of a point on the dial plane w.r.t. the origin. Optionally, (x, y, 0) in 3-D	length, length
(r, θ)	R, THETA	polar co-ordinates of a point on a dial plane w.r.t. the origin	length, angle

hec	HEC	hectemoros angle	angle
hor	HOR	horarius angle	angle
(f) Miscellaneous			
μ	MU	refractive index	dimensionless
R_o	R0	angle of atmospheric refraction	angle
T	TEMP	temperature	Kelvin

Notes: λ is traditionally used for both terrestrial and ecliptic longitudes. In the rare cases where this could cause confusion, they should be denoted λ_t and λ_e, respectively.

SUNDIAL EQUATIONS

"All this information is secured by means of instruments suitable for these purposes, and by tables and by canons.... For everything works through innate forces shown by lines, angles and figures" *Opus Majus*, Roger Bacon (1220-1292)

Sundial equations are published in many of the standard sources. Those reproduced here use the preferred symbols and definitions of the various parameters as described in the glossary. They are also self-consistent, and follow the sign conventions of the glossary, i.e. if the correct signs of the angles are input, and proper note is taken of the signs of the trigonometrical functions, the outputs will also have the correct signs.

Notes. In the equations for the hour line angle *X*, the equations are for $-90° < h < 90°$, i.e. between 6 a.m. and 6 p.m. L.A.T. For other times, the true hour line angle is given by:

$$X' = X \pm 180°$$

The hour angle, *h*, in degrees, is given by

$$h = (T_{24} - 12) \times 15°$$

where T_{24} is the time in 24-hour clock notation (hours after midnight) in decimal hours.

1. Horizontal dial (i = 0º)

Style height:

$$SH = \phi$$

Hour line angles:

$$X = \arctan\{\sin\phi . \tan(h)\}$$

2. Vertical direct S dial(i = 90º)

Style height:

$$SH = 90° - \phi$$

Hour line angles:

$$X = \arctan\{\cos\phi . \tan(h)\}$$

3. Declining dial(i = 90º)

Style height:

$$SH = \arcsin\{\cos d . \cos\phi\}$$

Sub-style angle:

$$SD = \arctan\left\{\frac{\sin d}{\tan \phi}\right\}$$

Hour line angles:

$$X = \arctan\left\{\frac{\cos\phi.\tan(h)}{\cos d + \sin d.\sin\phi.\tan(h)}\right\}$$

4. Declining-reclining dial

The case considered here is for $i > \phi$ and $d < d_{\text{crit}}$

$$d_{crit} = \arccos\left\{\frac{\tan\phi}{\tan i}\right\}$$

where

i.e. the common case of a roughly south-facing dial reclining slightly from the vertical. Then:

Noon line angle (with respect to the line of greatest slope):

$$v = \arctan\{\tan d.\cos i\}$$

Style height:

$$SH = \arcsin\{\cos\phi.\sin i.\cos d - \sin\phi.\cos i\}$$

Sub-style angle:

$$SD = \arctan\left\{\sin i \sin d \times \frac{\sin i.\cos d - \tan\phi.\cos i}{\cos i + \tan\phi.\cos d.\sin i}\right\}$$

Hour line angles (with respect to the noon line):

$$X = \arctan\left\{\frac{(\cos\phi\sin i - \sin\phi\cos i\cos d)\tan(h) + \cos i\sin d}{\cos d + \sin d.\sin\phi.\tan(h)}\right\} - v$$

5. Sun’s azimuth

$$A = \arctan\left(\frac{\sin(h)}{\sin\phi\cos(h) - \cos\phi\tan\delta}\right)$$

6. Sun's altitude

$$a = \arcsin\{\sin\phi\sin\delta + \cos\phi\cos\delta\cos(h)\}$$

7. Sunrise/sunset

The time (hour angle) of sunrise/sunset is given by:

$$h_{sr,ss} = \mp\arccos(-\tan\phi.\tan\delta)$$

The azimuth of the rising/setting sun is given by:

$$A_{sr,ss} = \mp \arccos\left(-\frac{\sin\delta}{\cos\phi}\right)$$

Note that these times and azimuths are for astronomical sunrise/sunset, i.e. when the centre of the sun is on the true horizon, neglecting atmospheric refraction. For other definitions of sunrise/sunset, the corresponding altitudes should be used in the equations of (5) and (6)

8. EoT (best fit equations)

A full calculation of the EoT for any time in any epoch is complex and the reader is referred to Meeus (see Sources), an Astronomical Almanac, or the NASS Dialist's Companion computer program , or use the on-line solar calculator at www.gcstudio.com/suncalc.html . Mean daily values of the EoT (over the period 2000 - 2099) are available from: http://www.chabot.demon.nl/sundials/sunmeangmt.htm. For many practical purposes, the fourier transform approximation given below, which has a worst-case error of 0.0025 radians (35 seconds of time), will be sufficient.

$$E_a = -0.0000075 - 0.001868\cos w + 0.032077\sin w + 0.014615\cos 2w + 0.040849\sin 2w$$

where E_a is in radians at 12:00 UT and w is calculated from day number n_d (ranging from 1 on 1 January to 365 on 31 December) by:

$$w = 2\pi n_d / 365$$

To convert to the EoT in seconds (of time), multiply E_a by $43200/\pi$.

For detailed values of the EoT (and many other solar parameters) on any particular day, use the NASS Diallers' Companion program.

9. Declination (best fit equations)

The comments made above for the EoT also apply to the Sun's declination. The fourier transform approximation below yields a maximum error of 0.0006 radians (less than 3 arcminutes) or, if the final two terms are omitted, 0.0035 radians (12 arcminutes:

$$\delta = 0.006918 - 0.399912\cos w + 0.070257\sin w - 0.006758\cos 2w + 0.000907\sin 2w - 0.002697\cos 3w + 0.001480\sin 3w$$

where δ is in radians and w is as defined for the EoT above.

10. Sun’s refraction

$$R_o = \frac{1}{\tan\left[a + 7.31/(a + 4.4)\right]}$$

R_o is the refraction in arcmins for a temperature of 10ºC and an atmospheric pressure of 1010 mb. For other conditions, a multiplying factor of 0.28P/T is required, where P is the pressure in mb and T is the temperature in kelvins (= temp in ºC + 273).

11. Babylonian and Italian Hours

The Babylonian hour t_B> and Italian hour t_I (in hours) are given by:

$$t_B = \{24 + (h + \zeta)/15\} \bmod 24$$

and

$$t_I = \{24 + (h - \zeta)/15\} \bmod 24$$

where *h* is in degrees and

$$\cos\zeta = -\tan\phi . \tan\delta$$

12. Seasonal or Temporal Hours

The temporal hour t_T (in hours) is given by:

If $h < -\zeta$:

$$t_T = \frac{6 \times (360 + h - \zeta)}{(180 - \zeta)}$$

If $\geq \zeta$:

$$t_T = \frac{6 \times (h - \zeta)}{(180 - \zeta)}$$

Otherwise:

$$t_T = \frac{6 \times (h + \zeta)}{\zeta}$$

where all angles are in degrees and ζ is as defined for Babylonian hours above.

CHRONOLOGY – some selected dates in the development of sundials and solar astronomy

in Filippo Brunelleschi's newly completed dome of the Santa Maria del Fiore, Florence.

Date	Development
9000 BC to 8000 BC	The Maya make astronomical inscriptions and constructions in Central America. A marked bone (possibly) indicating months and lunar phases in use in Ishango (Zaire)
4228 BC to 2773 BC	The Egyptians institute a 365-day calendar. The start of the year, coinciding with the annual Nile floods, is linked to the rising of Sirius (the Dog Star) in line with the sun.
1500 BC to 1450 BC	L-shaped sundials used in Egypt.
1450 BC to 1400 BC	Stonehenge achieves the form known today.
600 BC to 590 BC	Sundials are used in China and the Chinese text "Arithmetic classic of the gnomon and the circular paths of the heaven" contains a version of the Pythagorean theorem.
585 BC	Thales of Miletus (Turkey) correctly predicts a solar eclipse.
520 BC to 510 BC	Anaximander introduces the sundial to Greece (previously used in Mesopotamia, Egypt and China. He also produces a cylindrical (sic) model of the Earth.
500 BC to 490 BC	The Pythagoreans (Greece) introduce a spherical model of the Earth.
450 BC approx	Greek philosopher Democritus draws the first maps with rectangular grids of "latus and longus" (latitude and longitude).
480 BC to 470 BC	Greek philosopher Oenopides calculates that the axis of the Earth is tipped over by 24Ú from the plane of its orbit.
340 BC to 330 BC	Kiddinu (Babylonia) works out an (inaccurate) version of the precession of the equinoxes.

270 BC to 260BC	Aristarchus of Samos (near Turkey) challenges Aristotle's theory by asserting that the Sun is the centre of the solar system and the planets revolve around it. He estimates the distances of the Moon and (wrongly) the Sun from the Earth.
240 BC to 230 BC	Eratosthenes of Cyrene (Libya) calculates the circumference of the Earth from the difference in latitude between Alexandria and Aswan, using shadow lengths. He also lays down lines of longitude on a map.
190 BC to 180 BC	The Greek astronomer Seleucus is the last known astronomer to champion a helio-centric theory of the solar system until Copernicus.
164 BC	Pliny records that a sundial is properly set up for the first time in Rome, and the Romans begin to divide the hours of daylight into hours.
160 BC to 140 BC	Hipparchus of Nicea (Turkey) produces a more accurate theory of the precession of the equinoxes.
120 BC to 110 BC	Hipparchus of Nicea (Turkey) uses a total solar eclipse and parallax to measure the distances to and sizes of the Moon (correctly) and the Sun (an order of magnitude too small).
87 BC	A complex mechanical Greco-Egyptian astronomical calendar is made and shipped to Rome. It is later recovered from the sea and becomes known as the Antikythera mechanism.
52 BC	Chinese astronomer Ken Shou-Ch'ang builds a form of armillary ring, a metal circle representing the equator and used to observe the stars.
50 BC to 41 BC	Andronikos of Kyrrhestes builds the Tower of the Winds in Athens. It includes early sundials in the eight principal directions. The Roman architect Vitruvius (Marcus Vitruvius Pollio) includes information on sundials in his "De Architectura" on engineering and architecture. He uses the word analemma in referring to a form of orthographic projection.
10 BC	Augustus erects a monumental sundial in Rome. The 15 metre stone obelisk gnomon, brought from Egypt and now in the Piazza de Populo, commemorated victory over Mark Antony and Cleopatra, and was surrounded by numerous lines for the hours, days and months.

46 BC	Julius Caesar, acting on the advice of Greek astronomer Sosigenes (court astronomer of Egypt), introduces the Julian calendar. To account for previous errors, year 46 BC has 445 days.
84 AD	Fu An and Chia Kuei improve on the armillary sphere for locating stars by combining an equatorial ring with an ecliptic one.
100 to 109	Bhaskara measures the diameter of the sun. Menelaus of Alexandria's "Spherics" establishes spherical trigonometry.
140 to 149	Ptolemy, (Claudius Ptolemaeus) the last great astronomer of the Alexandrian school in Egypt, writes the book "Megale Syntaxis tes astronomias" (Great Astronomical composition) later called the Almagest by the Arabs. It includes his model of the solar system based on circles and epicycles.
450 approx	Palladius Rutilius Taurus Emilianus in Sicily writes "De Re Rustica", giving shadow lengths for this southerly location.
497	Aryabhata I (in India) recalculates Greek measurements of the solar system. He largely accepts Ptolemy's model, but also proposes that the Earth rotates.
530	Simplicius of Cilicea comments on Plato's 1000-year old theory that the heavenly bodies have uniform circular motions.
580 approx	Gregory of Tours writes "De Cursu Stellarum" (The tracks of the stars) providing monks with a set of rules for saying their nocturnal prayers.
664	The Synod of Whitby, attended by Bede and other leading monks, determine the inaccuracies in the current calendar. The term "Anno Domini" (in the year of Our Lord) is introduced.
650 approx	Pope Sabinianus commands that dials should be placed on churches to show the hour of the day.
670 to 679	The Venerable Bede (an English scholar at Jarrow, Northumbria), writes on the calendar, marine tides and the shape of the Earth in his English history "Historica Ecclesiastica gentis Anglorum". He also gives an accurate table of shadow lengths.

700 approx	The oldest surviving Anglo-Saxon sundials in England are built at Bewcastle (Cumbria) and Escomb (Co. Durham).
807	Einhard's "Life of Charlemagne" provides the first Western reference to sunspots
827	Egyptian astronomer and geographer Afragamus (Abu-al-'Abbas al Farghani) presents Ptolemy's works clearly in Arabic.
850 approx	The "Tiberius Horologium" is written by monks in northern England, giving accurate shadow lengths at different times throughout the year.
880 to 910	Arabian astronomer Albategnius re-calculates the length of the year and provides a refined measurement of the precession of the equinoxes.
890 to 900	Thabit Ibn Qurra (Baghdad) writes the manuscripts "Description of the figures formed by the extremity of a gnomon in its passage on a horizontal plane, in all the days, in all the places" and "Book on the instruments which indicate the hours, called solar dials".
940 to 950	The Dunhuang star map is produced in China. It uses a form of projection later used by Mercator.
1000 to 1010	Ibn Yunus's "The large astronomical tables of al-Hakim" contains accurate astronomical and mathematical tables based on 200 years of observations.
1010 to 1029	Alhazen (b. Basra, Iraq; d. Cairo) explains the cause of twilight as atmospheric refraction, develops quartz lenses and discovers the properties of parabolic mirrors.
1070 to 1090	Arzachel suggests that planetary orbits are elliptical.
1086	Chinese scientist Shen Kua's "Dream pool essays" contains the first known reference to a magnetic compass for navigation.
1092	In China, Su Sung builds a giant water clock and mechanical armillary sphere.

1100 approx.	Omar Khayyám (Persia, c1048-1131) calculates the year length correct to about 1 minute.
1100 to 1110	Chinese astronomers build a stone planisphere of the heavens that correctly demonstrates the cause of solar and lunar eclipses.
1126	Adelard of Bath (England) translates Al-Khowarizmi's "Astronomical tables" from the Arabic.
1200-1300	Returning Crusaders bring Islamic knowledge of the polar gnomon and many dial types to Europe.
1220	At the University of Paris, John of Holywood (Sacrobosco) writes "Sphaera mundi" (spheres of the world) introducing Ptolemy's Almagest to Europe and explaining solar and lunar eclipses.
1265-7	Roger Bacon, a Franciscan friar educated in Paris and Oxford, writes on many subjects including astronomy and astrology, and proposes the need for calendar reform to Pope Clement IV.
1270 to 1280	Kuo Shou-Ching builds the first torquetum, the first astronomical device to use an equatorial mounting.
1276	Chinese astronomer Zhou Kung sets up a 12 metre gnomon for measuring the sun's shadow.
1280	Abul Hhasan al Marrakushi writes a manuscript (translated into French by J. J. Sedillot in 1834) describing many types of dials and the methods for calculating them.
1288	Jacob ben Machir ibn Tibbon (Latin name Profatius, 1236-1305) designs a new quadrant of "quadrans novus" which allows the time to be found by the altitude of the sun or another star.
1290 to 1299	William of Saint-Cloud determines the obliquity of the ecliptic from the sun's position at the solstice – he is only 2 arc-mins in error.
1310 to 1319	The first mechanical clocks appear in Europe and unequal hours begin to be displaced by equal hours.

1348 to 1364	Giovanni de Dondi of Padua (Italy) builds his famous Astrarium, or astronomical clock. Using Ptolemeic astronomy, it shows the orbits of the Sun, Moon and the five known planets, together with many other features including sunrise and sunset.
1391	Geoffrey Chaucer’s "A treatise on the astrolabe" shows how this instrument can compute the position of a star. He describes a monk using a chilindrum (shepherd’s dial) in his "Canterbury Tales".
1438	The "horary quadrant" is invented by Johannes von Gmunden (1384-1442) as a simplified version of the old Islamic quadrant specifically for time-telling.
1471 to 1474	Regiomontanus (b. Johann Müller (1436-76) and adopted the name "the man from the Royal Mountain" from his birthplace in Königsberg) builds an observatory in Nuremberg, Germany. He publishes "Ephemerides astronomicae", although it is not until later editions that the tables of solar declination used by navigators (including Christopher Columbus) are included. His "universal rectilinear analemma" is a form of card dial. The Nuremberg group make much use of Ptolemy’s rulers, and further develop the torquetum.
1475	Italian mathematician and astronomer Paolo Toscanelli installs a 100 metre noon line in Filippo Brunelleschi's newly completed dome of the Santa Maria del Fiore, Florence.
1514	Copernicus writes the first version of his heliocentric theory, although it is not published until 1543.
1514	Copernicus writes the first version of his heliocentric theory, although it is not published until 1543.
1517	Nicholas Kratzer comes to England from Austria to be horologist to King Henry VIII. He later makes several famous dials and is painted by Hans Holbein making a polyhedral dial.
1525	Petrus Apianus publishes his book "Cosmographie" It includes a drawing of a universal diallist’s companion, a form of analogue computer for giving sunrise/sunset times, declinations etc. He supports the Aristotelian model of crystal spheres carrying the Sun, Moon and planets.

1530	Gemma Frisius' globe manual "De Principuiis Astronomae et Cosmographiae" describes the use of spherical gnomon for providing equal hours.
1532	Oronce Finé (Paris) publishes his "Protomathesis", giving a comprehensive treatment of dial types.
1533	Dutch geographer Reiner Gemma is the first to point out that comparisons of clock and solar time can be used to find longitude.
1550	Joanne de Rojas develops the universal astrolabe, based on the orthogonal projection.
1560	Oronce Finé (Paris) publishes "De Solaribus Horologiis".
1582	Pope Gregory XIII reforms the calendar, resulting in 1582 having only 354 days. The Gregorian calendar is adopted by most of mainland Europe.
1583	Joseph Justus Scaliger (Lot-et-Garonne, France) devises a system of counting days from 4713 BC, later to be incorporated in the Julian Day count.
1593	Thomas Fale publishes "Horologiographica: The art of Dialling", the earliest work devoted to the subject of making dials in the English language.
1595	Mercator's "Atlas sive cosmographicae" is published posthumously.
1598	Valentin Pini discusses Ptolemy and introduces an armillary dial
1606	Elias Allen, one of the greatest dial and scientific instrument makers of the era, is established near Fleet Street, London.
1609	Kepler’s "Astonomia nova" contains his views that the planets orbit the Sun in ellipses, sweeping out equal angles in equal time intervals (Kepler’s Law). Galileo builds his first telescope
1624	William Oughtred devises the double horizontal dial, manufactured to very high quality by Elias Allen.

1631	French engineer Pierre Vernier invents the vernier scale.
1633	The Roman Catholic Inquisition forces Galileo to recant his Copernican view that the Earth orbits the sun.
1638	Samuel Foster, of Gresham College, London, publishes "The Art of Dialling", including the first description of scales for drawing a dial.
1654	Samuel Foster describes a number of new types of dial, including analemmatic and diametral.
1655	Gian Domenico Cassini builds the great sundial in Bologna cathedral with which he measures new values for the obliquity of the ecliptic.
1657	George Serle puts dialling scales onto a ruler and describes them in his article "Dialling Universal".
1664	René Descartes' "Le Monde", published posthumously, affirms the Copernican theory.
1670	G. Mouton proposes the use of one-sixtieth part of a degree of the meridian as the unit of length.
1675	The Greenwich Observatory is founded by King Charles II. John Flamsteed is the first Astronomer Royal and calculates a table of the EoT.
1685	John Twysden publishes his "Use of the Great Planisphere called the Analemma".
1687	Newton publishes the "Principia" including the law of universal gravitation.
1714	The British Parliament sets a prize of £20,000 for a method for finding longitude at sea.
1724	Jai Singh, Rajah of Jaipur, builds his great sundials in India.
1725	Antoine Thiout (Vesoul, France) designs a clock to show solar time. It is called the equation clock.

1740	The modern figure-8 form of the analemma curve is conceived by Jean Paul Grandjean de Fouchy, secretary of the Académie des Sciences, Paris.
1748	James Bradley discovers the nutation of the Earth's axis.
1749	Jean le Rond d'Alembert gives the first mathematical description of the regular changes in the Earth's rotational axis.
1750	The Greenwich Meridian is established at its current position by James Bradley. It had initially been 20.4 metres further west.
1752	Great Britain finally adopts the Gregorian calendar, and moves the start of the civil year to 1 January. Johann Tobias Mayer (Marbach, Germany) publishes lunar ephemeris with sufficient accuracy to find longitude.
1754	John Dollond (London) invents the heliometer and uses it to find the semidiameter of the sun.
1756	J. J. de Lalande (Ain, France) designs the oldest analemmatic dial still in existence, in Brou churchyard.
1759	John Harrison completes his "Number Four" clock, later used to win the Longitude prize.
1764	Lagrange explains the libration of the Moon.
1767	Astronomer Royal Nevil Maskelyne publishes the first annual ephemeris which will later become the "Nautical Almanac".
1792	Jean-Baptiste Delambre and Pierre Mechain measure the arc of the meridian from Dunkirk to Barcelona, leading to the new definition of a metre.
1812	Laplace gives an accurate calculation for sunrise, using 5000 years of data.

1837	The London and Birmingham Railway deploy Cooke and Wheatsone's new telegraph signalling and use "railway time" for trains from Euston. Charles Dickens mentions railway time in "Dombey and Son".
1838	France adopts mean time rather than solar time for civil purposes.
1843	Edward Dent (England) patents the dipleidoscope.
1847	Railway time (now used by most railway companies) is declared "a dangerous innovation" in The Times.
1848	Sir Charles Wheatstone (1802-1875) invents the polarised light dial.
1852	Exeter Cathedral clock is put forward 14 minutes to read London Time. There are still many places using local time, e.g. Plymouth and Oxford, plus rural areas.
1862	Léon Foucault measures the distance from the Earth to the Sun.
1867	Lloyd Mifflin is granted a US patent for an analemma-shaped gnomon to tell mean time.
1872	Mrs Gatty publishes "The Book of Sundials", giving examples of many dials and their mottoes.
1880 (Aug)	The Definition of Time Act finally establishes Greenwich time as the basis for civil timekeeping throughout Great Britain.
1884 (Oct)	The International Meridian Conference in Washington, DC, sets the Prime Meridian through Greenwich and defines the standard time zones. It also established the mean solar day, and voiced a desire to extend the use of the decimal system.
1892	John Oliver is granted a British patent for a gnomon shaped to account for the EoT
1900	The last French railway stations abandon the use of heliochronometers for setting their clocks.

1905	The first time signals are broadcast by the US Naval Observatory, Washington D.C., to specialist radio receivers.
1911	France finally recognises Greenwich as the origin of longitude (but avoids referring to it as the Prime Meridian).
1922	Hugo Michnik invents the bifilar sundial.
1924	The BBC begins the world's first public time broadcast by transmitting the time "pips", having started with a piano playing the Westminster chimes two years earlier.
1960	The ephemeris second is set as the basic unit of time
1974	Robert Gundlach is awarded a US patent for a shadowless sundial; this design has some similarities to the later CD dial.
1981	Boon obtains a US patent for a digital sundial. It is later improved by R L Kellogg.
1984	The second is redefined based on atomic rather than Earth-rotation principles, and dynamical time replaces ephemeris time.
1989	The British Sundial Society is formed.
1994	The North American Sundial Society is formed.
1999	The diffraction sundial is invented by M. Catamo and C. Lucarini.
2000	The Japanese Sundial Society is formed.

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APPENDICES

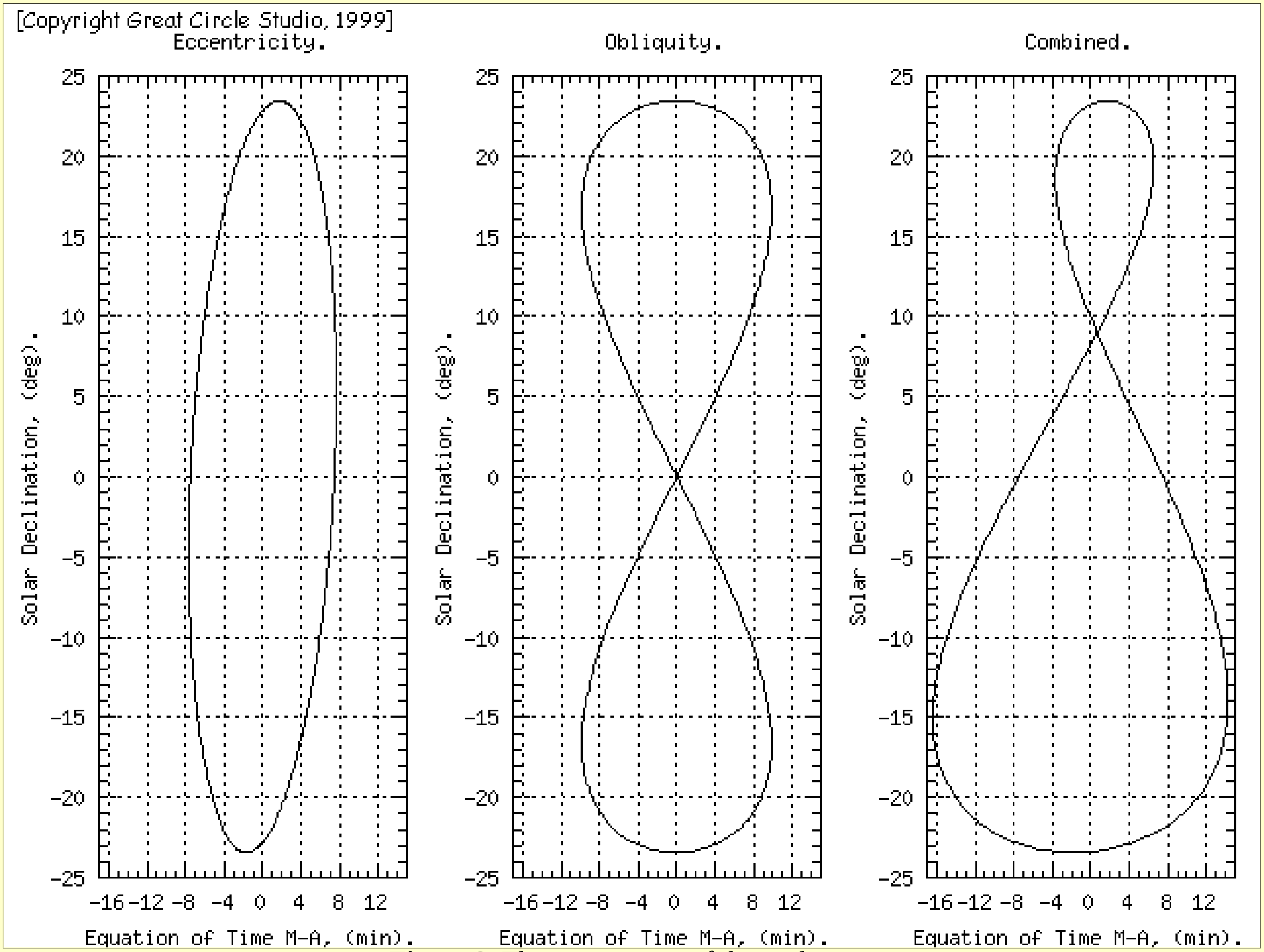
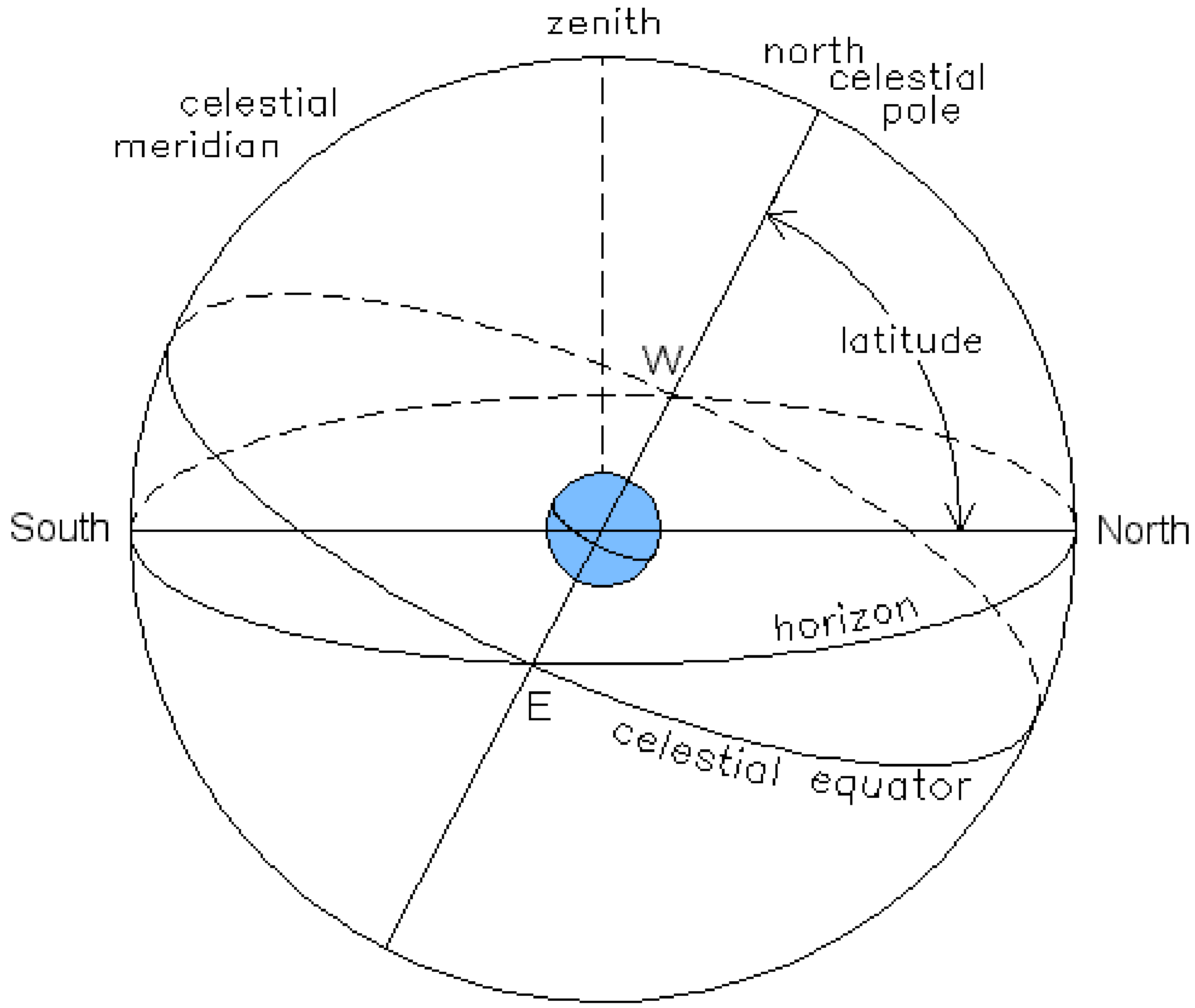


Figure 2. The components of the analemma

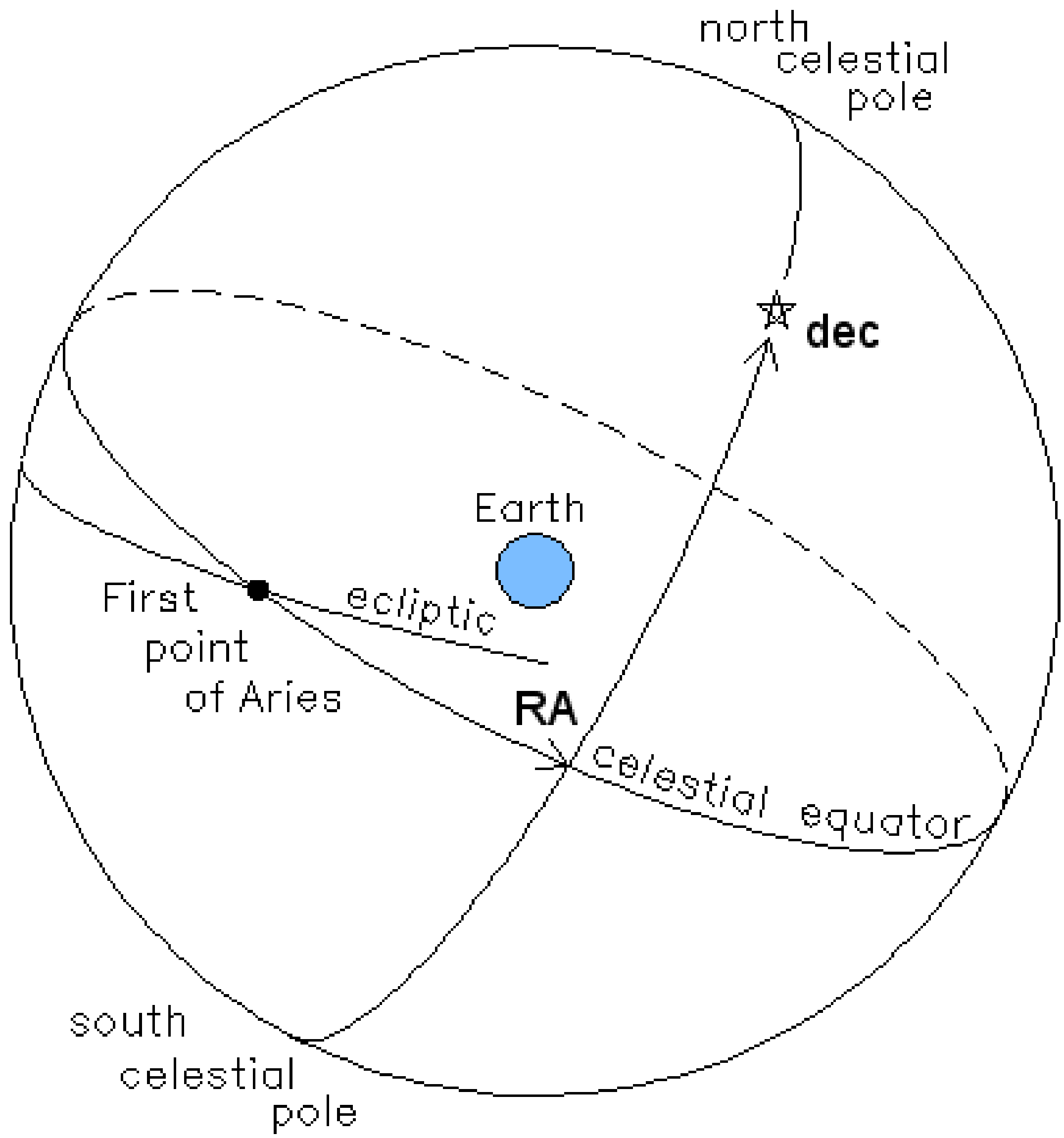
APPENDIX X. Astrolabe terms

English	Latin	Arabic
alidade	ostensor	al-'Idāda
astrolabe	astrolabium	asturlāb
back	dorsum	zahr
cord		'ilāqa
front, face	facies	wajh
limb	limbus, margo	hajra, tawq, kuffa
mater	mater	umm
pin, axis	clavus, axis	qutb, watad, mihwar
plate	tympanum, tabula regionem	safiha
rete, net, spider	rete, aranea	'ankabût, shabaka
ring	armilla suspensoria	halka
ruler	index (or ostensor)	
shackle		'urwa, habs
swivel pin	armilla reflexea	
throne	armilla fixa	kursī
washer, ring	armilla	fals
wedge, horse, dog	equus, caballus, cuneus	faras



Celestial coordinates as seen by an observer in mid-northern latitudes

Figure 3.



The equatorial system of celestial coordinates, showing the right ascension (RA) and declination (dec) of a star.

Figure 4.

APPENDIX XI. Ordnance survey grid squares

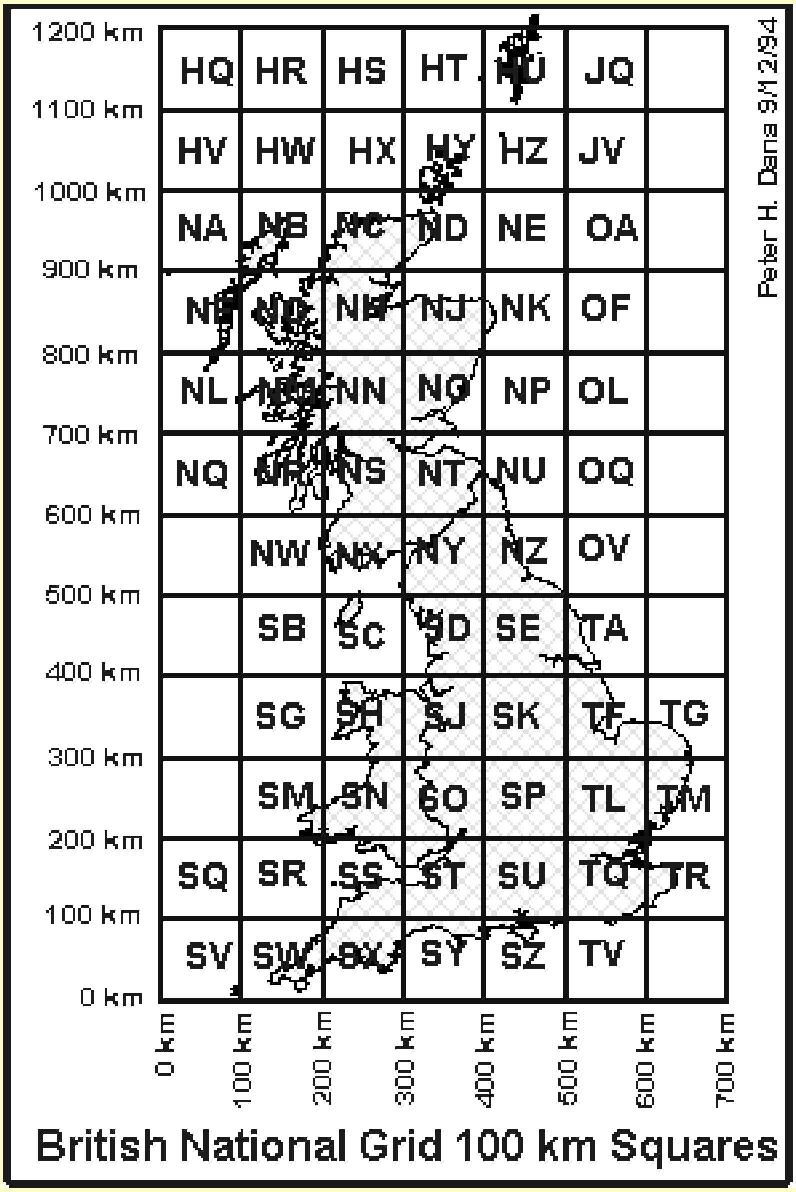
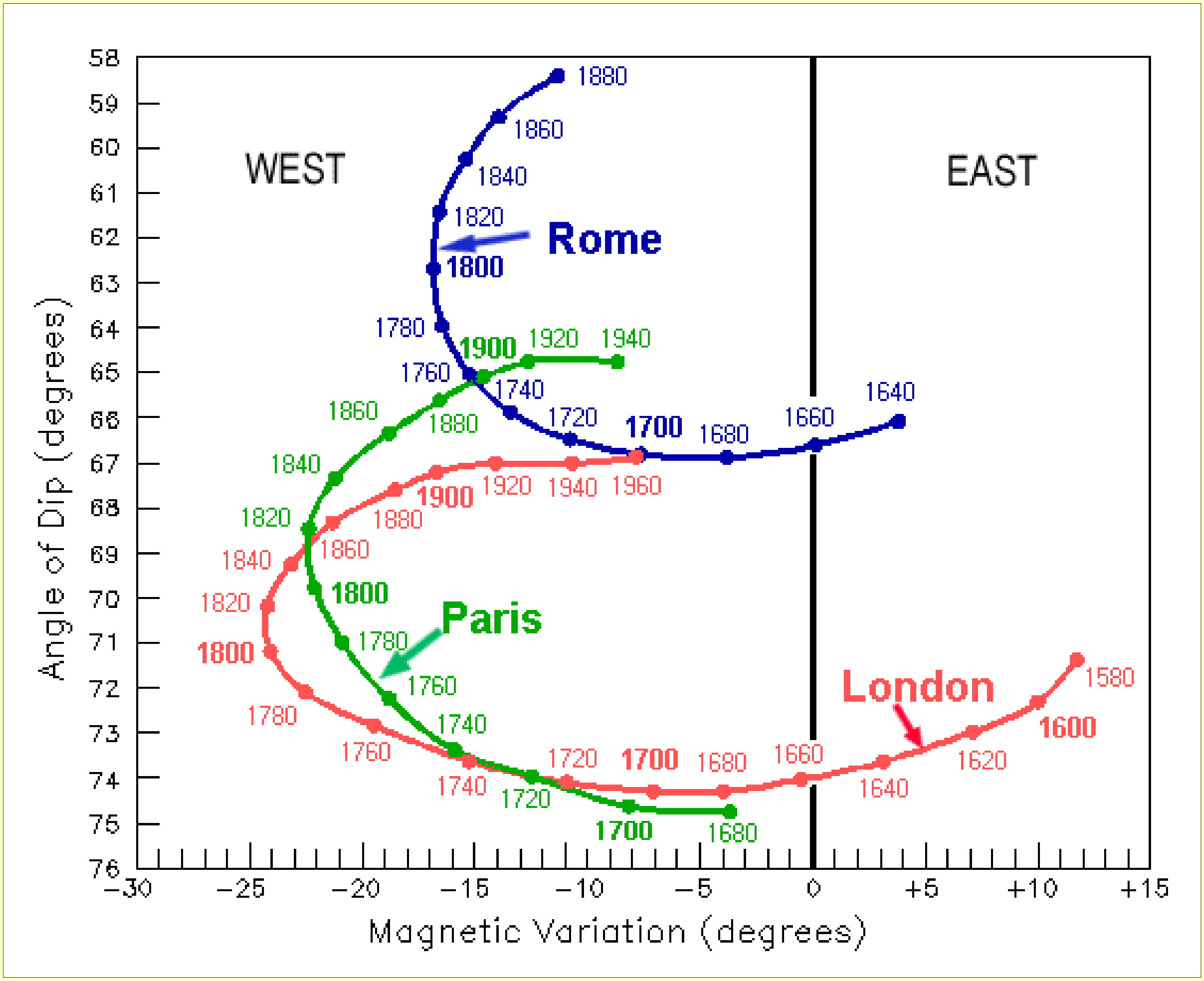


Figure 12. OS Grid Letters

APPENDIX II. Anglo-Saxon tides

Anglo-Saxon name	Approx. modern times (at equinoxes)	Notes
Morgan	4:30am to 7:30am	
Daeg-mael	7:30am to 10:30am	First of the daytime tides
Mid-daeg	10:30am to 1:30pm	noon bisects this tide
Ofanverthr-dagr	1:30pm to 4:30pm	
Mid-aften	4:30pm to 7:30pm	Last of the daytime tides
Onverth-nott	7:30pm to 10:30pm	
Mid-niht	10:30pm to 1:30am	Midnight bisects this tide
Ofanverth-not	1:30am to 4:30 am	

APPENDIX IX. Magnetic variation



In the UK, the current magnetic variation can be estimated by assuming (in 2000) a value of 2º 37' W on the Greenwich Meridian at 50º N, and then allowing an increase of 15' for each degree of latitude northwards and one of 27' for each degree of longitude westward. The annual change at present is about 12' decrease.

Historical values of the magnetic variation for London (Greenwich from 1900) are given in the following table:

Year	Magnetic variation
1580	11º 15' E
1622	5º 56' E

1665	1º 22' W
1730	13º 00' W
1773	21º 09' W
1850	22º 24' W
1900	16º 29' W
1925	13º 10' W
1950	9º 07' W
1975	6º 39' W
1998	3º 32' W

APPENDIX V. Domifying lines

Line	Regiomontanus House	Location on direct S dial
DOM.VII	Libra	Along E horizon line
DOM.VIII	Scorpio	
DOM.IX	Sagittarius	
DOM.X	Capricorn	Along noon line
DOM.XI	Aquarius	
DOM.XII	Pisces	
DOM.I	Aries	Along W horizon line

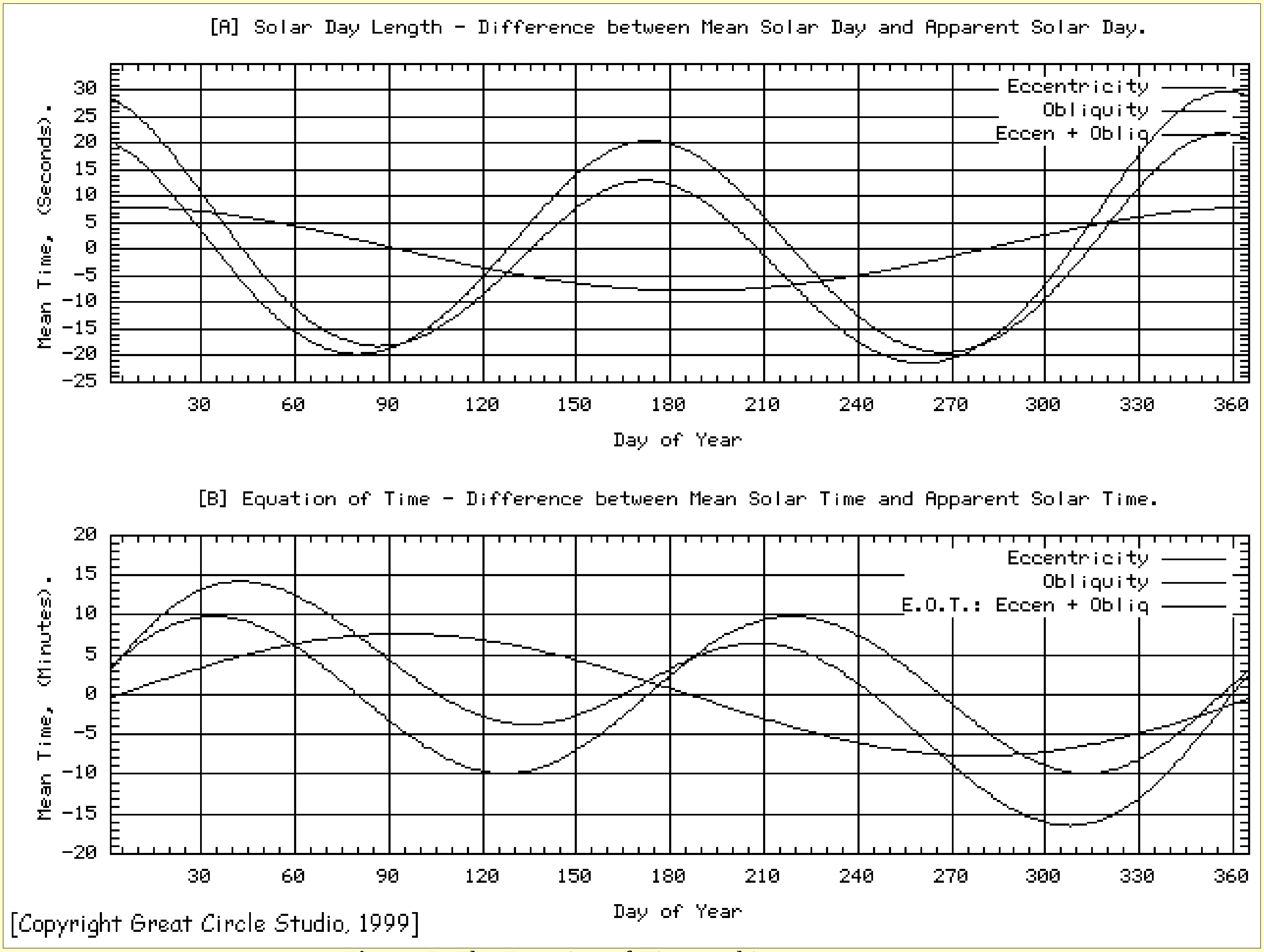


Figure 5. The Equation of Time and its components.

APPENDIX IV. Canonical hours

Name	Latin name	Period
Matins	Mattutinus	midnight to dawn
Prime	Prima	dawn
Terce	Tertia	mid-morning
Sext	Sexta	noon
Nones	Nona	mid-afternoon
Vespers	Vesperus	sunset
Compline	Compieta	sunset to midnight

APPENDIX III. Names of daytime periods in the Roman octaval system

Name	Period
mane	sunrise to end of 3rd hour
ad meridiem	3rd to 6th hour
de meridiem	6th to 9th hour
suprema	9th hour to sunset

APPENDIX VIII. Planetary hours symbols

Day	Masters of the Day Planetary hour												Masters of the Night	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**		
Sunday	☉	♀	☿	☽	♄	♃	♂	☉	♀	☿	☽	♄	♃	☿
Monday	☽	♄	♃	♂	☉	♀	☿	☽	♄	♃	♂	☉	♀	♃
Tuesday	♂	☉	♀	☿	☽	♄	♃	♂	☉	♀	☿	☽	♄	♀
Wednesday	☿	☽	♄	♃	♂	☉	♀	☿	☽	♄	♃	♂	☉	♄
Thursday	♃	♂	☉	♀	☿	☽	♄	♃	♂	☉	♀	☿	☽	☉
Friday	♀	☿	☽	♄	♃	♂	☉	♀	☿	☽	♄	♃	♂	☽
Saturday	♄	♃	♂	☉	♀	☿	☽	♄	♃	♂	☉	♀	☿	♂

☉ Sun ☽ Moon ♂ Mars ☿ Mercury ♃ Jupiter ♀ Venus ♄ Saturn

Note that the days are generally named after the master planet for the first hour of the day.

APPENDIX VI. Greek and Roman seasonal hours

Modern number	ROMAN			GREEK			
	Symbol	**Name of cardinal number**	**Seasonal hour name**	**Capital form**	**Cursive form**	**Name as a letter**	**Seasonal hour name**
1	I	unus	prima hora	Α	α	alpha	prote
2	II	duo	secunda hora	Β	β	beta	deutera
3	III	tres	tertia hora	Γ	γ	gamma	trite
4	IIII	quattuor	quarta hora	Δ	δ	delta	tetrate
5	V	quinque	quinta hora	Ε	ε	epsilon	pempte
6	VI	sex	sexta hora	F	ξ	digamma	hekta
7	VII	septem	septima hora	Ζ	ζ	zeta	hebdome
8	VIII	octo	octava hora	Η	η	eta	ogdoe
9	IX	novem	nona hora	Θ	θ	theta	enate
10	X	decem	horam decimam	Ι	ι	iota	dekate
11	XI	undecim	horam undecimam	ΙΑ	ι α	iota, alpha	hendekate
12	XII	duodecim	horam duodecimam	ΙΒ	ι β	iota, beta	dodekate

APPENDIX VII. Architectural and ecclesiastical terms used in dialling

The following terms, taken from the field of architecture (Fleming et al) have been adapted to describe architectural features found in dialling. Parts of a church are also included as they are frequently used to describe the location of a dial.

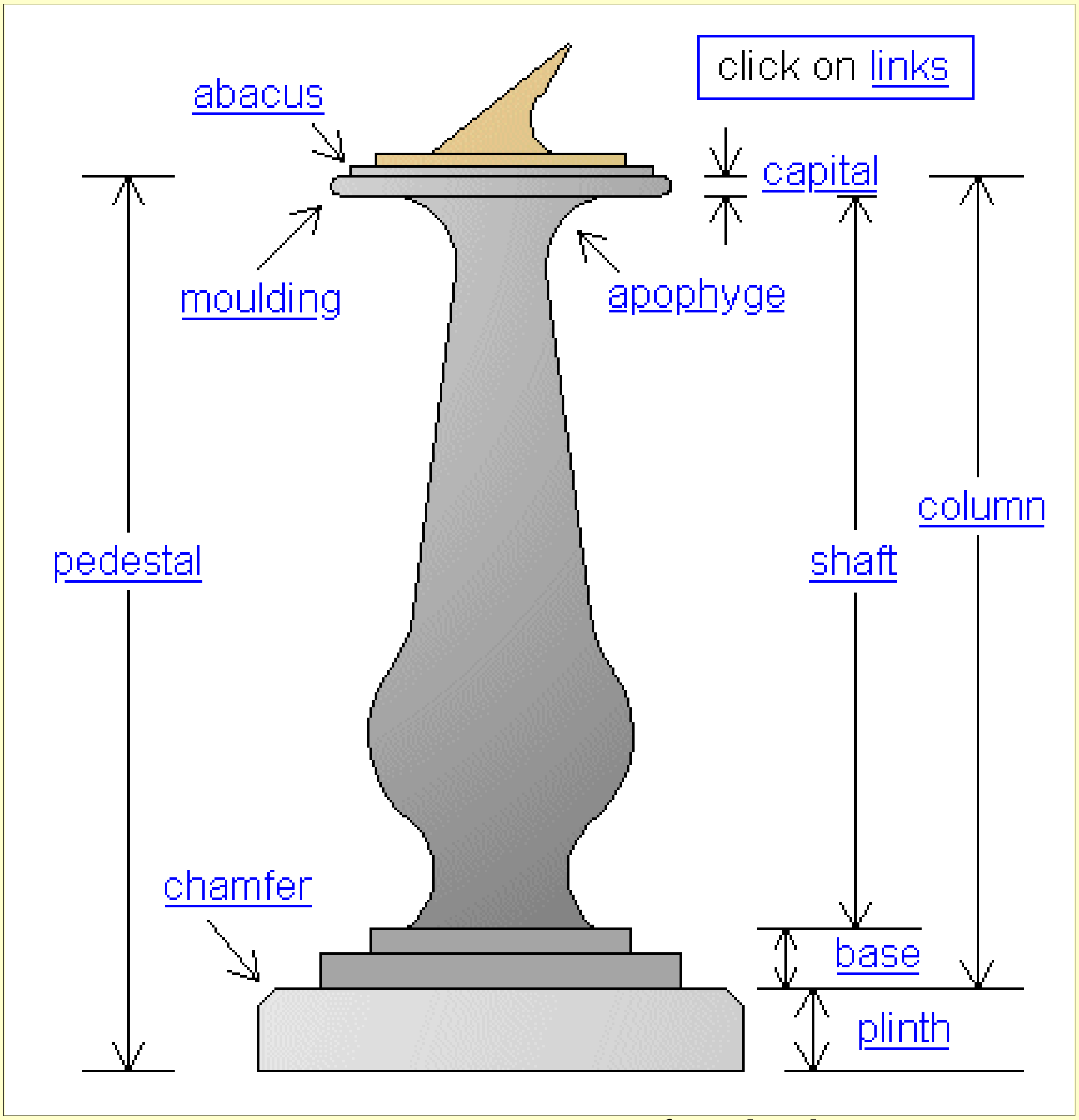


Figure 6. Component parts of a pedestal

abacus: the flat slab on the top of a capital, for example, immediately under a horizontal dial on a pedestal.

aisle: the part(s) of a church running alongside the central nave. There is often a north and a south aisle, and they are usually of lesser height than the nave.

apophyge: the slight curve at the top and bottom of a column where it joins the capital or base.

apse: large semicircular or polygonal recess, arched or dome-roofed, at the end of a church.

baluster: an architectural term for the short pillars which form the supports for a balustrade. The term can be used in dialling to describe the common variety of shaft for a pedestal which is bulbous towards the bottom and rises to a neck of smaller diameter, similar to that shown in **Figure 6**.

banded shaft: (or blocked shaft) a column broken by plain or rusticated blocks of stone.

base: part of a pedestal for a dial, it stands on the plinth and supports the column.

buttress: a mass of masonry or brickwork projecting from or built against a wall to give additional strength.

capital: the head or crowning feature of a column. Many stylised forms exist and have special names.

Figure7. A stiff leaf capital

caryatid: strictly, a sculptured female figure used as a column to support a dial, etc. It can be used more loosely for other human figures, e.g. **Atlantes** (male caryatids), **Herms** (three-quarter-length figures), and **Terms** (tapering columns merging at the top into human, animal or mythical figures).

chamfer: the surface made when the sharp edge (**arris**) of a stone block is cut away, usually at an angle of 45º to the other two surfaces. It is called a hollow chamfer when the surface is made concave.

chancel: a part of a church, at its east end and near the altar, reserved for the clergy, choir, etc.

clerestory: part of a wall of a cathedral or large church, with a series of window, above aisle roofs.

column: in classical architecture, it is a part of an Order, comprising the capital, shaft and base and is circular or square in cross-section.. This definition can also be adopted for dialling purposes.

compound column: a column comprising a number of merged or semi-merged shafts.

corbel: a projecting block, usually of stone, inserted into a wall to support, for example, a vertical dial.

crown: a decoration over the top of a vertical dial as an alternative to a pediment.

entablature: the upper part of an Order, made up of architrave, frieze, cornice etc. Loosely, everything above the capital.

finial: a formal pointed ornament on top of a canopy, gable etc. It is sometimes seen on top of a pillar dial, often in the from of a ball-and-spire or a fleur-de-lis.

Figure 8. Ball and Eagle finials

flute: a semicircular vertical groove in a pillar.

foliated: carved with a leaf ornament.

helix: a spiral motif, especially on a shaft or column.

moulding: a continuous ornamental band around a shaft, column, capital etc. There are many specially named types.

Figure 9. Ogee and reverse-ogee mouldings

nave: the body of a church, especially from the west door to the chancel and usually separated from the aisles by pillars.

obelisk: a tall tapering shaft of stone, usually monolithic with a square or rectangular section ending with a pyramidal apex. Prominent in Ancient Egypt as a solar symbol, often at the entrance to tombs or as a cult object in shrines to the sun.

Order: in classical architecture, a term used to describe a column with its base, shaft, capital and entablature, designed in one of a number of accepted modes, for example Doric or Ionic. The component description of these Orders have been adapted for dialling purposes.

pedestal: the term adopted by diallists to describe the whole structure, usually of stone, used to support a dial (most usually horizontal). See **Figure 6**.

pediment: a low-pitched gable, sometimes seen over the top of vertical dials. It may be open at the apex, in which case it is termed a **broken-apex ~** or sometimes just a **broken pediment**. Versions with curved segments are called **swan-neck ~**.

Figure 10. Swan and broken pediments

pillar: similar to the classical column, but need not have the simple circular or square cross section.

plinth: the bottom part of a pedestal, either in direct contact with the ground or with the general horizontal surface. It is often chamfered or with a moulding around it.

Priest's door: a door on the south-side of the chancel of a church, used by the clergy. Its surround is a common site for mass dials.

shaft: the trunk of a classical column, between the base and capital. It may be used more loosely in dialling to describe the similar section of a pedestal.

solarium: a sun terrace or loggia.

spandrel: an architectural term for the space between the shoulder of an arch and the surrounding rectangular brickwork. In dialling, the term can be used to describe the corner areas of a square dial plate with a circular chapter ring.

transept: the transverse arms of a cross-shaped church, usually between the nave and the chancel, but occasionally at the west end of the nave as well.

APPENDIX I. Signs of the Zodiac

Name	Ancient date	Symbol	Sign	Season	Mean duration (days)	Sun's longitude on entry	Sun's declination on entry
Aries	21 March to 19 April	♈		Spring	30.46	0°	0.00°
Taurus	20 April to 20 May	♉		Spring	30.97	30°	+11.47°
Gemini	20 May to 20 June	♊		Spring	31.33	60°	+20.15°
Cancer	21 June to 22 July	♋		Summer	31.45	90°	+23.44°
Leo	23 July to 22 August	♌		Summer	31.29	120°	+20.15°
Virgo	23 August to 21 September	♍		Summer	30.90	150°	+11.47°
Libra	22 September to 23 October	♎		Autumn	30.39	180°	0.00°
Scorpio	24 October to 21 November	♏		Autumn	29.90	210°	-11.47°
Sagittarius	22 November to 21 December	♐		Autumn	29.56	240°	-20.15°
Capricorn	22 December to 19 January	♑		Winter	29.45	270°	-23.44°
Aquarius	20 January to 18 February	♒		Winter	29.59	300°	-20.15°
Pisces	19 February to 20 March	♓		Winter	29.71	330°	-11.47°

The Dialist's Companion is a new computer program that calculates a wide range of data elements of interest to dialists and others who are concerned with phenomena associated with solar time. These data elements are presented in a dynamic format, changing each second with the tick of the user's system clock. The user can define any latitude and longitude as the platform for his observations, and explore any time or date between 1 A.D. and 2999 A.D. The program further adapts to the user's preferences through the use of start up options and user defined configuration files which can be saved and retrieved.

The program provides three different screens which present the output in different formats. The screens can be switched at a keystroke, and consist of the Main Screen, the Clock Screen, and the Equation Chart.

The **Main Screen** contains tabular output of the various computed values. These values are described and discussed in the program's **User's Guide**, which is provided in both on-line and printable versions.

The **Clock Screen** displays two digital clocks which can be set individually to any of the seven times systems calculated by the program. The display is designed to show selected times with maximum visibility for field use. An alarm can be set to either clock or independently to local apparent noon.

The **Equation Chart** presents the Equation of Time and the sun's declination in a monthly format.

> Click a screen to view: **[[Main Screen || Clock Screen || Equation Chart]]**

Dates and Times

The program date and time can be manipulated in two ways, either by direct entry or by incremental changes from the keyboard. The program clock can also be paused, permitting examination of an instant. At any point, a keystroke will return the program to the system date and time.

Dates between 1 A.D and 2999 A.D. (inclusive) are permitted. Dates before Oct 15, 1582 are based on the Julian calendar; dates after October 4, 1582 are based on the modern Gregorian calendar.

Data Elements

The following is a list of the included data elements. All values can be viewed simultaneously. Dynamic elements are updated every second.

- Solar Ephemeris
  - Sunrise and Sunset
  - Altitude and Azimuth
  - Declination
  - Equation of Time
  - Zodiac
- Time Systems
  - Local Standard Time
  - Greenwich Mean Time
  - Dial Time
  - Sidereal Time
  - Julian Day Number
  - Babylonian and Italian Hours
  - Temporal Hours
- Factors affecting a specific sundial
  - Longitude Correction
  - Refraction Correction
  - Total Correction
- Other Useful Data
  - Solar Noon
  - Shadow
- Mottos
  - If all of the above isn't enough, the program also randomly displays a series of 23 appropriate sundial mottos.

The Dialist's Companion is written for DOS platforms and requires 336k of disk space and a VGA monitor. It runs well under Windows 9x, but Windows 3.1 users may find performance improvements when run from DOS.

The Dialist's Companion was written by

Robert Terwilliger	Frederick Sawyer
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Coconut Grove, FL	Glastonbury, CT
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bobt@twigsdigs.com	frederick.sawyer.es.72@aya.yale.edu

The program was originally released as part of the **North American Sundial Society's** Digital ***Compendium*** as one of the many benefits of NASS membership. It is now being released to non-members as Shareware. The registration fee is $15 US, and may be sent to Fred Sawyer at the address above. (Please make checks payable to NASS.)

If you choose to join NASS, the registration fee may be applied to your first year's dues. Basic dues are $25, but there are options. See the **Join NASS** link at:

http://sundials.org

The Dialist's Companion is a DOS program,
available as a self-extracting EXE of 168,378 bytes.

Download the Dialist's Companion

History of Releases

```
Version 1.1b   Released May 2003
               Updated author's email addresses and NASS website URL.
               Converted DIALIST.DOC to plain text
               and renamed to DIALIST.TXT

Version 1.1    Released January 1997
               Fixed a bug which occurred only in latitudes south
               of the Equator, when the Refraction Correction option
               was selected.

Version 1.0    Released as part of The Compendium 3-3, September 1996
```

Great Circle Studio's Solar Calculator

Read Solar Calculator usage information.
Form defaults are for Pacific Grove, Calif. USA.

Local Latitude	36 °	37 '	05 "	(•) N ( ) S
Local Longitude	121 °	55 '	39 "	( ) E (•) W
Time Zone Offset	-8 h	0 m		
Data Interval	0 d	0 h	15 m	
Altitude Mask	-2 °			

Starting Date & Time [ ] [ ]
6 30

Ending Date & Time [ ] [ ]
18 30

Output Mode
- (•) Horizontal Coords. (HTML)
- ( ) Ecliptic/Equatorial Coords. (HTML)
- ( ) Horizontal Coords. (TEXT)
- ( ) Ecliptic/Equatorial Coords. (TEXT)
- (•) Enable Header Info (HTML/TEXT)
- ( ) Disable Header Info (HTML/TEXT)
- ( ) Altitude vs Azimuth 2D-Plot
- ( ) Altitude vs Azimuth 3D-Plot

[Solar Data] [Reset Forms]

Click ONCE on buttons for selection.

Email Feedback.

Last Update: **March 2001**

LJ Coletti

===Mean Solar values at 12:00 GMT (from 2000 - 2099)=== (corected version: march 2000)

date	day nr	declination DD:MM:SS.ss	declination DD.dddddd	time equation HH:MM:SS.ss	time equation HH.hhhhhh	time equation seconds
01JAN	1	-22:58:00.38	-22.966771	-0:03:31.95	-0.058876	-211.953356
02JAN	2	-22:52:40.95	-22.878043	-0:03:59.92	-0.066644	-239.917845
03JAN	3	-22:46:54.21	-22.781725	-0:04:27.53	-0.074315	-267.534094
04JAN	4	-22:40:40.32	-22.677866	-0:04:54.77	-0.081881	-294.772817
05JAN	5	-22:33:59.46	-22.566516	-0:05:21.61	-0.089335	-321.605383
06JAN	6	-22:26:51.82	-22.447729	-0:05:48.00	-0.096668	-348.003856
07JAN	7	-22:19:17.63	-22.321563	-0:06:13.94	-0.103873	-373.941044
08JAN	8	-22:11:17.09	-22.188079	-0:06:39.39	-0.110942	-399.390535
09JAN	9	-22:02:50.43	-22.047343	-0:07:04.33	-0.117869	-424.326734
10JAN	10	-21:53:57.92	-21.899421	-0:07:28.72	-0.124646	-448.724903
11JAN	11	-21:44:39.79	-21.744385	-0:07:52.56	-0.131267	-472.561195
12JAN	12	-21:34:56.31	-21.582309	-0:08:15.81	-0.137726	-495.812681
13JAN	13	-21:24:47.77	-21.413269	-0:08:38.46	-0.144016	-518.457388
14JAN	14	-21:14:14.45	-21.237347	-0:09:00.47	-0.150132	-540.474318
15JAN	15	-21:03:16.64	-21.054623	-0:09:21.84	-0.156068	-561.843480
16JAN	16	-20:51:54.66	-20.865184	-0:09:42.55	-0.161818	-582.545908
17JAN	17	-20:40:08.82	-20.669116	-0:10:02.56	-0.167379	-602.563685
18JAN	18	-20:27:59.44	-20.466511	-0:10:21.88	-0.172744	-621.879958
19JAN	19	-20:15:26.85	-20.257459	-0:10:40.48	-0.177911	-640.478956
20JAN	20	-20:02:31.40	-20.042056	-0:10:58.35	-0.182874	-658.346003
21JAN	21	-19:49:13.43	-19.820398	-0:11:15.47	-0.187630	-675.467526
22JAN	22	-19:35:33.30	-19.592582	-0:11:31.83	-0.192175	-691.831067
23JAN	23	-19:21:31.36	-19.358710	-0:11:47.43	-0.196507	-707.425286
24JAN	24	-19:07:07.98	-19.118883	-0:12:02.24	-0.200622	-722.239967

25JAN	25	-18:52:23.54	-18.873204	-0:12:16.27	-0.204518	-736.266017
26JAN	26	-18:37:18.40	-18.621779	-0:12:29.50	-0.208193	-749.495468
27JAN	27	-18:21:52.97	-18.364713	-0:12:41.92	-0.211645	-761.921470
28JAN	28	-18:06:07.61	-18.102114	-0:12:53.54	-0.214872	-773.538288
29JAN	29	-17:50:02.72	-17.834090	-0:13:04.34	-0.217873	-784.341294
30JAN	30	-17:33:38.71	-17.560752	-0:13:14.33	-0.220646	-794.326959
31JAN	31	-17:16:55.95	-17.282209	-0:13:23.49	-0.223192	-803.492836
01FEB	32	-16:59:54.87	-16.998574	-0:13:31.84	-0.225510	-811.837555
02FEB	33	-16:42:35.85	-16.709959	-0:13:39.36	-0.227600	-819.360800
03FEB	34	-16:24:59.32	-16.416477	-0:13:46.06	-0.229462	-826.063296
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11FEB	42	-13:54:25.64	-13.907122	-0:14:10.55	-0.236264	-850.550408
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13FEB	44	-13:14:20.95	-13.239152	-0:14:08.81	-0.235780	-848.808615
14FEB	45	-12:53:58.95	-12.899708	-0:14:06.81	-0.235224	-846.806754
15FEB	46	-12:33:24.41	-12.556780	-0:14:04.07	-0.234463	-844.065852
16FEB	47	-12:12:37.74	-12.210483	-0:14:00.60	-0.233499	-840.598000
17FEB	48	-11:51:39.36	-11.860933	-0:13:56.42	-0.232338	-836.415970
18FEB	49	-11:30:29.68	-11.508243	-0:13:51.53	-0.230981	-831.533176
19FEB	50	-11:09:09.11	-11.152530	-0:13:45.96	-0.229434	-825.963649
20FEB	51	-10:47:38.07	-10.793908	-0:13:39.72	-0.227701	-819.722003
21FEB	52	-10:25:56.97	-10.432491	-0:13:32.82	-0.225784	-812.823406
22FEB	53	-10:04:06.21	-10.068392	-0:13:25.28	-0.223690	-805.283549

23FEB	54	-9:42:06.21	-9.701726	-0:13:17.12	-0.221422	-797.118615
24FEB	55	-9:19:57.38	-9.332606	-0:13:08.35	-0.218985	-788.345250
25FEB	56	-8:57:40.11	-8.961143	-0:12:58.98	-0.216383	-778.980532
26FEB	57	-8:35:14.82	-8.587450	-0:12:49.04	-0.213623	-769.041943
27FEB	58	-8:12:41.90	-8.211640	-0:12:38.55	-0.210708	-758.547341
28FEB	59	-7:50:01.76	-7.833823	-0:12:27.51	-0.207643	-747.514930
01MAR	60	-7:21:32.05	-7.358904	-0:12:13.00	-0.203610	-732.997035
02MAR	61	-6:58:37.11	-6.976975	-0:12:00.82	-0.200229	-720.822664
03MAR	62	-6:35:36.24	-6.593399	-0:11:48.17	-0.196714	-708.171717
04MAR	63	-6:12:29.82	-6.208283	-0:11:35.06	-0.193073	-695.063578
05MAR	64	-5:49:18.25	-5.821736	-0:11:21.52	-0.189311	-681.517840
06MAR	65	-5:26:01.92	-5.433867	-0:11:07.55	-0.185432	-667.554285
07MAR	66	-5:02:41.22	-5.044783	-0:10:53.19	-0.181442	-653.192862
08MAR	67	-4:39:16.53	-4.654591	-0:10:38.45	-0.177348	-638.453661
09MAR	68	-4:15:48.23	-4.263398	-0:10:23.36	-0.173155	-623.356898
10MAR	69	-3:52:16.72	-3.871310	-0:10:07.92	-0.168867	-607.922891
11MAR	70	-3:28:42.36	-3.478433	-0:09:52.17	-0.164492	-592.172042
12MAR	71	-3:05:05.54	-3.084871	-0:09:36.12	-0.160035	-576.124819
13MAR	72	-2:41:26.63	-2.690730	-0:09:19.80	-0.155500	-559.801737
14MAR	73	-2:17:46.01	-2.296113	-0:09:03.22	-0.150895	-543.223345
15MAR	74	-1:54:04.05	-1.901125	-0:08:46.41	-0.146225	-526.410205
16MAR	75	-1:30:21.12	-1.505867	-0:08:29.38	-0.141495	-509.382882
17MAR	76	-1:06:37.60	-1.110444	-0:08:12.16	-0.136712	-492.161926
18MAR	77	-0:42:53.85	-0.714957	-0:07:54.77	-0.131880	-474.767859
19MAR	78	-0:19:10.23	-0.319508	-0:07:37.22	-0.127006	-457.221161
20MAR	79	0:04:32.88	0.075801	-0:07:19.54	-0.122095	-439.542262
21MAR	80	0:28:15.13	0.470869	-0:07:01.75	-0.117153	-421.751524
22MAR	81	0:51:56.15	0.865596	-0:06:43.87	-0.112186	-403.869232
23MAR	82	1:15:35.57	1.259882	-0:06:25.92	-0.107199	-385.915584

24MAR	83	1:39:13.05	1.653626	-0:06:07.91	-0.102197	-367.910678
25MAR	84	2:02:48.23	2.046729	-0:05:49.87	-0.097187	-349.874503
26MAR	85	2:26:20.73	2.439093	-0:05:31.83	-0.092174	-331.826930
27MAR	86	2:49:50.22	2.830618	-0:05:13.79	-0.087163	-313.787698
28MAR	87	3:13:16.34	3.221206	-0:04:55.78	-0.082160	-295.776410
29MAR	88	3:36:38.73	3.610758	-0:04:37.81	-0.077170	-277.812520
30MAR	89	3:59:57.04	3.999178	-0:04:19.92	-0.072199	-259.915320
31MAR	90	4:23:10.92	4.386367	-0:04:02.10	-0.067251	-242.103939
01APR	91	4:46:20.02	4.772228	-0:03:44.40	-0.062333	-224.397327
02APR	92	5:09:23.99	5.156665	-0:03:26.81	-0.057448	-206.814245
03APR	93	5:32:22.49	5.539580	-0:03:09.37	-0.052604	-189.373260
04APR	94	5:55:15.16	5.920878	-0:02:52.09	-0.047804	-172.092730
05APR	95	6:18:01.66	6.300462	-0:02:34.99	-0.043053	-154.990795
06APR	96	6:40:41.65	6.678236	-0:02:18.09	-0.038357	-138.085370
07APR	97	7:03:14.78	7.054105	-0:02:01.39	-0.033721	-121.394129
08APR	98	7:25:40.71	7.427974	-0:01:44.93	-0.029148	-104.934495
09APR	99	7:47:59.09	7.799746	-0:01:28.72	-0.024645	-88.723632
10APR	100	8:10:09.58	8.169328	-0:01:12.78	-0.020216	-72.778429
11APR	101	8:32:11.85	8.536625	-0:00:57.12	-0.015865	-57.115489
12APR	102	8:54:05.55	8.901542	-0:00:41.75	-0.011598	-41.751115
13APR	103	9:15:50.34	9.263984	-0:00:26.70	-0.007417	-26.701300
14APR	104	9:37:25.89	9.623859	-0:00:11.98	-0.003328	-11.981710
15APR	105	9:58:51.86	9.981072	0:00:02.39	0.000665	2.392330
16APR	106	10:20:07.90	10.335529	0:00:16.41	0.004557	16.405849
17APR	107	10:41:13.70	10.687138	0:00:30.04	0.008346	30.044245
18APR	108	11:02:08.90	11.035805	0:00:43.29	0.012026	43.293303
19APR	109	11:22:53.18	11.381438	0:00:56.14	0.015594	56.139208
20APR	110	11:43:26.20	11.723943	0:01:08.57	0.019047	68.568563
21APR	111	12:03:47.63	12.063230	0:01:20.57	0.022380	80.568406

22APR	112	12:23:57.14	12.399205	0:01:32.13	0.025591	92.126225
23APR	113	12:43:54.40	12.731778	0:01:43.23	0.028675	103.229977
24APR	114	13:03:39.08	13.060857	0:01:53.87	0.031630	113.868104
25APR	115	13:23:10.86	13.386350	0:02:04.03	0.034453	124.029553
26APR	116	13:42:29.40	13.708168	0:02:13.70	0.037140	133.703792
27APR	117	14:01:34.39	14.026219	0:02:22.88	0.039689	142.880827
28APR	118	14:20:25.50	14.340415	0:02:31.55	0.042098	151.551223
29APR	119	14:39:02.40	14.650666	0:02:39.71	0.044363	159.706120
30APR	120	14:57:24.78	14.956883	0:02:47.34	0.046483	167.337251
01MAY	121	15:15:32.32	15.258977	0:02:54.44	0.048455	174.436959
02MAY	122	15:33:24.70	15.556860	0:03:01.00	0.050277	180.998215
03MAY	123	15:51:01.60	15.850445	0:03:07.01	0.051949	187.014636
04MAY	124	16:08:22.72	16.139646	0:03:12.48	0.053467	192.480501
05MAY	125	16:25:27.75	16.424375	0:03:17.39	0.054831	197.390768
06MAY	126	16:42:16.37	16.704548	0:03:21.74	0.056039	201.741088
07MAY	127	16:58:48.28	16.980079	0:03:25.53	0.057091	205.527821
08MAY	128	17:15:03.18	17.250884	0:03:28.75	0.057986	208.748053
09MAY	129	17:31:00.77	17.516881	0:03:31.40	0.058722	211.399604
10MAY	130	17:46:40.75	17.777986	0:03:33.48	0.059300	213.481047
11MAY	131	18:02:02.82	18.034118	0:03:34.99	0.059720	214.991718
12MAY	132	18:17:06.70	18.285195	0:03:35.93	0.059981	215.931724
13MAY	133	18:31:52.10	18.531140	0:03:36.30	0.060084	216.301957
14MAY	134	18:46:18.74	18.771872	0:03:36.10	0.060029	216.104100
15MAY	135	19:00:26.33	19.007313	0:03:35.34	0.059817	215.340637
16MAY	136	19:14:14.60	19.237389	0:03:34.01	0.059449	214.014858
17MAY	137	19:27:43.28	19.462022	0:03:32.13	0.058925	212.130862
18MAY	138	19:40:52.10	19.681139	0:03:29.69	0.058248	209.693567
19MAY	139	19:53:40.80	19.894667	0:03:26.71	0.057419	206.708703
20MAY	140	20:06:09.13	20.102536	0:03:23.18	0.056440	203.182822

21MAY	141	20:18:16.82	20.304674	0:03:19.12	0.055312	199.123290
22MAY	142	20:30:03.65	20.501013	0:03:14.54	0.054038	194.538289
23MAY	143	20:41:29.35	20.691486	0:03:09.44	0.052621	189.436812
24MAY	144	20:52:33.70	20.876028	0:03:03.83	0.051064	183.828656
25MAY	145	21:03:16.47	21.054575	0:02:57.72	0.049368	177.724416
26MAY	146	21:13:37.43	21.227065	0:02:51.14	0.047538	171.135475
27MAY	147	21:23:36.38	21.393438	0:02:44.07	0.045576	164.073996
28MAY	148	21:33:13.09	21.553635	0:02:36.55	0.043487	156.552905
29MAY	149	21:42:27.36	21.707601	0:02:28.59	0.041274	148.585881
30MAY	150	21:51:19.01	21.855279	0:02:20.19	0.038941	140.187340
31MAY	151	21:59:47.83	21.996619	0:02:11.37	0.036492	131.372413
01JUN	152	22:07:53.65	22.131569	0:02:02.16	0.033932	122.156933
02JUN	153	22:15:36.29	22.260081	0:01:52.56	0.031266	112.557410
03JUN	154	22:22:55.59	22.382109	0:01:42.59	0.028498	102.591010
04JUN	155	22:29:51.39	22.497609	0:01:32.28	0.025632	92.275531
05JUN	156	22:36:23.55	22.606540	0:01:21.63	0.022675	81.629377
06JUN	157	22:42:31.91	22.708863	0:01:10.67	0.019631	70.671531
07JUN	158	22:48:16.34	22.804540	0:00:59.42	0.016506	59.421527
08JUN	159	22:53:36.73	22.893537	0:00:47.90	0.013305	47.899419
09JUN	160	22:58:32.96	22.975822	0:00:36.13	0.010035	36.125751
10JUN	161	23:03:04.92	23.051366	0:00:24.12	0.006700	24.121524
11JUN	162	23:07:12.51	23.120143	0:00:11.91	0.003308	11.908163
12JUN	163	23:10:55.66	23.182126	-0:00:00.49	-0.000137	-0.492522
13JUN	164	23:14:14.27	23.237296	-0:00:13.06	-0.003627	-13.058364
14JUN	165	23:17:08.28	23.285633	-0:00:25.77	-0.007157	-25.766883
15JUN	166	23:19:37.63	23.327121	-0:00:38.60	-0.010721	-38.595319
16JUN	167	23:21:42.28	23.361745	-0:00:51.52	-0.014311	-51.520673
17JUN	168	23:23:22.18	23.389496	-0:01:04.52	-0.017922	-64.519744
18JUN	169	23:24:37.31	23.410364	-0:01:17.57	-0.021547	-77.569172

19JUN	170	23:25:27.64	23.424345	-0:01:30.65	-0.025179	-90.645472
20JUN	171	23:25:53.16	23.431435	-0:01:43.73	-0.028813	-103.725079
21JUN	172	23:25:53.88	23.431634	-0:01:56.78	-0.032440	-116.784389
22JUN	173	23:25:29.81	23.424946	-0:02:09.80	-0.036055	-129.799796
23JUN	174	23:24:40.95	23.411376	-0:02:22.75	-0.039652	-142.747735
24JUN	175	23:23:27.35	23.390931	-0:02:35.60	-0.043224	-155.604723
25JUN	176	23:21:49.04	23.363623	-0:02:48.35	-0.046763	-168.347397
26JUN	177	23:19:46.07	23.329465	-0:03:00.95	-0.050265	-180.952558
27JUN	178	23:17:18.51	23.288474	-0:03:13.40	-0.053721	-193.397206
28JUN	179	23:14:26.40	23.240668	-0:03:25.66	-0.057127	-205.658583
29JUN	180	23:11:09.85	23.186069	-0:03:37.71	-0.060476	-217.714211
30JUN	181	23:07:28.92	23.124701	-0:03:49.54	-0.063762	-229.541925
01JUL	182	23:03:23.73	23.056590	-0:04:01.12	-0.066978	-241.119919
02JUL	183	22:58:54.36	22.981767	-0:04:12.43	-0.070119	-252.426774
03JUL	184	22:54:00.94	22.900262	-0:04:23.44	-0.073178	-263.441497
04JUL	185	22:48:43.60	22.812110	-0:04:34.14	-0.076151	-274.143554
05JUL	186	22:43:02.45	22.717347	-0:04:44.51	-0.079031	-284.512903
06JUL	187	22:36:57.65	22.616013	-0:04:54.53	-0.081814	-294.530026
07JUL	188	22:30:29.33	22.508147	-0:05:04.18	-0.084493	-304.175959
08JUL	189	22:23:37.66	22.393795	-0:05:13.43	-0.087065	-313.432320
09JUL	190	22:16:22.81	22.273001	-0:05:22.28	-0.089523	-322.281339
10JUL	191	22:08:44.93	22.145814	-0:05:30.71	-0.091863	-330.705880
11JUL	192	22:00:44.22	22.012283	-0:05:38.69	-0.094080	-338.689469
12JUL	193	21:52:20.85	21.872460	-0:05:46.22	-0.096171	-346.216315
13JUL	194	21:43:35.04	21.726399	-0:05:53.27	-0.098131	-353.271332
14JUL	195	21:34:26.96	21.574155	-0:05:59.84	-0.099956	-359.840157
15JUL	196	21:24:56.84	21.415788	-0:06:05.91	-0.101641	-365.909169
16JUL	197	21:15:04.88	21.251355	-0:06:11.47	-0.103185	-371.465506
17JUL	198	21:04:51.31	21.080918	-0:06:16.50	-0.104583	-376.497075

18JUL	199	20:54:16.35	20.904540	-0:06:20.99	-0.105831	-380.992570
19JUL	200	20:43:20.23	20.722286	-0:06:24.94	-0.106928	-384.941479
20JUL	201	20:32:03.19	20.534221	-0:06:28.33	-0.107871	-388.334095
21JUL	202	20:20:25.48	20.340412	-0:06:31.16	-0.108656	-391.161520
22JUL	203	20:08:27.34	20.140929	-0:06:33.42	-0.109282	-393.415675
23JUL	204	19:56:09.03	19.935841	-0:06:35.09	-0.109747	-395.089303
24JUL	205	19:43:30.79	19.725221	-0:06:36.18	-0.110049	-396.175966
25JUL	206	19:30:32.90	19.509140	-0:06:36.67	-0.110186	-396.670053
26JUL	207	19:17:15.62	19.287673	-0:06:36.57	-0.110157	-396.566774
27JUL	208	19:03:39.22	19.060894	-0:06:35.86	-0.109962	-395.862159
28JUL	209	18:49:43.97	18.828880	-0:06:34.55	-0.109598	-394.553053
29JUL	210	18:35:30.14	18.591707	-0:06:32.64	-0.109066	-392.637111
30JUL	211	18:20:58.03	18.349453	-0:06:30.11	-0.108365	-390.112793
31JUL	212	18:06:07.91	18.102198	-0:06:26.98	-0.107494	-386.979352
01AUG	213	17:51:00.07	17.850020	-0:06:23.24	-0.106455	-383.236826
02AUG	214	17:35:34.80	17.593000	-0:06:18.89	-0.105246	-378.886029
03AUG	215	17:19:52.39	17.331219	-0:06:13.93	-0.103869	-373.928538
04AUG	216	17:03:53.13	17.064760	-0:06:08.37	-0.102324	-368.366678
05AUG	217	16:47:37.33	16.793703	-0:06:02.20	-0.100612	-362.203511
06AUG	218	16:31:05.28	16.518133	-0:05:55.44	-0.098734	-355.442822
07AUG	219	16:14:17.28	16.238133	-0:05:48.09	-0.096691	-348.089099
08AUG	220	15:57:13.63	15.953787	-0:05:40.15	-0.094485	-340.147520
09AUG	221	15:39:54.65	15.665180	-0:05:31.62	-0.092118	-331.623939
10AUG	222	15:22:20.63	15.372396	-0:05:22.52	-0.089590	-322.524862
11AUG	223	15:04:31.88	15.075521	-0:05:12.86	-0.086905	-312.857433
12AUG	224	14:46:28.71	14.774641	-0:05:02.63	-0.084064	-302.629416
13AUG	225	14:28:11.43	14.469841	-0:04:51.85	-0.081069	-291.849175
14AUG	226	14:09:40.35	14.161209	-0:04:40.53	-0.077924	-280.525656
15AUG	227	13:50:55.79	13.848831	-0:04:28.67	-0.074630	-268.668369

16AUG	228	13:31:58.06	13.532793	-0:04:16.29	-0.071191	-256.287366
17AUG	229	13:12:47.46	13.213184	-0:04:03.39	-0.067609	-243.393225
18AUG	230	12:53:24.33	12.890090	-0:03:50.00	-0.063888	-229.997029
19AUG	231	12:33:48.96	12.563600	-0:03:36.11	-0.060031	-216.110349
20AUG	232	12:14:01.68	12.233800	-0:03:21.75	-0.056040	-201.745224
21AUG	233	11:54:02.81	11.900780	-0:03:06.91	-0.051921	-186.914144
22AUG	234	11:33:52.65	11.564626	-0:02:51.63	-0.047675	-171.630029
23AUG	235	11:13:31.54	11.225428	-0:02:35.91	-0.043307	-155.906216
24AUG	236	10:52:59.78	10.883274	-0:02:19.76	-0.038821	-139.756437
25AUG	237	10:32:17.71	10.538252	-0:02:03.19	-0.034221	-123.194806
26AUG	238	10:11:25.62	10.190451	-0:01:46.24	-0.029510	-106.235801
27AUG	239	9:50:23.86	9.839960	-0:01:28.89	-0.024693	-88.894247
28AUG	240	9:29:12.72	9.486868	-0:01:11.19	-0.019774	-71.185304
29AUG	241	9:07:52.55	9.131263	-0:00:53.12	-0.014757	-53.124448
30AUG	242	8:46:23.65	8.773236	-0:00:34.73	-0.009647	-34.727461
31AUG	243	8:24:46.35	8.412874	-0:00:16.01	-0.004447	-16.010415
01SEP	244	8:03:00.96	8.050268	0:00:03.01	0.000836	3.010338
02SEP	245	7:41:07.83	7.685507	0:00:22.32	0.006199	22.318182
03SEP	246	7:19:07.25	7.318680	0:00:41.90	0.011638	41.896248
04SEP	247	6:56:59.56	6.949878	0:01:01.73	0.017147	61.727421
05SEP	248	6:34:45.08	6.579190	0:01:21.79	0.022721	81.794356
06SEP	249	6:12:24.14	6.206705	0:01:42.08	0.028355	102.079485
07SEP	250	5:49:57.06	5.832515	0:02:02.57	0.034046	122.565027
08SEP	251	5:27:24.15	5.456710	0:02:23.23	0.039787	143.232996
09SEP	252	5:04:45.76	5.079379	0:02:44.07	0.045574	164.065212
10SEP	253	4:42:02.21	4.700613	0:03:05.04	0.051401	185.043307
11SEP	254	4:19:13.81	4.320504	0:03:26.15	0.057264	206.148732
12SEP	255	3:56:20.91	3.939142	0:03:47.36	0.063156	227.362767
13SEP	256	3:33:23.83	3.556618	0:04:08.67	0.069074	248.666527

14SEP	257	3:10:22.89	3.173025	0:04:30.04	0.075011	270.040968
15SEP	258	2:47:18.43	2.788453	0:04:51.47	0.080963	291.466895
16SEP	259	2:24:10.78	2.402994	0:05:12.92	0.086924	312.924968
17SEP	260	2:01:00.27	2.016741	0:05:34.40	0.092888	334.395708
18SEP	261	1:37:47.23	1.629786	0:05:55.86	0.098850	355.859505
19SEP	262	1:14:32.00	1.242222	0:06:17.30	0.104805	377.296624
20SEP	263	0:51:14.91	0.854143	0:06:38.69	0.110746	398.687211
21SEP	264	0:27:56.30	0.465640	0:07:00.01	0.116670	420.011301
22SEP	265	0:04:36.51	0.076809	0:07:21.25	0.122569	441.248826
23SEP	266	-0:18:44.12	-0.312257	0:07:42.38	0.128439	462.379620
24SEP	267	-0:42:05.27	-0.701463	0:08:03.38	0.134273	483.383430
25SEP	268	-1:05:26.57	-1.090714	0:08:24.24	0.140067	504.239924
26SEP	269	-1:28:47.70	-1.479916	0:08:44.93	0.145814	524.928697
27SEP	270	-1:52:08.30	-1.868971	0:09:05.43	0.151508	545.429284
28SEP	271	-2:15:28.03	-2.257785	0:09:25.72	0.157145	565.721169
29SEP	272	-2:38:46.54	-2.646261	0:09:45.78	0.162718	585.783797
30SEP	273	-3:02:03.48	-3.034300	0:10:05.60	0.168221	605.596583
01OCT	274	-3:25:18.51	-3.421807	0:10:25.14	0.173650	625.138927
02OCT	275	-3:48:31.26	-3.808683	0:10:44.39	0.178997	644.390225
03OCT	276	-4:11:41.39	-4.194829	0:11:03.33	0.184258	663.329887
04OCT	277	-4:34:48.53	-4.580147	0:11:21.94	0.189427	681.937346
05OCT	278	-4:57:52.33	-4.964536	0:11:40.19	0.194498	700.192081
06OCT	279	-5:20:52.43	-5.347897	0:11:58.07	0.199465	718.073628
07OCT	280	-5:43:48.47	-5.730129	0:12:15.56	0.204323	735.561600
08OCT	281	-6:06:40.07	-6.111131	0:12:32.64	0.209065	752.635707
09OCT	282	-6:29:26.89	-6.490802	0:12:49.28	0.213688	769.275775
10OCT	283	-6:52:08.54	-6.869038	0:13:05.46	0.218184	785.461765
11OCT	284	-7:14:44.65	-7.245737	0:13:21.17	0.222548	801.173797
12OCT	285	-7:37:14.86	-7.620795	0:13:36.39	0.226776	816.392175

13OCT	286	-7:59:38.79	-7.994109	0:13:51.10	0.230860
831.097403					
14OCT	287	-8:21:56.07	-8.365574	0:14:05.27	0.234797
845.270218					
15OCT	288	-8:44:06.31	-8.735085	0:14:18.89	0.238581
858.891611					
16OCT	289	-9:06:09.13	-9.102536	0:14:31.94	0.242206
871.942855					
17OCT	290	-9:28:04.15	-9.467820	0:14:44.41	0.245668
884.405531					
18OCT	291	-9:49:51.00	-9.830832	0:14:56.26	0.248962
896.261558					
19OCT	292	-10:11:29.27	-10.191464	0:15:07.49	0.252081
907.493219					
20OCT	293	-10:32:58.59	-10.549607	0:15:18.08	0.255023
918.083193					
21OCT	294	-10:54:18.55	-10.905154	0:15:28.01	0.257782
928.014584					
22OCT	295	-11:15:28.78	-11.257996	0:15:37.27	0.260353
937.270951					
23OCT	296	-11:36:28.88	-11.608022	0:15:45.84	0.262732
945.836340					
24OCT	297	-11:57:18.45	-11.955125	0:15:53.70	0.264915
953.695314					
25OCT	298	-12:17:57.09	-12.299192	0:16:00.83	0.266898
960.832988					
26OCT	299	-12:38:24.41	-12.640114	0:16:07.24	0.268676
967.235054					
27OCT	300	-12:58:40.01	-12.977780	0:16:12.89	0.270247
972.887822					
28OCT	301	-13:18:43.48	-13.312078	0:16:17.78	0.271605
977.778244					
29OCT	302	-13:38:34.43	-13.642896	0:16:21.89	0.272748
981.893951					
30OCT	303	-13:58:12.44	-13.970123	0:16:25.22	0.273673
985.223280					
31OCT	304	-14:17:37.13	-14.293647	0:16:27.76	0.274376
987.755312					
01NOV	305	-14:36:48.08	-14.613355	0:16:29.48	0.274856
989.479897					
02NOV	306	-14:55:44.88	-14.929135	0:16:30.39	0.275108
990.387684					
03NOV	307	-15:14:27.14	-15.240874	0:16:30.47	0.275131
990.470158					
04NOV	308	-15:32:54.45	-15.548459	0:16:29.72	0.274922
989.719660					
05NOV	309	-15:51:06.40	-15.851779	0:16:28.13	0.274480
988.129421					
06NOV	310	-16:09:02.59	-16.150720	0:16:25.69	0.273804
985.693587					
07NOV	311	-16:26:42.62	-16.445171	0:16:22.41	0.272891
982.407247					
08NOV	312	-16:44:06.07	-16.735019	0:16:18.27	0.271741
978.266454					
09NOV	313	-17:01:12.55	-17.020153	0:16:13.27	0.270352
973.268252					
10NOV	314	-17:18:01.66	-17.300461	0:16:07.41	0.268725
967.410699					

11NOV	315	-17:34:33.00	-17.575833	0:16:00.69	0.266859	960.692882
12NOV	316	-17:50:46.17	-17.846157	0:15:53.11	0.264754	953.114942
13NOV	317	-18:06:40.77	-18.111325	0:15:44.68	0.262411	944.678091
14NOV	318	-18:22:16.42	-18.371227	0:15:35.38	0.259829	935.384622
15NOV	319	-18:37:32.72	-18.625755	0:15:25.24	0.257011	925.237930
16NOV	320	-18:52:29.29	-18.874802	0:15:14.24	0.253956	914.242517
17NOV	321	-19:07:05.74	-19.118261	0:15:02.40	0.250668	902.404006
18NOV	322	-19:21:21.70	-19.356027	0:14:49.73	0.247147	889.729147
19NOV	323	-19:35:16.78	-19.587995	0:14:36.23	0.243396	876.225823
20NOV	324	-19:48:50.63	-19.814065	0:14:21.90	0.239418	861.903053
21NOV	325	-20:02:02.88	-20.034133	0:14:06.77	0.235214	846.770989
22NOV	326	-20:14:53.16	-20.248100	0:13:50.84	0.230789	830.840922
23NOV	327	-20:27:21.13	-20.455868	0:13:34.13	0.226146	814.125271
24NOV	328	-20:39:26.43	-20.657341	0:13:16.64	0.221288	796.637580
25NOV	329	-20:51:08.73	-20.852424	0:12:58.39	0.216220	778.392508
26NOV	330	-21:02:27.69	-21.041024	0:12:39.41	0.210946	759.405818
27NOV	331	-21:13:22.98	-21.223051	0:12:19.69	0.205471	739.694365
28NOV	332	-21:23:54.30	-21.398417	0:11:59.28	0.199799	719.276076
29NOV	333	-21:34:01.33	-21.567036	0:11:38.17	0.193936	698.169934
30NOV	334	-21:43:43.76	-21.728823	0:11:16.40	0.187888	676.395957
01DEC	335	-21:53:01.32	-21.883699	0:10:53.98	0.181660	653.975172
02DEC	336	-22:01:53.71	-22.031585	0:10:30.93	0.175258	630.929593
03DEC	337	-22:10:20.66	-22.172406	0:10:07.28	0.168689	607.282187
04DEC	338	-22:18:21.92	-22.306088	0:09:43.06	0.161960	583.056851
05DEC	339	-22:25:57.23	-22.432563	0:09:18.28	0.155077	558.278371
06DEC	340	-22:33:06.35	-22.551764	0:08:52.97	0.148048	532.972394
07DEC	341	-22:39:49.06	-22.663628	0:08:27.17	0.140879	507.165385
08DEC	342	-22:46:05.14	-22.768094	0:08:00.88	0.133579	480.884594
09DEC	343	-22:51:54.38	-22.865107	0:07:34.16	0.126155	454.158008

10DEC	344	-22:57:16.61	-22.954613	0:07:07.01	0.118615	427.014315
11DEC	345	-23:02:11.62	-23.036562	0:06:39.48	0.110967	399.482853
12DEC	346	-23:06:39.28	-23.110910	0:06:11.59	0.103220	371.593570
13DEC	347	-23:10:39.41	-23.177614	0:05:43.38	0.095382	343.376970
14DEC	348	-23:14:11.89	-23.236636	0:05:14.86	0.087462	314.864069
15DEC	349	-23:17:16.59	-23.287942	0:04:46.09	0.079468	286.086340
16DEC	350	-23:19:53.40	-23.331501	0:04:17.08	0.071410	257.075666
17DEC	351	-23:22:02.23	-23.367287	0:03:47.86	0.063296	227.864282
18DEC	352	-23:23:43.00	-23.395279	0:03:18.48	0.055135	198.484728
19DEC	353	-23:24:55.64	-23.415457	0:02:48.97	0.046936	168.969787
20DEC	354	-23:25:40.11	-23.427808	0:02:19.35	0.038709	139.352436
21DEC	355	-23:25:56.36	-23.432321	0:01:49.67	0.030463	109.665789
22DEC	356	-23:25:44.37	-23.428992	0:01:19.94	0.022206	79.943039
23DEC	357	-23:25:04.15	-23.417819	0:00:50.22	0.013949	50.217406
24DEC	358	-23:23:55.69	-23.398804	0:00:20.52	0.005701	20.522077
25DEC	359	-23:22:19.04	-23.371955	-0:00:09.11	-0.002531	-9.109848
26DEC	360	-23:20:14.21	-23.337281	-0:00:38.65	-0.010735	-38.645410
27DEC	361	-23:17:41.28	-23.294800	-0:01:08.05	-0.018903	-68.051849
28DEC	362	-23:14:40.30	-23.244529	-0:01:37.30	-0.027027	-97.296659
29DEC	363	-23:11:11.37	-23.186493	-0:02:06.35	-0.035097	-126.347638
30DEC	364	-23:07:14.59	-23.120718	-0:02:35.17	-0.043104	-155.172945
31DEC	365	-23:02:50.05	-23.047237	-0:03:03.74	-0.051039	-183.741152

Prepaired by Thibaud Taudin-Chabot

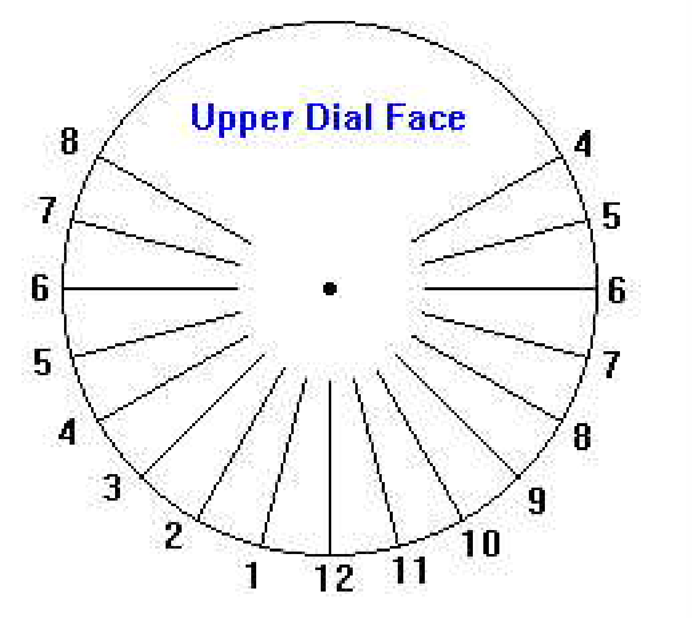
Make your own Equatorial sundial:

Materials required: A pencil, protractor, compass and a straight edge.

The equatorial dial is the easiest to lay out, the gnomon is a rod that runs through and perpendicular to the dial face. Since the gnomon must point to the North Celestial Pole the face of the dial is ,therefore, parallel to the Equator. This is called an Equatorial Dial.

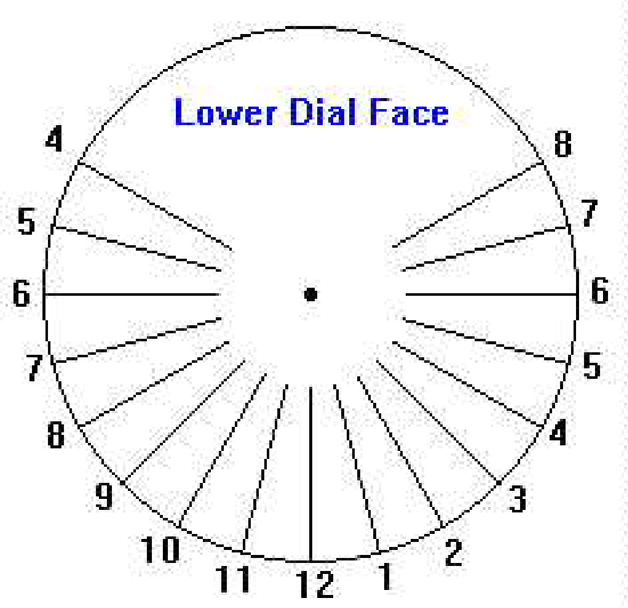
Draw a circle and divide it into 15 degree pieces (use the protractor).

Why 15 degrees? One day is 24 hours, or the amount of time it take for "the sun to go around the earth". So in 24 hours the sun "moves" through 360 degrees (recall that there are 360 degrees in a circle). Therefore to find how many degrees are in 1 hour we divide 360 by 24. 360/24=15 degrees, this is called the hour angle of the sun.

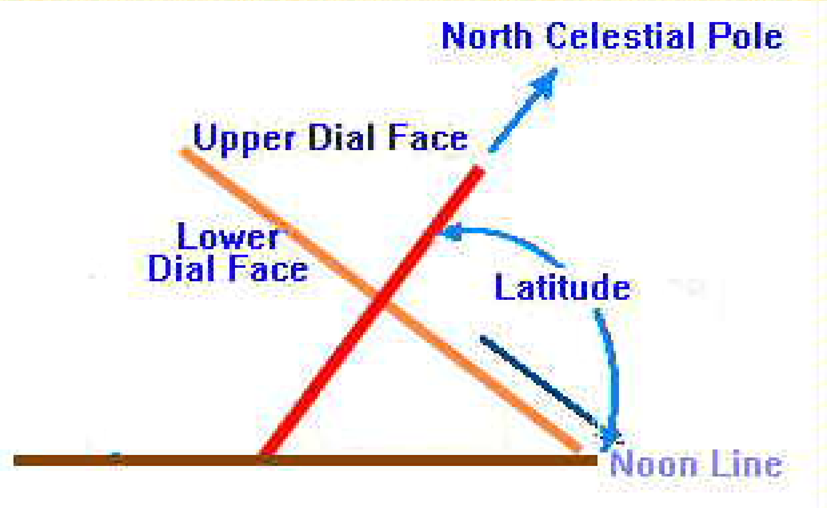


Number the lines as shown, this is the upper dial.

Now turn the the dial over and draw the same lines on the other side. Number these counterclockwise.



Now run a rod (the gnomon) through the center of the dial making sure that the face of the dial is perpendicular to the gnomon. Set the dial so that the gnomon is pointing to true north and is elevated from the vertical by latitude (as measured in degrees) and the 12:00 hour line is pointing toward the ground.



Why the two dial faces?

Since the sun is north of the Equator half the year and south of the Equator the other half each dial will only receive sunlight half the year.

The upper dial receives sunlight from March 21 (the Spring or Vernal Equinox) through September 21 (the Fall or Autumnal Equinox). Therefore the upper dial gets sun from the first day of spring through the summer and stops in the fall.

The lower dial receives sunlight from September 21 (the Fall or Autumnal Equinox) through March 21 (the Spring or Vernal Equinox). Therefore the lower dial gets sun from the first day of fall through the winter and stops in the spring.

Make your own Horizontal Sundial.

Make your own Vertical Sundial.

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sundials | equation of time | build a sundial | the zodiac | astronomy | longitude

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Page created by: abraxas2@ix.netcom.com

Changes last made on: *January 20, 1998*

Make your own Vertical Sundial:

Materials required: A pencil, protractor, compass and a straight edge.

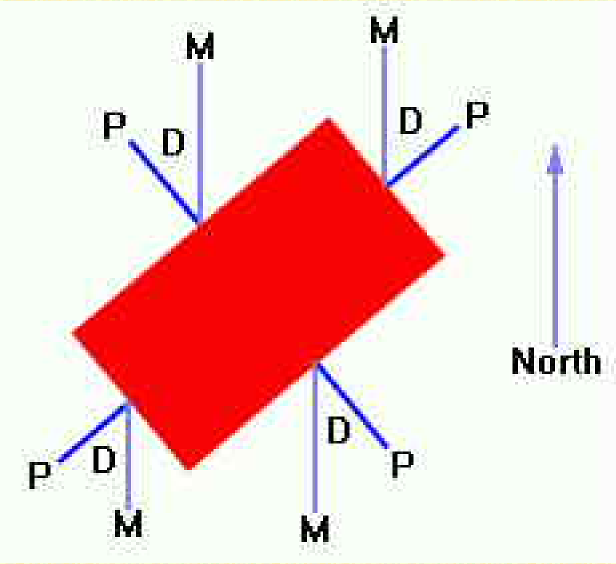
A vertical sundial is a dial that is placed on a wall. It is therefore vertical to the ground. There are two types of vertical dials; the direct vertical (these dials are upon surfaces that face a cardinal direction, which is to say they face true north, south, east or west) and the declining vertical dial (these dials DO NOT face a true compass point).

These directions are for a vertical declining dial.

NOTE: This is one of the HARDEST dials to create, if you are not familar with sundial "language" please read ALL my related pages before trying this.

Before we can start there are a few things we need to know. What is the latitude of the place where the dial is to be used and what is the declination of the wall on which the dial is to be placed?

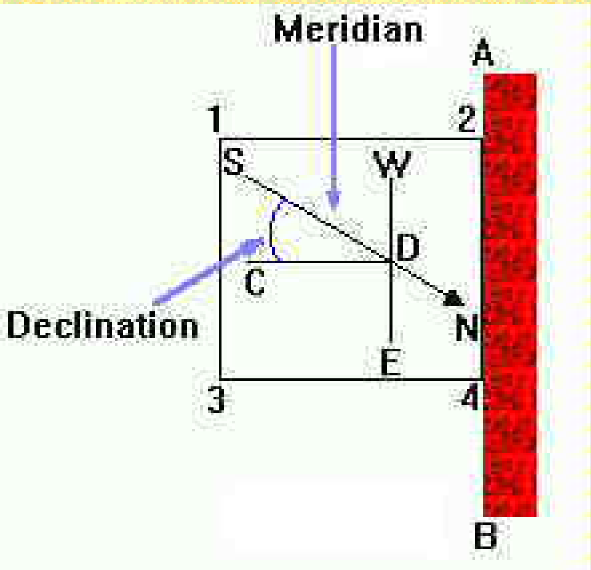
The diagram below shows the four possible directions that a wall can decline. The lines P are perpendicular to the face of the wall, the lines M lie along the meridan the angles D are the declination of the wall and North is as shown.



The four possible directions of declination are: Southwest, Southeast, Northwest and Northeast.

We must now determine the amount that the wall declines. Take care when finding this angle since all other values rely upon its accuracy.

In the diagram below AB represents the side of the wall where we wish to place a dial. A board 1234 is placed **horizontally** against the wall (AB) and leveled. Find the meridian line NS. Draw the line EW parallel to AB bisecting the line NS at D. From the point D draw the line DC perpendicular to the line EW. The angle CDS is the declination of the wall.



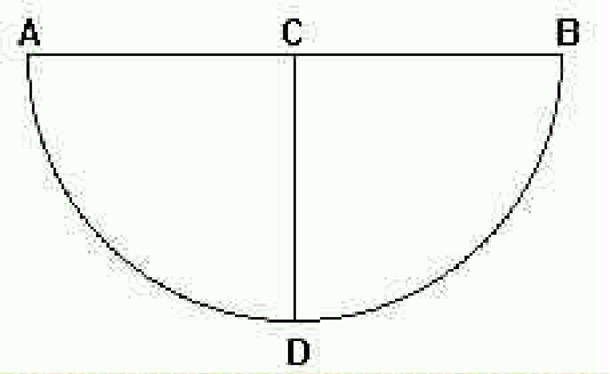
The above diagram shows a wall the faces south and declines east.

To complete a vertical dial we will need to determine three items. The first is the sub-style distance (SD). This is the line along which the gnomon will lie (perpendicular to the dial face). Recall that on a horizontal dial the sub-style line is the same as the 12:00 (noon) line. This is not the case in a vertical dial.

The second item is the style height (SH). This is the angle that the gnomon makes with the face of the dial. Recall that in a horizontal dial the style height is equal to the latitude of the place where the horizontal dial is to be used.

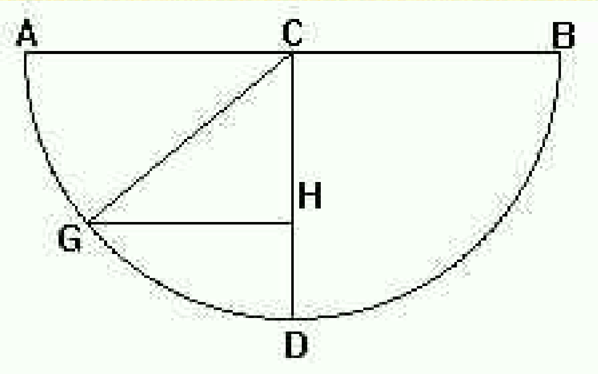
The final item is the positions of the hour lines.

Draw AB as a horizontal line. At C draw the line CD perpendicular to line AB. Now draw a semi-circle centered at C to form the semi-circle ADB.

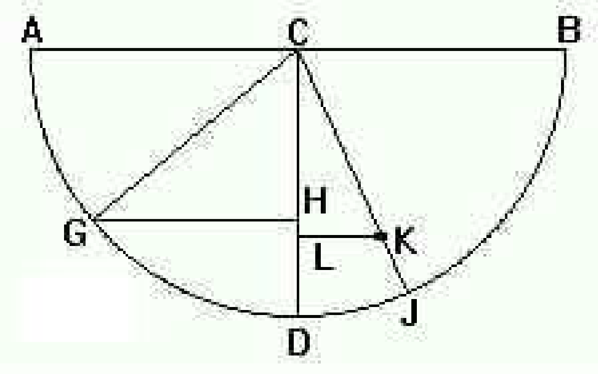


Draw line CG so that the angle DCG is equal to the colatitude of the place where the dial is to be used. The colatitude is equal to 90 (degrees) minus the latitude (in degrees). If the latitude is 40 degrees then the colatitude is 50 degrees. From G draw line GH such that it is parallel to AB, crossing line CD at H.

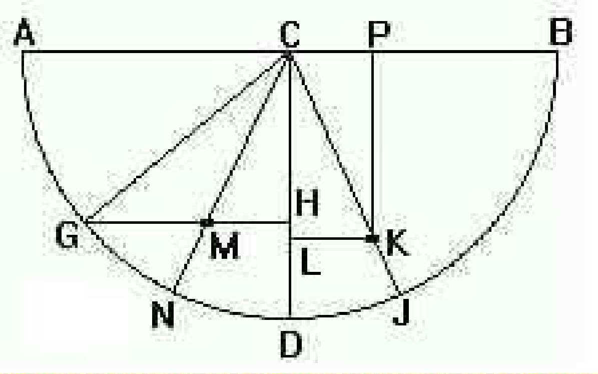
NOTE: If the dial declines toward the West the angle DCG will lie to the right of line CD, if the dial declines to the East the angle DCG will lie to the left of line CD. In this example we are using a declination to the East.



On the side of CD opposite the line CG draw the line CJ such that the angle DCJ equals the angle of the dial's declination. To find the point K lay off on the line CJ (from C) a distance equal to GH (use the compass). Draw line KL from the point K that is parallel to line AB and intersects line CD at L.

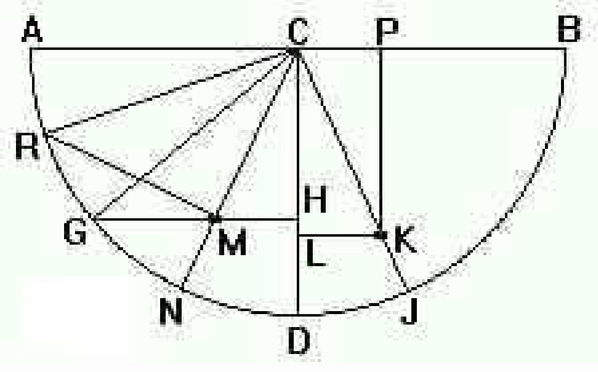


On line HG lay off line HM so that line HM is equal to line KL. Draw a line from C through M and tangent to the semi-circle. Label this point N.



This completes the first step! The angle DCN is the sub-style distance (SD).

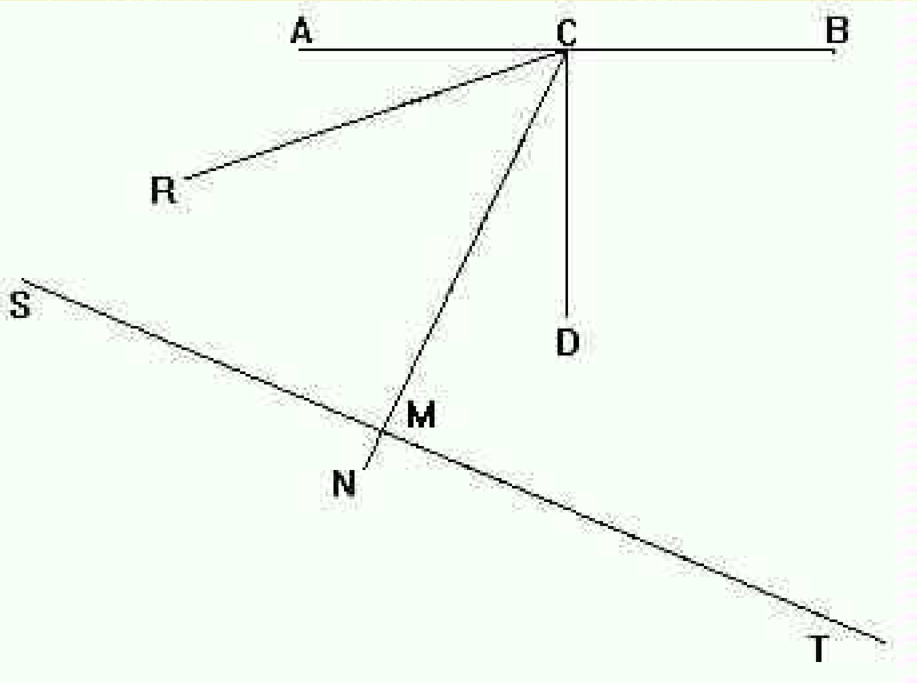
Draw line KP such that it is parallel to line CD and intersects line AB at point P. Find point R on the semi-circle such that the line MR is equal to the line KP (use the compass). Draw a line from point C to point R.



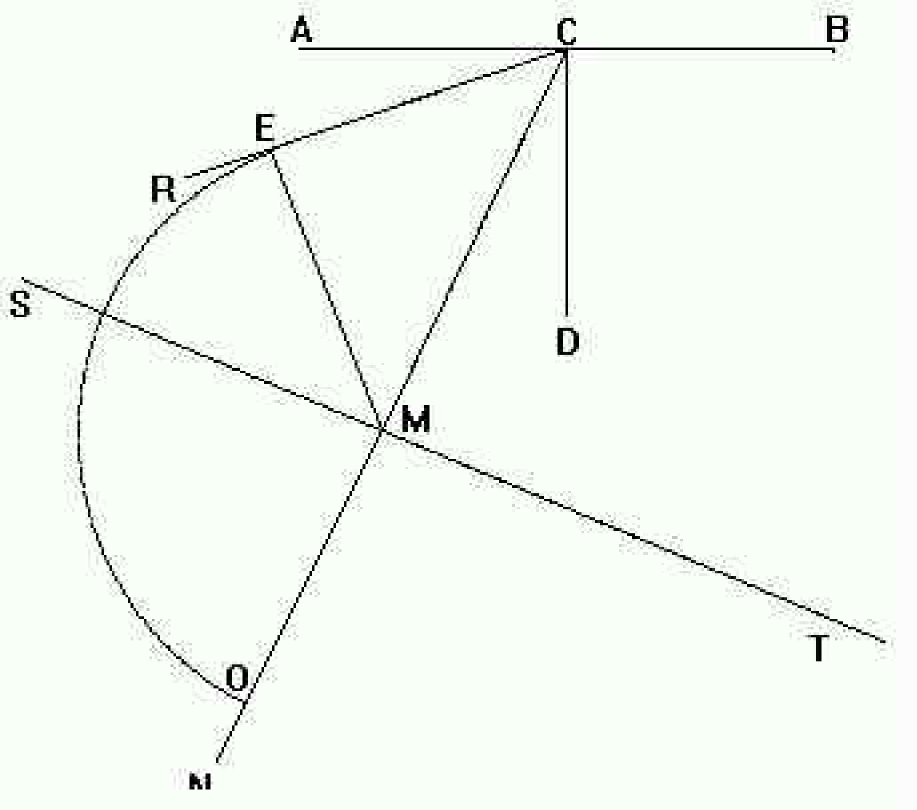
This completes the second step! The angle NCR is the style height distance (SH).

The final step is to determine the positions of the hour lines. Let us use a new diagram, using only the line from the preceding diagram(s) which are necessary to the hour line construction. We need the lines AB, CD, CN and CR from the above diagrams.

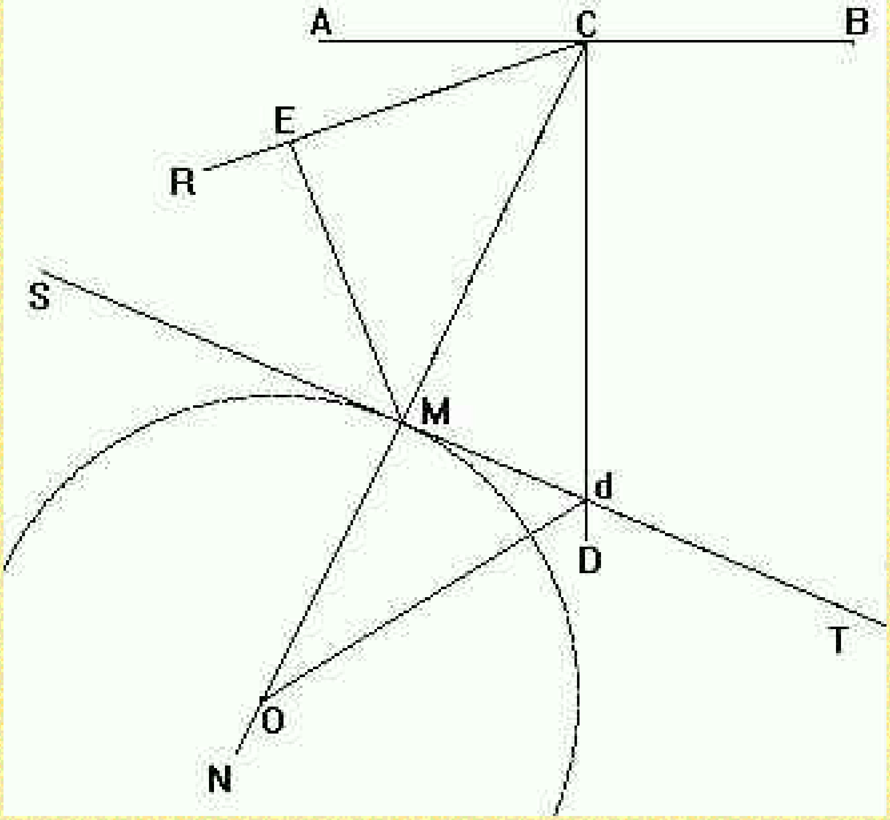
At some point along the line CN pick a point M and draw the line ST such that it is perpendicular to line CN. The distance of CM will determine the scale of the final diagram (so make it as large as your paper will allow).



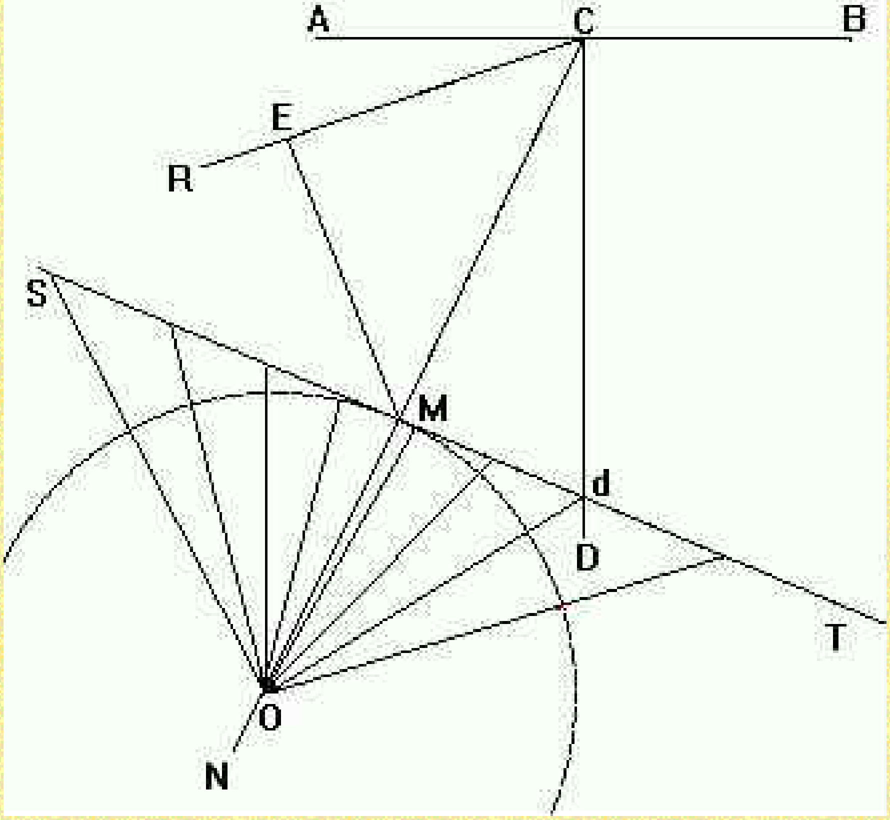
Draw line ME such that is perpendicular to line CR. Find the point O along the line CN such that the line ME is equal to the line MO (use the compass).



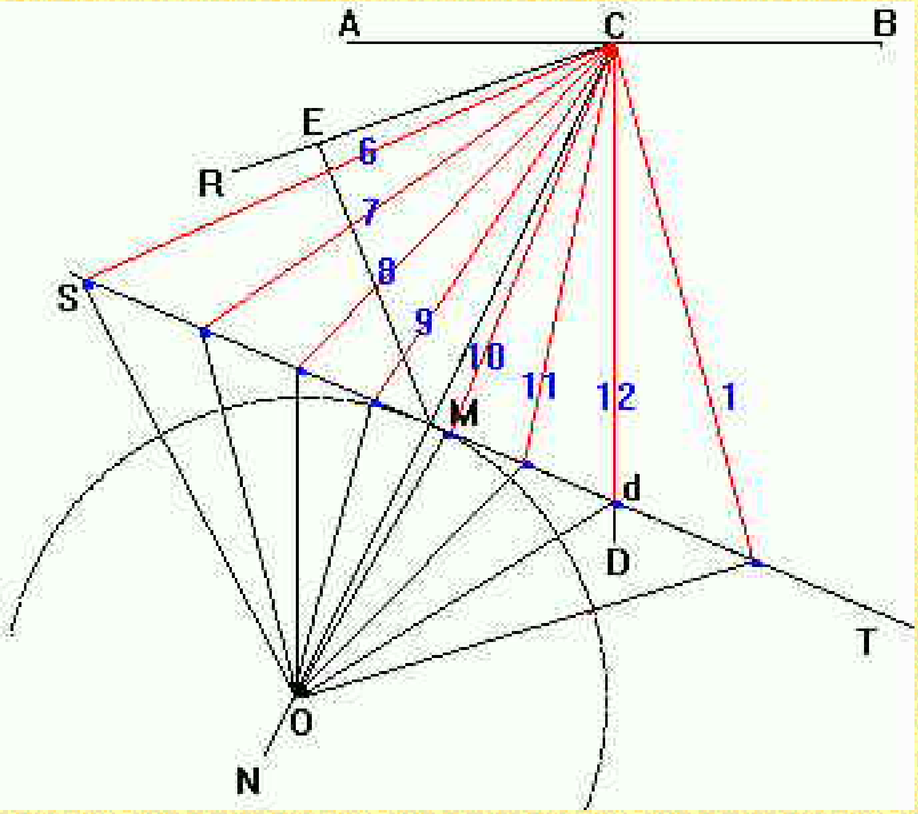
With point O as the center draw a circle of any radius. Label the intersection of line CD and line ST point d. Draw a line from point O to point d.



Starting at line Od divide the circle into 15 degree sections, draw lines from O that intersect line ST using these 15 degree marks on the circle centered at O.



Draw lines from the 15 degree intersections along line ST to the point C. These are the hour lines of the vertical sundial.



Now all that remains is to make and attach the gnomon. The angle of the gnomon is the style-height (SH) and it is attached along the style-distance line (both of these were found graphically above). Attach the gnomon so that the "point" of the triangle is at point C (see diagrams above).

Now attach the dial to the wall it was calculated for, remember to make sure that the 12:00 line (noon) is vertical (Perpendicular to the ground).

NOTE: If the wall declines to the NORTH then the dial is placed such that the hour line radiate UPWARDS (in the diagrams above the hour lines radiate downward [a southern dial]). Also, in a NORTH dial the 12:00 line is no longer Noon but Midnight. It is not usual to place dials on Northern walls since they receive little sunshine.

Make your own Horizontal Sundial.

Make your own Equatorial Sundial.

Page created by: abraxas2@ix.netcom.com
Changes last made on: *January 20, 1998*

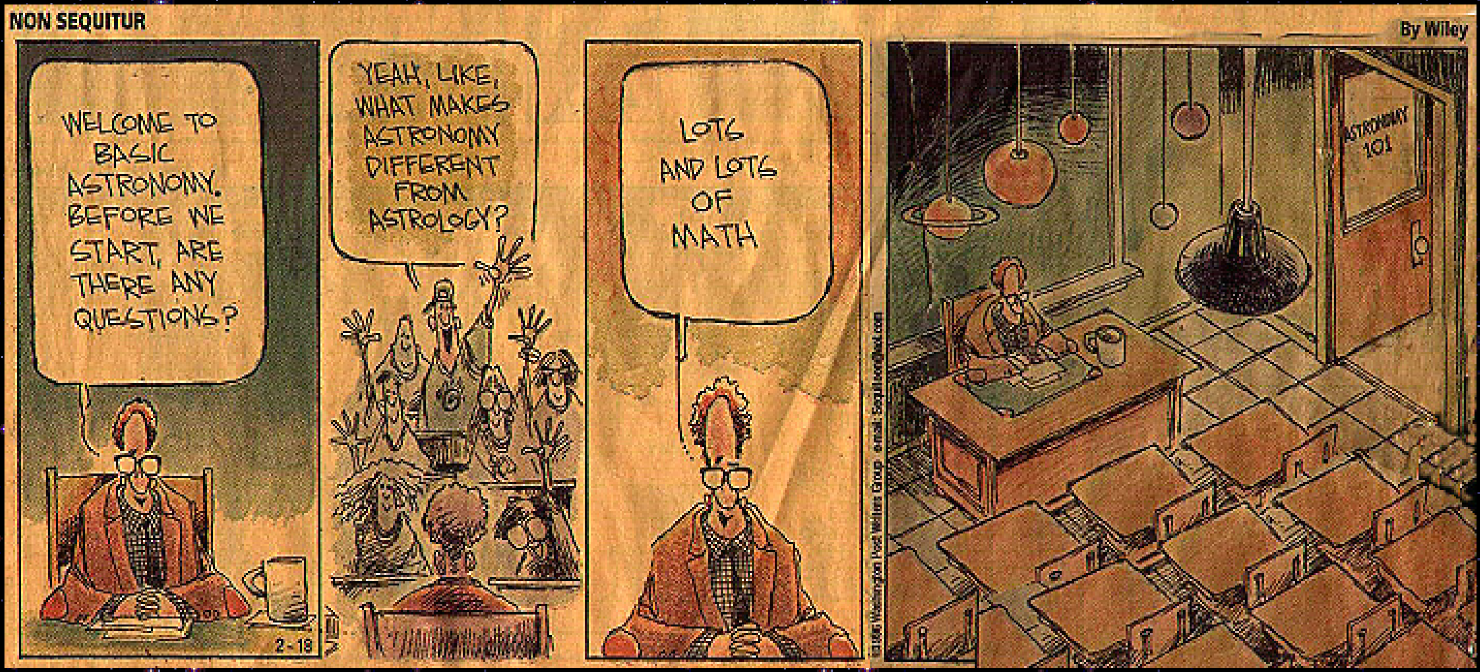
Longitude Adjustments:

There are 24 hours in a day and there are 24 Time Zones in the world. Those that live in the United States are familar with Eastern Standard, Central, Mountain and Pacific time zones. When it is 12:00 in Washington, D.C. it is 9:00am in San Francisco, CA. The meridian of a place is the longitude. Standard meridians are every 15 degrees starting in Greenwich England (Longitude=0 degrees) and going around the world. If you happen to live on your standard meridian then the only difference between your sundial and your watch is the equation of time. If you live off your standard meridian then you have to adjust your dial for its longitude. Since one full rotation (360 degrees) of the Earth takes 24 hours we see that 1 hour of time equates to 15 degrees of longitude (360 degrees of longitude/24 hours= 15 degrees of longitude). Therefore each degree of longitude equals 4 minutes of time and each minute of longitude equals 4 seconds.

Example: A sundial at a longitude of 75 degrees (The standard meridan for Eastern Standard Time) reads 12:00, a sundial in Alexandria, VA (Longitude=78 degrees) reads 11:48. Since the difference in longitude between Alexandria and the EST meridian is 3 degrees the time difference is 12 minutes. The EST meridian is East of Alexandria so since the Sun rises in the East it must be earlier as you go West.

Page created by: abraxas2@ix.netcom.com
Changes last made on: *Oct 18, 1997*

* ASTRONOMY *



NON SEQUITUR By: WILEY 2/18/1996

The most improperly used term from astronomy is the lightyear. A lightyear is NOT a measure of time but a measure of distance. It is the distance that light can travel in one year.

Light travels at 2.998*10^8 meters per second or Two hundred and ninety-nine million meters in one second. Therefore a lightminute is equal to 2.998*10^8*60, a lighthour is 2.998*10^8*60*60, a lightday is 2.998*10^8*60*60*24, and a lightyear is 2.998*10^8*60*60*24*365. Multiplied out a light year is 9.454*10^15 which written without scientific notation is:

9,454,000,000,000,000 meters

This is Nine quadrillion Four hundred and fifty-four trillion meters. This equates to traveling around the Earth about 7 billion times!

How far can light travel in 1 nano-second? Well since we have the speed of light given above we can determine that in .000000001 seconds (1 nano-second) That light will travel .2998 meters. Since 1 meter is about 39.37 inches we can say that in 1 nano-second light will travel 11.8 inches, let's call it a foot!!

Therefore a light-foot is the distance light travels in 1 nano-second!!

SETI

Search for Extraterrestrial Intelligence

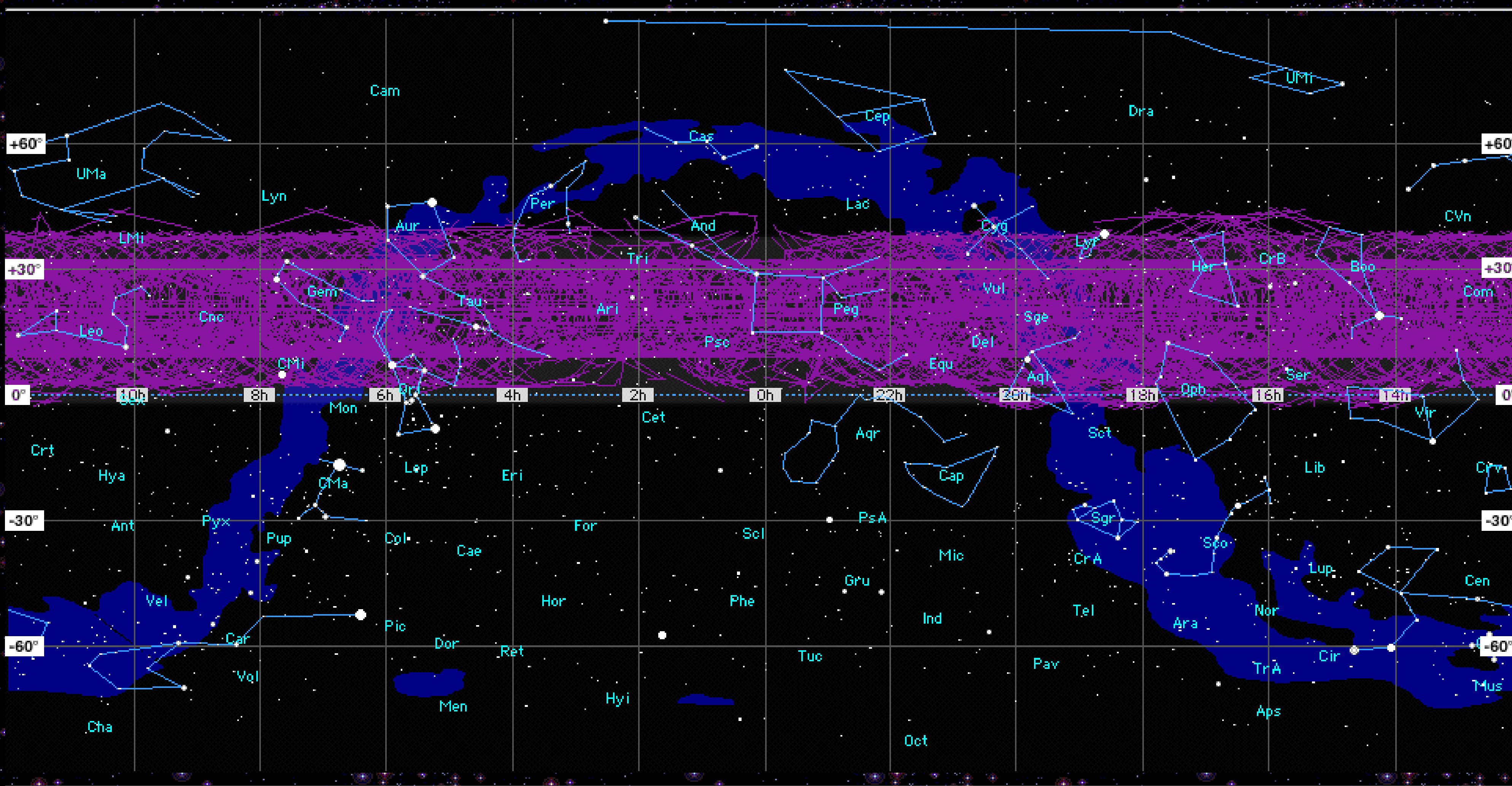
On a clear night have you ever looked up into the heavens and wondered is there intelligent life out there ? . . .

Or are they just like us !!

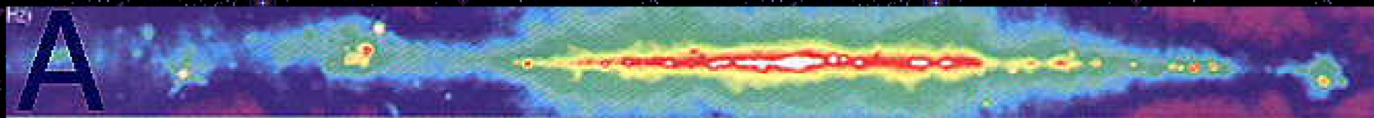
SETI@HOME allows users to download freeware that looks at data 'chunks' received from the Arecibo telescope in Puerto Rico, this 'screensaver' program works when your computer is inactive and attempts to find any signs of intelligent life.

Below is an image of the Arecibo radio telescope (in Puerto Rico), the dish covers an area of about 20 acres.

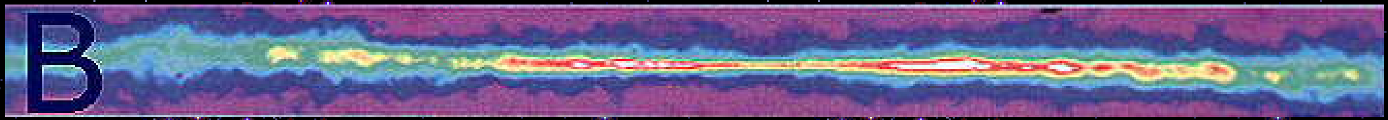
Below is the area where the Arecibo telescope is 'looking/listening'.



What does our own galaxy (Milky Way) look like?

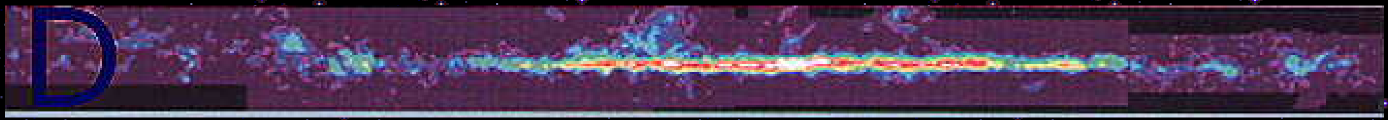


A: Radio Continuum (0.4 GHz)

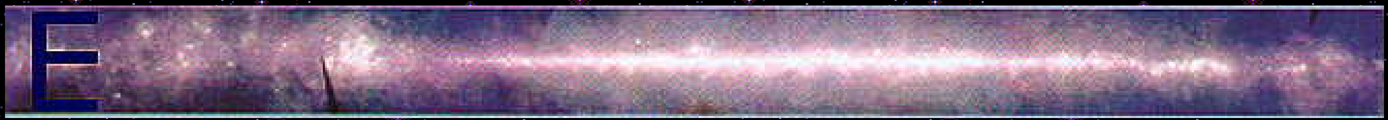


B: Atomic Hydrogen

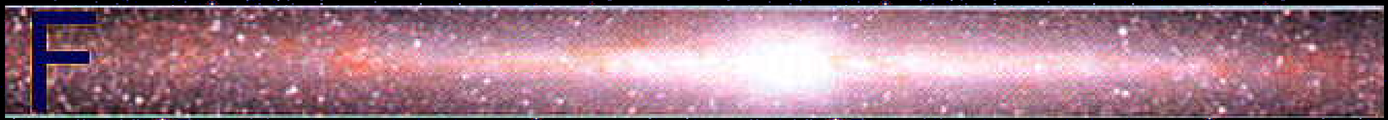
C: Radio Continuum (2.7 GHz)



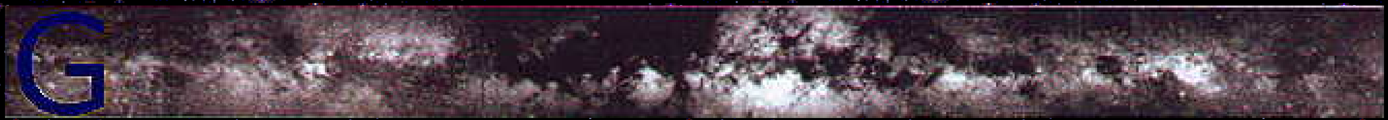
D: Molecular Hydrogen



E: Infrared

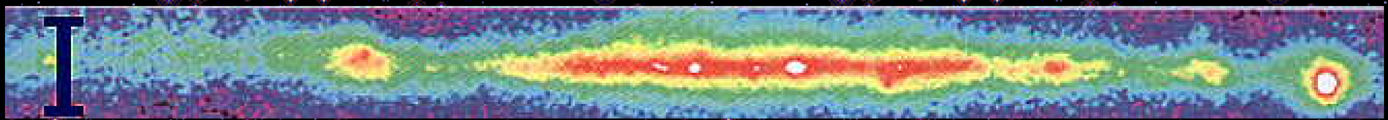


F: Near Infrared



G: Optical

H: X-Ray



I: Gamma Ray

[SETI@HOME home page (Get freeware here).]

[Stardate Online (as heard on NPR)]

[A FANTASTIC Astronomy Site !]

Current Moon Phase

Updated every 4 hours, courtesy USNO

THE PLANETARY SOCIETY

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sundials | equation of time | build a sundial | the zodiac | astronomy | longitude

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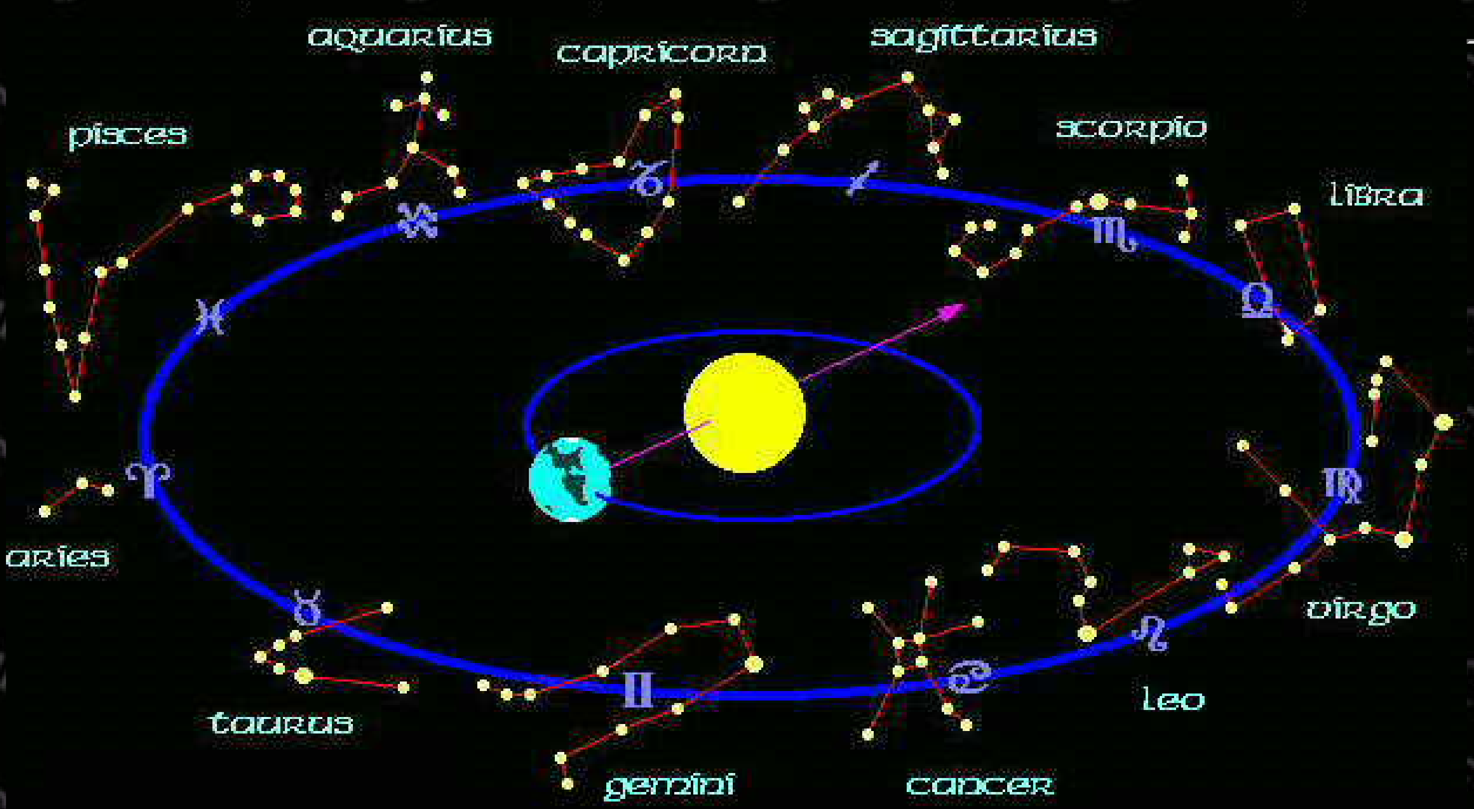
This page accessed times.

Page created by: abraxas2@ix.netcom.com
Changes last made on: *September 9, 2002*



What's your sign?

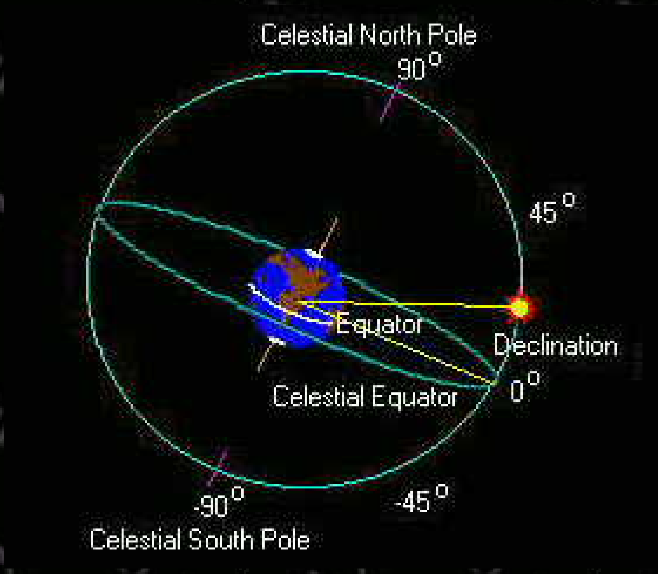
Almost all of us know our birthsign, but not all of us know why it's our birthsign.

In it's yearly orbit around the Sun, the Sun appears to cross different star patterns. The Sun follows a path along the these star patterns (the celestial sphere) called the *ecliptic*. Most of the other planets also stay along this path. The belt in the sky, about 18 degrees wide and centered on the ecliptic is called the Zodiac.

When early astronomers looked up into the night sky they noticed that some of the "stars" moved from night to night. These wandering "stars" always moved over the same fixed stars. These wandering stars where in fact the planets, the word planet comes from a Greek word meaning "wanderer". The background stars that the planets moved across where catagorized and named as constellations. Most are figures of animals, this is the Zodiac (The word is again derived from the Greek, the same word that gives us zoo, zoology etc.).

The zodiac is divided into 12 zones, each zone has a constellation. When you are born the Earth projects the Sun onto one of these zones and that is your birthsign. The Zodiac lines on a Sundial show this apparent movement from one sign to the next.

The dates for Zodiac change over time. We live in a Universe where everything is moving and on a planet that wobbles. Because of this the dates that the Sun enters the different Zodiac vary. I was born in late March, my sign is Aries however in the year I was born the Sun was in Pisces. If I was born 1000 years from now the Sun would be in Aquarius.

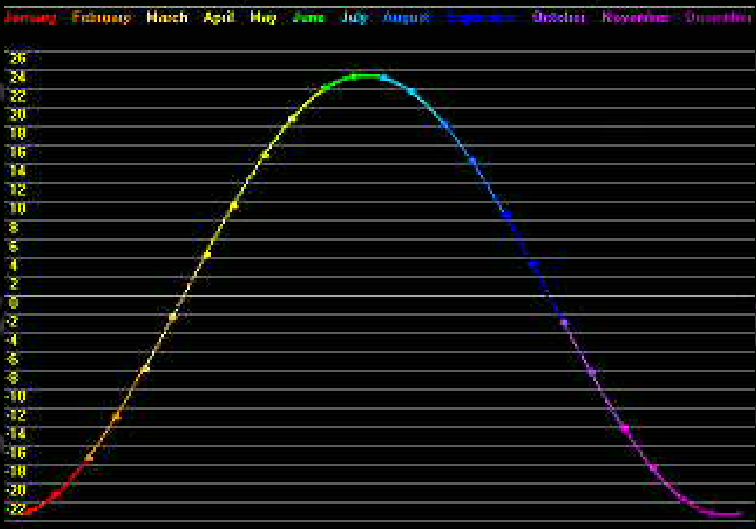


The Zodiac lines on a sundial are usually labled with the accepted signs. Aries at the *Vernal Equinox* (first day of spring), Cancer at the *Summer Solstice* (first day of summer), Libra at the *Autumnal Equinox* (the first day of fall), and Capricorn at the *Winter Solstice* (the first day of winter).

The Zodiac lines on a Sundial are based on the declination of the Sun. The ecliptic is at an angle of about 23.5 degrees with the *celestial equator*. The Sun appears north of the celestial equator half the year and south of it the other half. The dates that the Sun crosses the celestial equator it has a declination of 0 degrees. Because of this day and night are of equal length. These are Spring/Fall Equinox (from the latin meaning equal night). When the Sun reaches its maximum northen or southern declination, about +/-23.5 degrees, these are the Solstices.

The declination of the Sun varies from day to day. The declination values can be found in an Astronomical Ephemeris or calculated. It is because of this that a sundial can be built with anniversary lines on it.

Below is a graph which shows how the declination of the Sun varies with the date. These values are used to calculate the Zodiac lines on a sundial.



This graph is from a program that is in development, available for Free download.

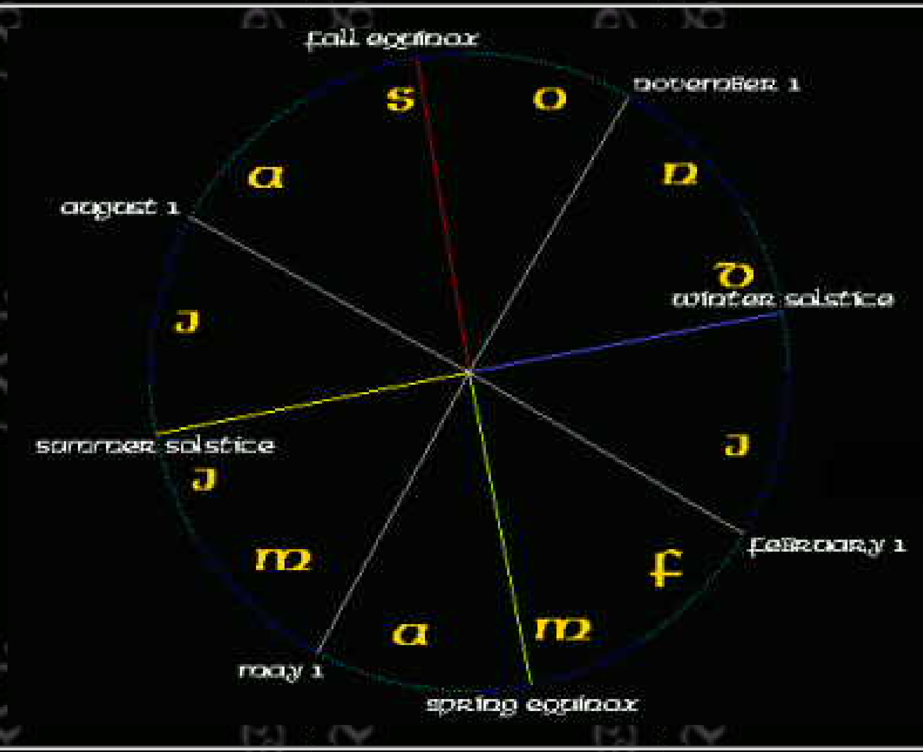
Below is a chart that shows that data used in Sundial (Zodiac Lines) development.

Name of Sign	Symbol	Date Sun Enters	Declination	Season
Aries	♈	March 20	0°00'	
Taurus	♉	April 20	11°28.5'	SPRING
Gemini	♊	May 21	20°09.3'	
Cancer	♋	June 21	23°26.6'	
Leo	♌	July 23	20°09.3'	SUMMER
Virgo	♍	August 23	11°28.5'	
Libra	♎	September 23	0°00'	
Scorpio	♏	October 23	-11°28.5'	AUTUMN
Sagittarius	♐	November 22	-20°09.3'	
Capricornus	♑	December 21	-23°26.6'	
Aquarius	♒	January 20	-20°09.3'	WINTER
Pisces	♓	Feburary 18	-11°28.5'	

The Sky and the Calendar

The Equinox (Spring, Fall) and the Solstice (Summer, Winter) are not usually associated with 'holidays', however the mid-points between were used by ancient people (the Celts) and have become 'modern' holidays.

The chart below shows a graphical representation of the Equinox (Spring/ Fall) and the Solstice (Summer/Winter) and the 'mid-points'.



February 2, (Groundhog Day/Imbolic)

The U.S. tradition that a groundhog emerges from his burrow after a long Winter sleep to look for his shadow. If the shadow is seen he runs back to his burrow to sleep for six more weeks, If no shadow is seen he stays above ground and Spring will soon follow.

In England this day is Candlemas; an old English song:

If Candlemas be fair and bright,

Come, Winter, have another flight;

If Candlemas bring clouds and rain,

Go, Winter, and come not again.

May 1, (May Day/Beltain)

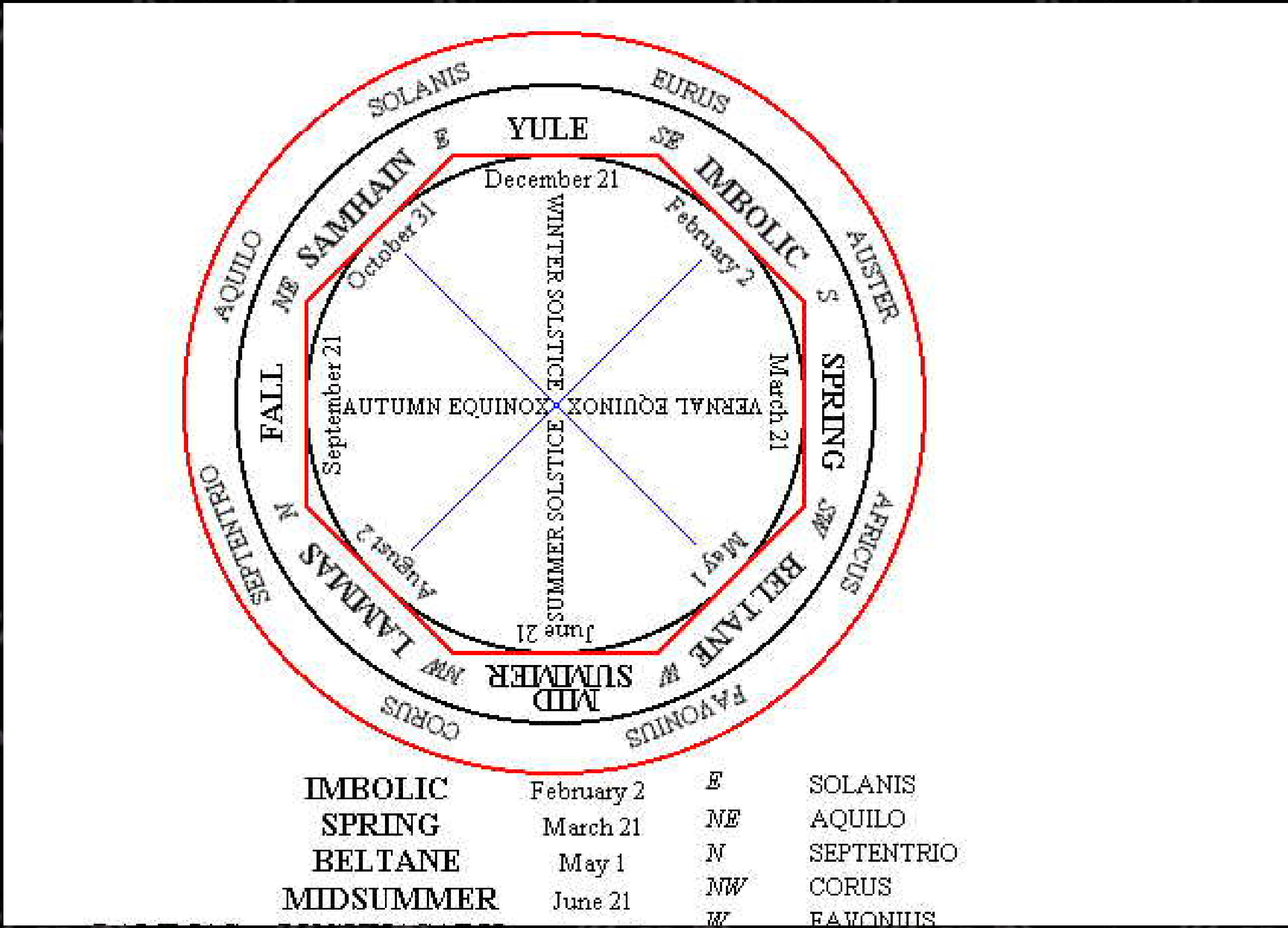
The festival of Spring also an important holiday in Europe honoring workers.

October 31, (Halloween/Samhain)

The Celtic and Anglo-Saxon end of Summer and the start of a new year. The souls of the dead were supposed to revisit their homes on this day and needed to be 'scared' into returning to the nether-world. Bonfires and costumes were used to frighten the evil spirits.

What of August 1?

A related 'modern' holiday is unknown to me, please email an opinions to the address below.



LAMMAS	LUGHNASADH	August 2	W	[illegible]
			SW	AFRICUS
	FALL	September 21	S	AUSTER
	SAMHAIN	October 31	SE	EURUS
	YULE	December 21	E	

The above list (and diagram) shows the 'Holiday', date, Cardinal (or semi- cardinal) direction, and the name of the 'Wind' (Greek) associated with the direction.

How Old are the Zodiac constellations?

The zodiac Taurus is of particular interest. It has been attributed to the Mesopotamians (around 6000 years ago). Some scholars believe that the Mesopotamians may have borrowed the bull figure from earlier people.

In Southwest France is the Lascaux cave, a cave that has many paintings and animal figures. These figures have been dated to 15000 BC and one in particular has caught the attention of stargazers. The painting shows a bull with a cluster of dots over his shoulder. The Pleiades (the sisters) is a star cluster that is associated with the constellation Taurus. The constellation of Taurus is easily identified as a V. It is interesting to note that the cluster of "dots" on the cave painting is in the general position of the Pleiades (with respect to the V). The brightest star in Taurus is Aldeberan (the eye of the Bull), look carefully at the painting and note that there seems to be a collection of "dots" in the shape of a V around the eye of the bull.

The image on the left is from the cave in Lascaux, the image on the right is how the constellations appeared in the South of France in 15000 BC

For more information about Lascaux (and other palaeoastronomy subjects) please visit : INFIS

It is important not to confuse Astronomy with Astrology. What is discussed here is Astronomy.

Page created by: abraxas2@ix.netcom.com
Changes last made on: *April 6, 1999*

The Equation of Time:

Values presented are averages and may be in error by 10-15 seconds in January and December of certain years.

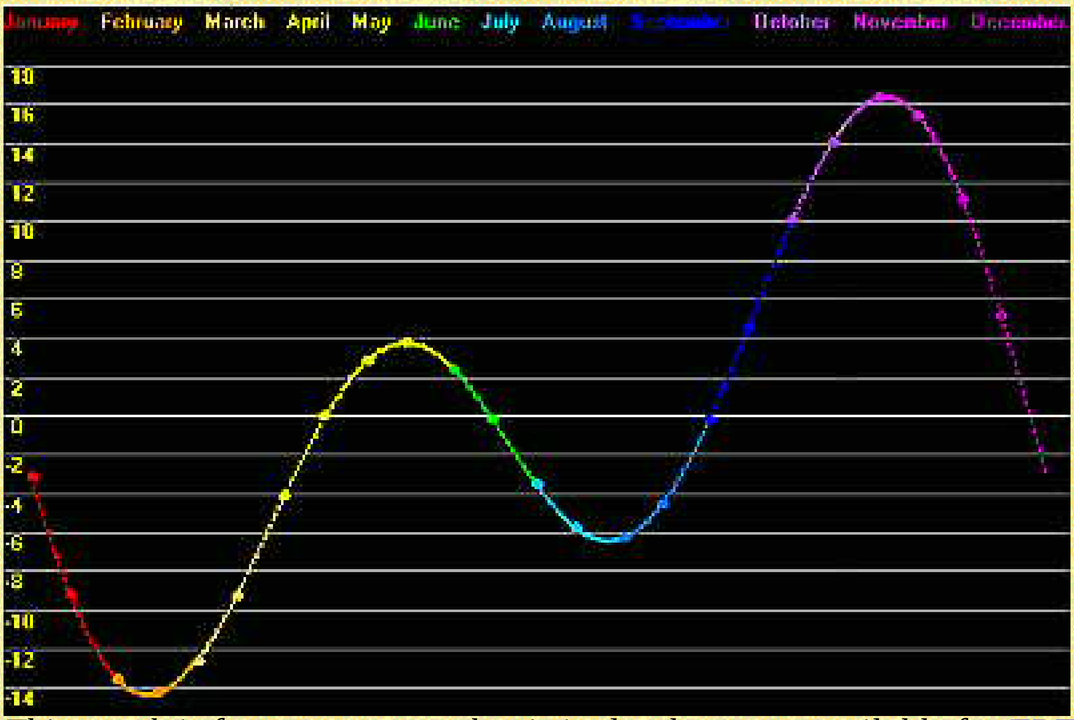
The apparent motion of the Sun along the plane of the ecliptic is not regular. This non-uniform motion is caused by two things: 1)The Earth's orbit is not circular but elliptical and 2) the Earth's axis is tilted about 23 degrees from the ecliptic. Mean Solar time assumes that the orbit is circular that there is no tilt and everything is like "clockwork". However this is not the case, so a Sundial (which shows Real Solar time) differs from the Mean time by the Equation of Time. Since clocks and watches use Mean Solar Time there will be an apparent error between the time your watch reads and the time your dial reads.

Day	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	-3:12	-13:33	-12:34	-4:08	+2:51	+2:25	-3:33	-6:16	-0:12	+10:05	+16:20	+11:11
2	-3:40	-13:41	-12:23	-3:50	+2:59	+2:16	-3:45	-6:13	+0:07	+10:24	+16:22	+10:49
3	-4:08	-13:48	-12:11	-3:32	+3:06	+2:06	-3:57	-6:09	+0:26	+10:43	+16:23	+10:26
4	-4:36	-13:55	-11:58	-3:14	+3:12	+1:56	-4:08	-6:04	-0:45	+11:02	+16:23	+10:02
5	-5:03	-14:01	-11:45	-2:57	+3:18	+1:46	-4:19	-5:59	-1:05	+11:20	+16:22	+9:38
6	-5:30	-14:06	-11:31	-2:40	+3:23	+1:36	-4:29	-5:53	+1:25	+11:38	+16:20	+9:13
7	-5:57	-14:10	-11:17	-2:23	+3:27	+1:25	-4:39	-5:46	+1:45	+11:56	+16:18	+8:48
8	-6:23	-14:14	-11:03	-2:06	+3:31	+1:14	-4:49	-5:39	+2:05	+12:13	+16:15	+8:22
9	-6:49	-14:16	-10:48	-1:49	+3:35	+1:03	-4:58	-5:31	+2:26	+12:30	+16:11	+7:56
10	-7:14	-14:18	-10:33	-1:32	+3:38	+0:51	-5:07	-5:23	+2:47	+12:46	+16:06	+7:29
11	-7:38	-14:19	-10:18	-1:16	+3:40	+0:39	-5:16	-5:14	+3:08	+13:02	+16:00	+7:02
12	-8:02	-14:20	-10:02	-1:00	+3:42	+0:27	-5:24	-5:05	+3:29	+13:18	+15:53	+6:34
13	-8:25	-14:19	-9:46	-0:44	+3:44	+0:15	-5:32	-4:55	+3:50	+13:33	+15:46	+6:06
14	-8:48	-14:18	-9:30	-0:29	+3:44	+0:03	-5:39	-4:44	+4:11	+13:47	+15:37	+5:38
15	-9:10	-14:16	-9:13	-0:14	+3:44	-0:10	-5:46	-4:33	+4:32	+14:01	+15:28	+5:09
16	-9:32	-14:13	-8:56	+0:01	+3:44	-0:23	-5:52	-4:21	+4:53	+14:14	+15:18	+4:40
17	-9:52	-14:10	-8:39	+0:15	+3:43	-0:36	-5:58	-4:09	+5:14	14:27	+15:07	+4:11
18	-10:12	-14:06	-8:22	+0:29	+3:41	-0:49	-6:03	-3:57	+5:35	+14:39	+14:56	+3:42
19	-10:32	-14:01	-8:04	+0:43	+3:39	-1:02	-6:08	-3:44	+5:56	+14:51	+14:43	+3:13
20	-10:50	-13:55	-7:46	+0:56	+3:37	-1:15	-6:12	-3:30	+6:18	+15:02	+14:30	+2:43
21	-11:08	-13:49	-7:28	+1:00	+3:34	-1:28	-6:15	-3:16	+6:40	+15:12	+14:16	+2:13
22	-11:25	-13:42	-7:10	+1:21	+3:30	-1:41	-6:18	-3:01	+7:01	+15:22	+14:01	+1:43
23	-11:41	-13:35	-6:52	+1:33	+3:24	-1:54	-6:20	-2:46	+7:22	+15:31	+13:45	+1:13

24	-11:57	-13:27	-6:34	+1:45	+3:21	-2:07	-6:22	-2:30	+7:43	+15:40	+13:28	+0:43
25	-12:12	-13:18	-6:16	+1:56	+3:16	-2:20	-6:24	-2:14	+8:04	+15:47	+13:11	+0:13
26	-12:26	-13:09	-5:58	+2:06	+3:10	-2:33	-6:25	-1:58	+8:25	+15:54	+12:53	-0:17
27	-12:39	-12:59	-5:40	+2:16	+3:03	-2:45	-6:25	-1:41	+8:46	+16:01	+12:34	-0:47
28	-12:51	-12:48	-5:21	+2:26	+2:56	-2:57	-6:24	-1:24	+9:06	+16:06	+12:14	-1:16
29	-13:03	-12:42	-5:02	+2:35	+2:49	-3:09	-6:23	-1:07	+9:26	+16:11	+11:54	-1:45
30	-13:14		-4:44	+2:43	+2:41	-3:21	-6:21	-0:49	+9:46	+16:15	+11:33	-2:14
31	-13:24		-4:26		+2:33		-6:19	-0:31		+16:18		-2:43
Day	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**

Format of data is: [(+/-) minutes:seconds] where + is fast and - is slow.

The equation of time data is usually represented graphically for ease in use. Below is a graph of the data from the table above.



This graph is from a program that is in development, available for FREE download.

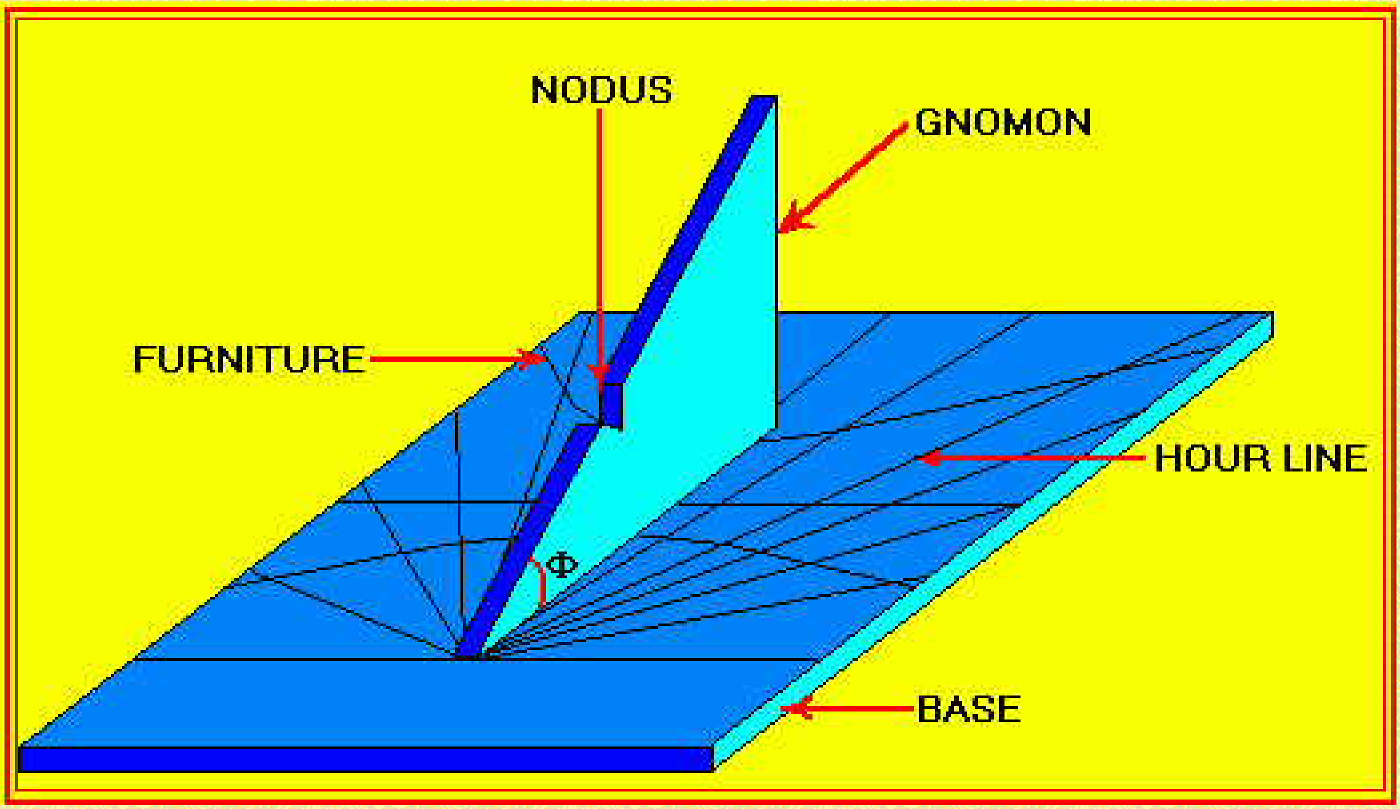
Example: There is a dial in Allentown PA (Longitude=75 deg, which is the Standard Meridian). the dial reads 12:00(noon) on October 18, this is the Local Apparent Time. We see that the equation of time for October 18 is about 14 minutes fast, when we subtract this from the dial time we get 11:46 which is the Local Standard Time and will agree with our watch!

Page created by: abraxas2@ix.netcom.com

Changes last made on: *Nov 8, 1997*

Sundial Information

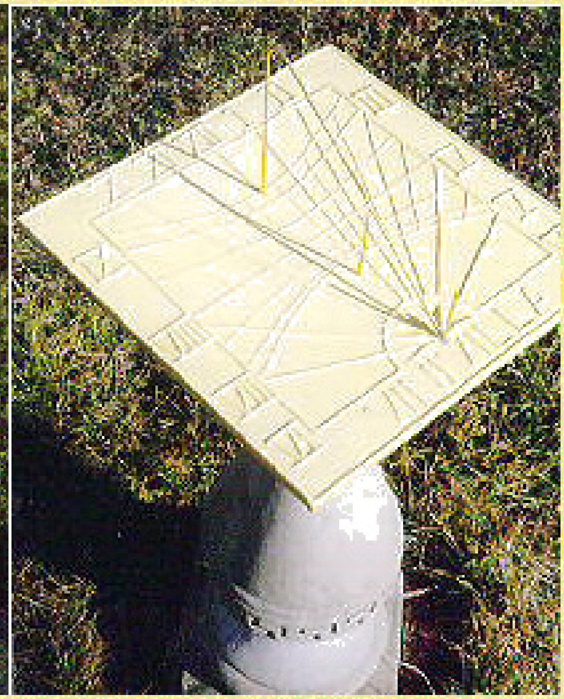
Parts of a Sundial:



- Gnomon: The shadow caster, in a horizontial dial the angle phi is equal to the Latitude of the location.
- Hour Line(s): The numbered lines that the shadow falls along.
- Nodus: A "marker" along the gnomon to get an exact point on the shadow.
- Furniture: Lines and "functions" other than the Hour lines, usually date lines (this is what the nodus is for).

Common Types of Sundials:

- HORIZONTAL: The base of the dial is parallel to the ground, the gnomon's angle is the latitude. The dial below is a horizontal SUNTILE.



The dial above is a sandblasted piece of slate in the design of a Jeffersonian tile, made for Poplar Forest.
To learn more about Jefferson's sundial calculations, click here.

- VERTICAL: These dials are attached to walls (like the sides of buildings). The dials below are vertical dials made of copper.

- EQUATORIAL: The base of the dial is parallel to the plane of the Earth's equator, hour lines are 15 degrees apart.

The above Equatorial dial is a hemisphere which has direct East, West, and North dials on the sides.

All the pictured dials were designed and constructed by my father and myself.

Usually any other lines, graphs, analemmas, mottos, and compass roses are called dial furniture.

The most common furniture is the zodiac lines, these lines (with the aid of the gnomon's nodus) show the date the Sun enters a new zodiac. These lines can be calculated for any date and therefore create an anniversary dial.

Anniversary SunTile

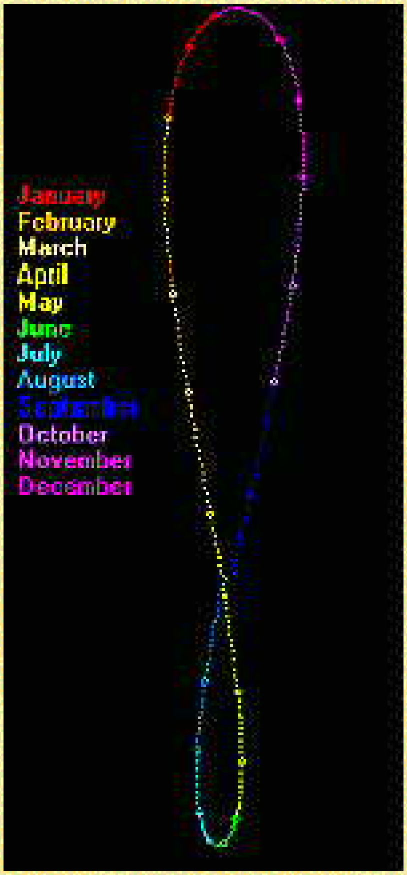
The dial above is an example of a SunTile anniversary dial. The zodiac lines on this particular dial show birthday's and other significant dates for the family. This dial also has a compass rose.

The graph of the Equation of Time. which converts Sundial time (local apparent time) to local mean time.

A compass rose (usually on a horizontal dial) shows the azimuth of the sun.

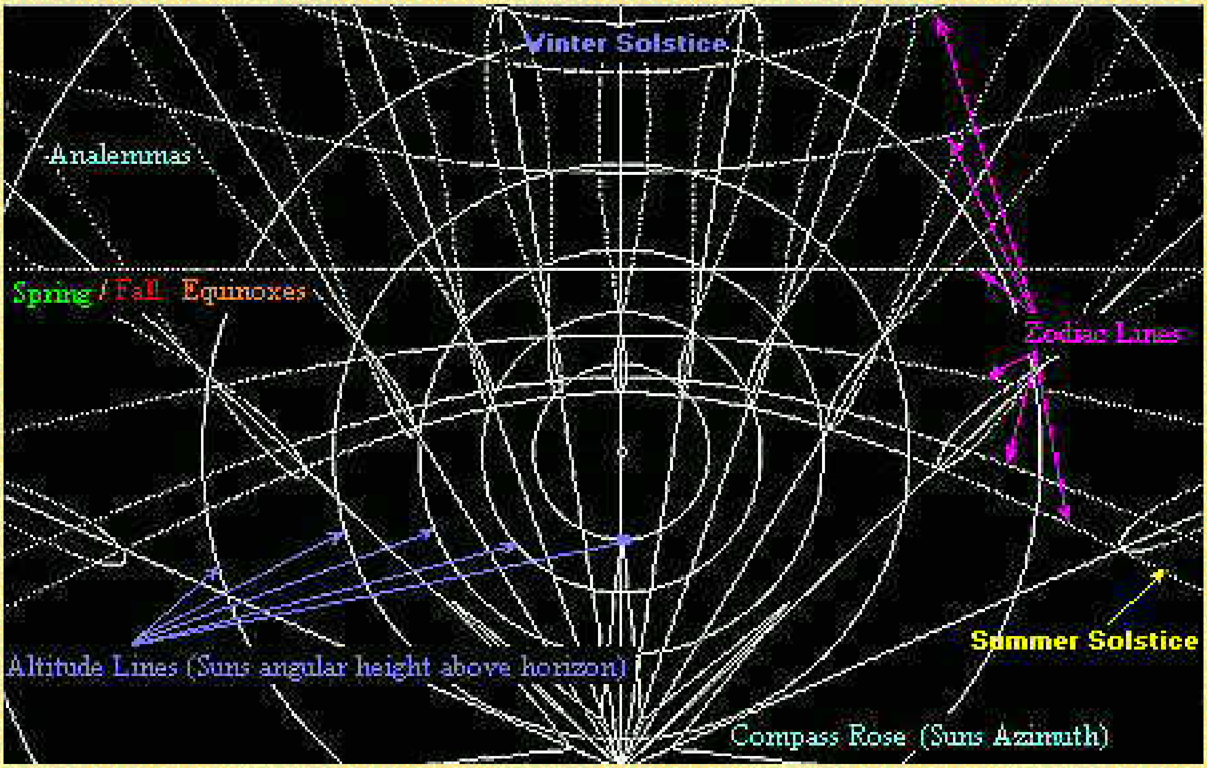
Mottos, sayings or poems included on the dial (a popular example is Tempus Fugit QuoQue Serpit).

Analemmas show the relation between the equation of time and the Suns declination.



This graph is from a program that is in development, available for Free download.

A Horizontal Dial for Washington, D.C. with Furniture:



This graph is from a program that is in development, available for Free download.

Make your own Horizontal Sundial.

Make your own Equatorial Sundial.

Make your own Vertical Sundial.

A Monumental horizontal Sundial.

A Sundial for Reutte

A Sundial design contest was announced for Reutte, Austria. The closing date for an entry was 9/25/1998. The judging date was 10/3/1998.

Click here to see our entry.

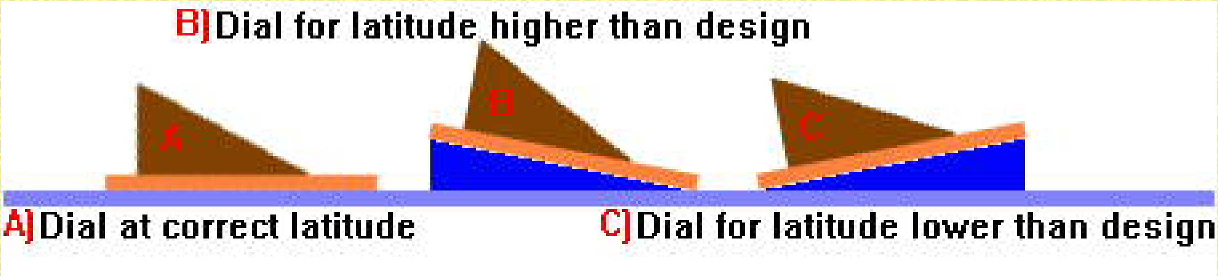
Most sundials that are available (science shops, garden shops etc.) are not going to work without a little adjusting.

Many of these "popular" horizontal dials have a gnomon which is 45 degrees. As we know this means that this dial was, hopefully, designed for a latitude of 45 degrees (like Minneapolis, MN). Make sure by measuring the angle of the gnomon.

The gnomon needs to point to the North Celestial Pole (true North) so unless the angle of the gnomon is equal to the latitude the horizontal dial must be "tipped".

If the gnomon was measured to be 45 degrees, but the latitude is 30. Then there is a difference of -15 degrees between the gnomon and the latitude. So we must tip the whole dial so the the gnomon is lowered 15 degrees. If the latitude was greater than the angle of the gnomon then we would tip the whole dial so the gnomon is raised the correct amount.

These adjustments will correctly adjust for one latitude any properly constructed horizontal dial for a different latitude.



Why don't the sundials agree with the clocks? This is partly because of the Equation of Time.

A serious sundial link(s) page !

This page accessed 19553 times.

Page created by: abraxas2@ix.netcom.com

Changes last made on: *March 13, 2001*

Member of the North American Sundial Society

This Universal Ring site is owned by P.R. Field.

Want to join the Universal Ring?

[Skip Prev] [Prev] [Next] [Skip Next] [Random] [Next 5] [List Sites]

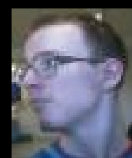
SETI@home
The Search for Extraterrestrial Intelligence

SETI@home is a scientific experiment that uses Internet-connected computers in the Search for Extraterrestrial Intelligence (SETI). You can participate by running a free program that downloads and analyzes radio telescope data.

Software & operations

- **Download SETI@home**
- Add-ons
- Server status
- Technical news March 27, 2003

User of the Day — January 11, 2004



The SETI@home User of the Day is Hans Johansson.

Science

- Current progress
- Learn about SETI@home
- Science newsletters
- Signal candidates (new)
- Science links

User Zone

- User account - User profiles - Groups
- SETI@home poll
- Users grouped by signup date
- Anniversaries: 2004 2003 2002 2001
- Certificate of appreciation TPS

Help & information

Site search search tips

- FAQ (Frequently Asked Questions)
- Problems and help
- SETI@home message boards

Statistics

- Current total statistics
- Individual user statistics
- Group statistics
- Country statistics

How you can help

- Join the Planetary Society TPS
- **Donate to SETI@home**
- Become a corporate sponsor

Other resources

- International pages
- Chat and message boards
- SETI@home bookstore (new)

News

December 13, 2003
There is a new Greek language site about SETI@home.

December 11, 2003
Summary of a talk in Australia by SETI@home founder David Gedye.

December 4, 2003
Here is a brief summary and current status of our reobservations.

November 29, 2003
Emilio González (Astroseti.org founder) interviews David Anderson (Spanish, English).

November 14, 2003
It is possible that one or more viruses/worms are circulating around the Internet installing SETI@home on infected computers. For more information, click here.

October 30, 2003
If you are unable to connect to our server because of "100" errors, please click here.

User submissions & entertainment

- Links to user and group pages
- User submissions
- The lighter side of SETI

About the project

- Personnel and plan
- Photo gallery
- Future directions

Sponsors and acknowledgements

If you'd like to become one of SETI@home's supporters, please click here. Donations are fully tax deductible.

Corporations may become Corporate Sponsors of SETI@home with a minimum $10K (or equivalent in-kind) donation. We are also interested in Corporate Participants willing to run SETI@home on their PCs. For more info, click here.

Sponsors of SETI@home include:

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The Planetary Society

The University of California Digital Media Innovation Program

Sun Microsystems

The Friends of SETI@home (people like you) !

MAJOR SPONSORS

October 6, 2003
Plans for our transition to BOINC are here.

September 26, 2003
New article just released at the Planetary Society: New and Improved SETI@home will form Backbone of Distributed Computing Network.

September 23, 2003
Who's faster, Intel or AMD? Benchmarks of SETI@home on various current CPU chips are here.

August 28, 2003
New SETI@home Science Newsletter released today: Telescope Pointing Corrections.

August 27, 2003
We made an error in the generation of reobservaton workunits. We have corrected the error and are redistributing these workunits. Here are some details.

Older news

Powered by NetworkAppliance

Network Appliance, Inc.

FUJIFILM

Fuji Film Computer Products

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Quantum.

Quantum Corporation

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Spacesounds	**Dillon Engineering, Inc.**

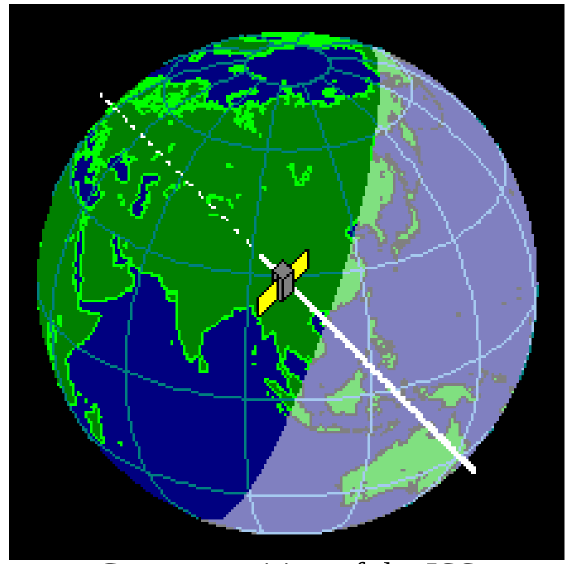
Thanks also to Starwave, who sponsored the scientific feasibility study.

Welcome to the new-look Heavens-Above!

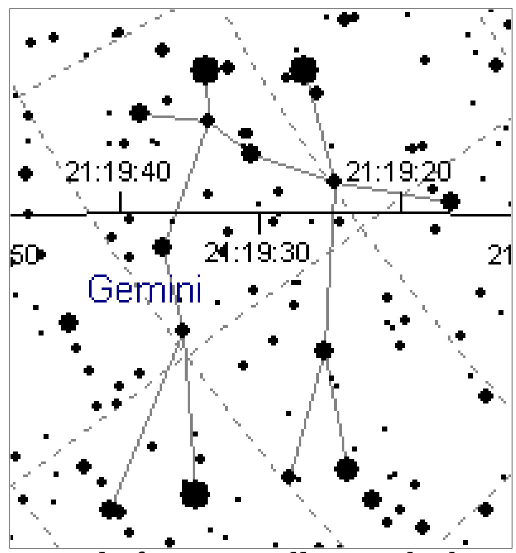
If you're interested in satellites or astronomy, you've come to the right place! Our aim is to provide you with all the information you need to observe satellites such as the **International Space Station** and the **Space Shuttle**, spectacular events such as the dazzlingly bright **flares from Iridium satellites** as well as a wealth of other spaceflight and astronomical information.

We not only provide the times of visibility, but also detailed star charts showing the satellite's track through the heavens. All our pages, including the graphics, are **generated in real-time** and **customized** for your location and time zone. Frequent visitors will notice we have changed the appearance of the site somewhat and added the option of user registration. This has been done to open the door to a host of new, customisable features which will be appearing over the coming months.

Before we can generate the predictions for you, we need to know where you are, and there are several ways you can do this, depending on whether you are a registered user, want to become one, or prefer to use the site anonymously. For a discussion of the merits of registering, please click here. For some tips on how to get the best out of the site as an anonymous user, click here.



Current position of the ISS



Sample from a satellite track chart

Registered Users

- Simply **log-on**. All your location details and preferences will be retrieved from our database.

Anonymous Users

- **Register** as a user with Heavens-Above. We encourage all our visitors to do so.
- **Select** your location from our huge database.
- **Enter** your coordinates manually.

Developed and maintained by Chris Peat, Heavens-Above GmbH
Please read the updated FAQ before sending e-mail.

Hosted by DLR/GSOC

THE PLANETARY SOCIETY

The largest nonprofit, nongovernmental space advocacy group on Earth.

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The Planetary Society is on Mars!

Crack the Secret Code on the DVD & What Time is it on the Mars Dial

HEADLINES

Spirit Images of Mars - January 9, 2004

Mars Express Tries Again, But Still No 'Bark' from *Beagle*

Spirit Returns More "Exquisite" Data, Inspires New Generation of Space Explorers

What (Mars) Time is it?

Crack the Code for a Message from Mars

Spirit's Landing Site Designated Columbia Memorial Station

Following Stormy Encounter, *Stardust* Stores Samples, Heads for Home

- News Archives
- Special Features

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★ Sign Up for Society Updates

★ Discovery Team

TAKING ACTION

The Planetary Society Completes Faxing Campaign to White House. The Fight for the Human Exploration of Mars Continues

Ask for a Delay in Orbital Space Plane Decision

Save the Pluto Mission Campaign Page

Members and interested US citizens can write their congressional representatives and other government officials with their views about the space program.

SOCIETY UPDATES

The Future of Human Space Flight: View a Video of Planetary Society Leaders' Testimony before Congress

WHAT'S HAPPENING NOW

The Future of Human Spaceflight

Astrobot Diary 24, Jan 8: Remembering Biff's Entry, Descent, and Landing

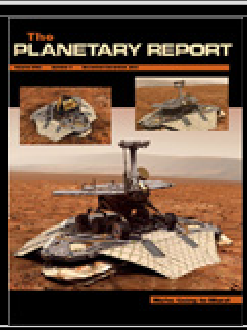
Planetary Radio, Jan. 5: *Spirit* Lands on Mars!

Get a Kid's-Eye View of Life Inside *Spirit* Mission Operations from the Student Astronauts!

What a time at *Wild About Mars!*

The Mars Exploration Rover - *Spirit*

Mars Stations: Drive a Simulated Mars Rover



The Planetary Report

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Getting students involved in real space missions.

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The Future of Human Space Exploration

Meet the Student Astronauts!

Travel to the Galapagos Islands and Ecuador with the Planetary Society!

EVENTS

Get ready to get *"Wild About Mars"*

Space-related events around the world

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Planetary Radio is now a weekly radio show airing every Monday and archived here!

Planetary Radio, Jan. 5: Spirit Lands on Mars!

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Members-Only Discounts on Telescopes

Members-Only Discounts on Planetarium Admissions

High School and College Scholarships

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Pick of the month by Louis Friedman, Executive Director of The Planetary Society: *Almost Heaven: The Story of Women in Space*, by Bettyann Holtzmann Kevles

Purchase recent "picks" from Amazon.com and help Planetary Society programs!

Near Earth Objects

The science, discovery, and tracking of comets and asteroids, including the Shoemaker NEO Grant Program

Solar Sailing

Cosmos 1, the first solar sail: Follow this historic mission here!

- Launch Planned for Early 2004

Red Rover, Red Rover

Operate a rover from your classroom, or over the internet.

Extrasolar Planets

Learn about the search for planets beyond our solar system.

The Earthdial Project

Track the passage of time, with Sundials around the world

The Mars Millennium Project

Help design a community on Mars in the year 2030.

Planetrek

Bringing the solar system down to Earth.

OPINIONS

What Next After Columbia? by Louis Friedman

Stepping into the Future: A workshop on the future of human space exploration

The Planetary Society's Nuclear Propulsion Space Initiative

Contact Us

Planetary Society Volunteer Network

en español ¡Bienvenidos al Sitio de La Sociedad Planetaria en Español!

Privacy Statement

Site Map

Last Updated 1/9/2004

Free Sundial Software

The graphs you have seen on my other pages were created by an original program developed in Visual Basic ver 3.0.

What you get

If you are interested download the file called SUNZIP.ZIP. This file is 816,763 bytes. It is the complete program which when 'UNZIPPED' will have a SETUP.EXE file that will take care of all the 'behind the scenes' work.

This software is still in development, so PLEASE send me comments and suggestions on making it better. It is not 'finished' but I believe that it is complete enough to offer.

DISCLAIMER: I know that it works in the Windows for Workgroups ver 3.11, WIN 95, and WIN 98 and is virus free. Any problems should be brought to my attention, but the software is offered on an as is basis.

If you know a little about Visual Basic programs and setting up groups and items in the windows environment then you may download the same program called DIAL.ZIP, this zipped file contains the SUNDIALS.EXE file, the LOCATION.DAT file, the EQNOTIME.DAT file, and the SOLARDEC.DAT file. The .DAT files are data files for Location, Equation of Time, and Solar Declination. You will need to set up your own directories and copy the VBRUN300.DLL file to your windows directory. The good news is that this file is only 21,641 bytes!!

The program 'assumes' the user has a basic understanding of Sundial theory.

To date versions of this program have been sent to:

- Italy
- England
- Australia
- Germany
- South Africa
- Ireland
- Spain
- France
- Czech Republic
- India

- Brazil
- Canary Islands
- Several American States

PLEASE relay your comments to me (positive or negative). The only way to improve the program is to know what needs should be addressed. If you download please send me your name and where you live so I can add to the list above. This information is for my eyes only.

Sundial Software

Download SUNZIP.ZIP
Download DIAL.ZIP

Page created by: abraxas2@ix.netcom.com
Changes last made on: *January 28, 2002*

INFIS

Institute for Interdisciplinary Studies

11-04-2003

Thomas Jefferson's POPLAR FOREST

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History of Poplar Forest
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MUSEUM SHOP
MAP/DIRECTIONS
EVENTS CALENDAR
KID'S PAGE
SITE INDEX
CONTACT US

It is the most valuable of my possessions.
Th: Jefferson

Jefferson enjoyed "the solitude of a hermit" at his year-round retreat near Lynchburg, Virginia. At the heart of this 4800-acre plantation in beautiful Bedford County, Jefferson built his final, personal architectural masterpiece -- an octagonal house surrounded by an elaborate villa landscape. The rescue of this National Historic Landmark began in 1984, and today you can watch the state-of-the-art restoration under way. Come discover the private, contemplative side of Thomas Jefferson.

Poplar Forest Guide Book Now Available

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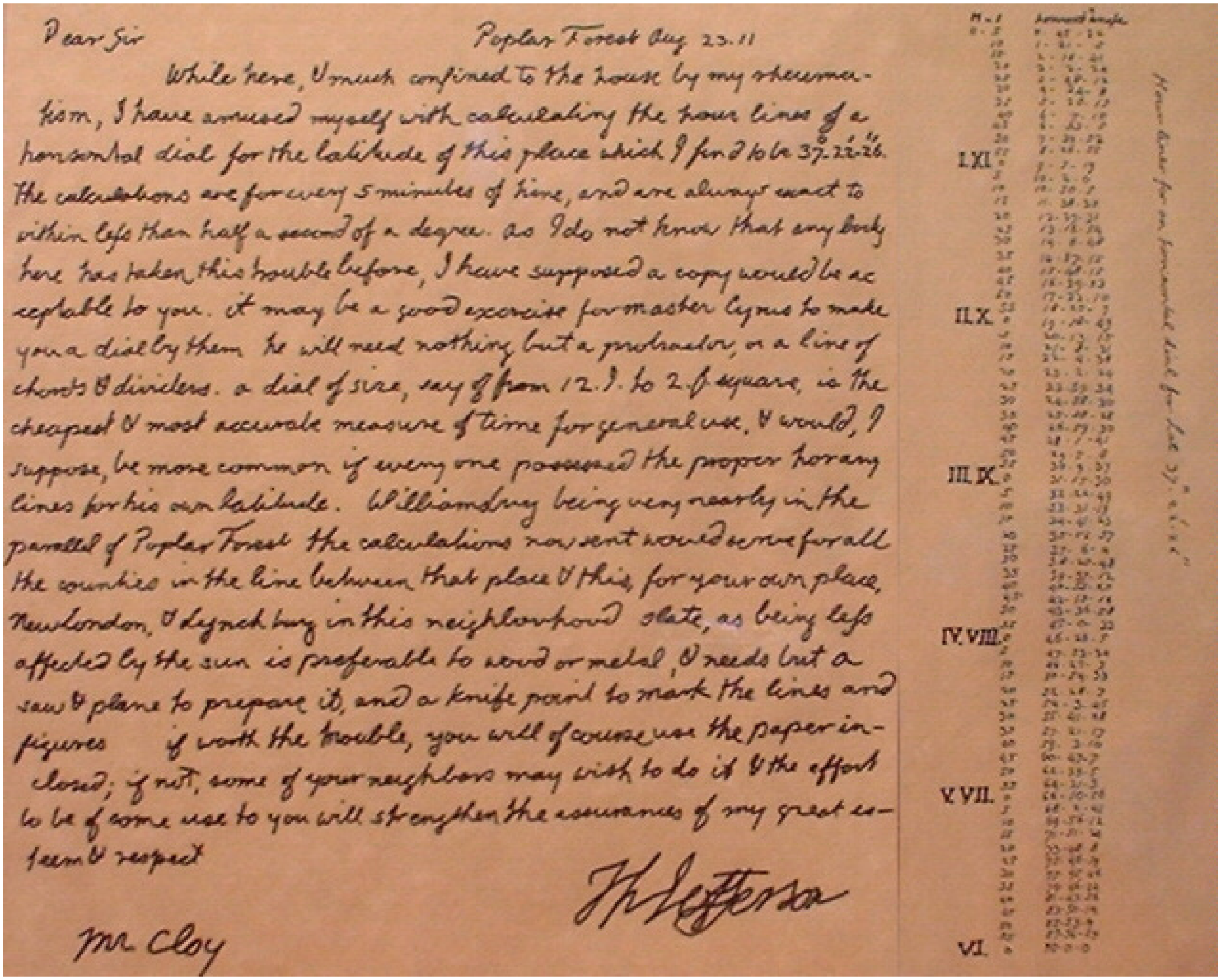
The Corporation for Jefferson's Poplar Forest
P.O. Box 419 • Forest, VA 24551-0419
Voice (434) 525-1806 • Fax (434) 525-7252

Send comments about the Poplar Forest website to webmaster@poplarforest.org



Dear Sir Poplar Forest Aug. 23.11

While here, & much confined to the house by my rheumatism, I have amused myself with calculating the hour lines of a horizontal dial for the latitude of this place which I find to be 37.22.26. the calculations are for every 5 minutes of time, and are always exact to within less than half a second of a degree. as I do not know that any body here has taken this trouble before, I have supposed a copy would be acceptable to you. it may be a good excercise for master Cyrus to make you a dial by them he will need nothing but a protractor, or a line of chords & dividers. a dial of size, say of from 12.I. to 2.f. square, is the cheapest & most accurate measure of time for general use, & would, I suppose, be more common if every one possessed the proper horary lines for his own latitude. Williamsburg being very nearly in the parallel of Poplar Forest the calculations now sent would serve for all the counties in the line between that place & this, for your own place, New London, & Lynchburg in this neighborhood slate, as being less affected by the sun is preferable to wood or metal, & needs but a saw & plane to prepare it, and a knife point to mark the lines and figures if worth the trouble, you will of course use the paper inclosed; if not, some of your neighbors may wish to do it & the effort to be of some use to you will strengthen the assurances of my great esteem & respect

Th: Jefferson

Mr. Clay

I.XI. II.X. III.IX. IV.VIII. V.VII. VI.

Enhanced using opaque projection of a facsimile copy of the original letter preserved at the University of Virginia's Alderman Library at Charlottesville.

Transcription of Mr. Clay's Letter

Dear Sir Poplar Forest Aug. 23.11

While here, & much confined to the house by my rheuma-
tism, I have amused myself with the calculating the hour lines of a
horizontal dial for the latitude of this place which I find to be 37°-22'-26"
The calculations are for every 5 minutes of time, and are always exact to
within less than half a second of a degree. As I do not know that anybody
here has taken this trouble before, I have supposed a copy would be ac-
ceptable to you. It may be a good excercise for Master Cyrus to make
you a dial by them. He will need nothing but a protractor, or a line of
chords & dividers. A dial of size, say of from 12.i. to 2.f.square, is the
cheapest & most accurate measure of time for general use, it would, I
suppose, be more common if every one possessed the proper horary
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Th. Jefferson

Mr. Clay

Thomas Jefferson's Sundial Calculations

Comparison to Computer Calculation

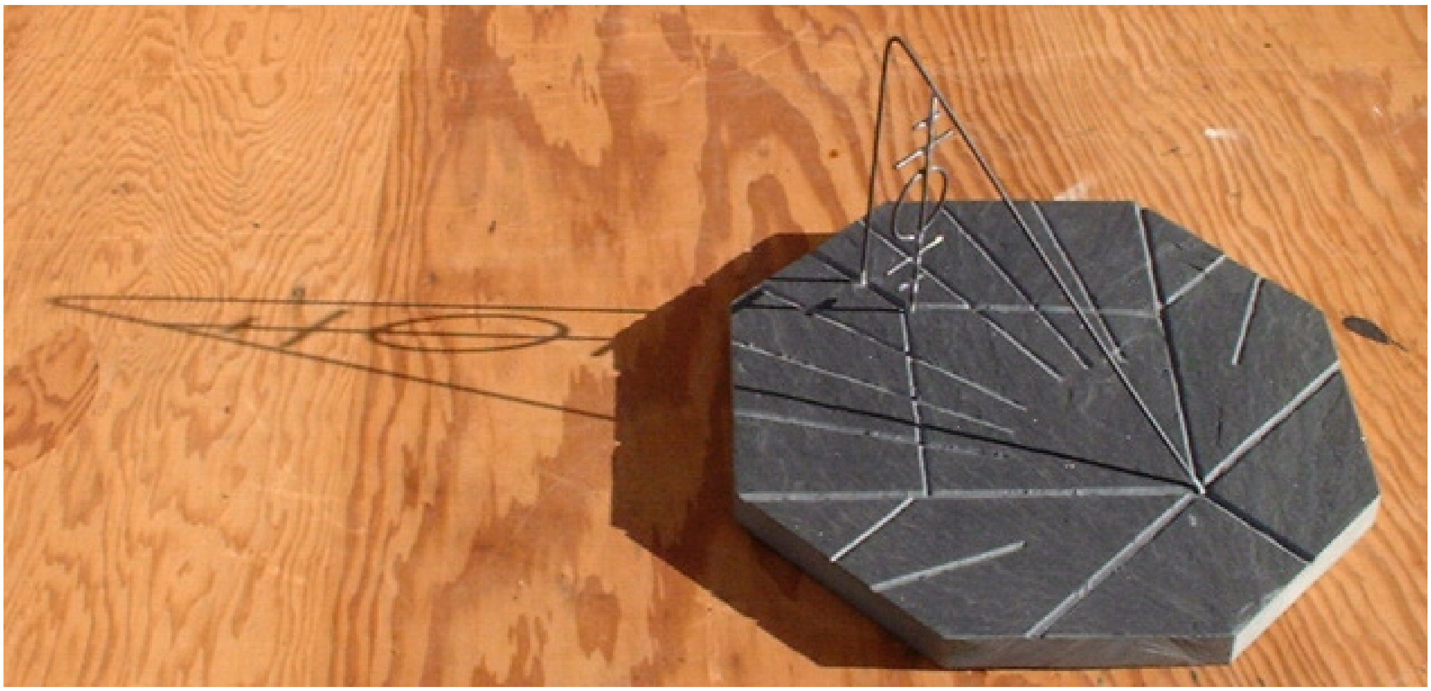
HOURS	min	PC (deg-min-sec)	TJ
XII / XI	-00/60:	00 - 00 - 00	
	-05/55:	00 - 45 - 32	
	-10/50:	01 - 31 - 05	
	-15/45:	02 - 16 - 42	02 - 16 - 41
	-20/40:	03 - 02 - 24	
	-25/35:	03 - 48 - 12	
	-30/30:	04 - 34 - 09	04 - 34 - 08
	-35/25:	05 - 20 - 15	
	-40/20:	06 - 06 - 33	06 - 07 - 10
	-45/15:	06 - 53 - 05	
	-50/10:	07 - 39 - 52	07 - 39 - 56
	-55/05:	08 - 26 - 55	
I / X	-00	09 - 14 - 17	09 - 05 - 19
	-05	10 - 02 - 00	
	-10	10 - 50 - 05	
	-15	11 - 38 - 35	
	-20	12 - 27 - 31	
	-25	13 - 16 - 55	13 - 16 - 54
	-30	14 - 06 - 49	14 - 06 - 48
	-35	14 - 57 - 15	
	-40	15 - 48 - 16	15 - 48 - 15
	-45	16 - 39 - 54	16 - 39 - 53
	-50	17 - 32 - 10	
	-55	18 - 27 - 07	
II / IX	-00	19 - 18 - 49	
	-05	20 - 13 - 16	20 - 13 - 15
	-10	21 - 08 - 31	
	-15	22 - 04 - 38	
	-20	23 - 01 - 38	23 - 02 - 24
	-25	23 - 59 - 35	
	-30	24 - 58 - 30	
	-35	25 - 58 - 28	
	-40	26 - 59 - 30	
	-45	28 - 01 - 41	
	-50	29 - 05 - 02	29 - 05 - 08
	-55	30 - 09 - 37	

HOURS	min	PC (deg-min-sec)	TJ
III / VIII	-00	31 - 15 - 30	
	-05	32 - 22 - 43	32 - 22 - 49
	-10	33 - 31 - 19	
	-15	34 - 41 - 23	
	-20	35 - 52 - 57	
	-25	36 - 06 - 04	
	-30	38 - 20 - 48	
	-35	39 - 37 - 12	
	-40	59 - 03 - 10	
	-45	42 - 15 - 14	
	-50	43 - 56 - 38	
	-55	45 - 00 - 34	45 - 00 - 33
IV / VII	-00	46 - 26 - 05	
	-05	47 - 53 - 34	
	-10	49 - 23 - 03	49 - 27 - 03
	-15	71 - 51 - 24	
	-20	52 - 28 - 07	
	-25	54 - 03 - 45	
	-30	55 - 41 - 28	
	-35	57 - 21 - 17	
	-40	59 - 03 - 10	
	-45	60 - 47 - 07	
	-50	62 - 33 - 05	
	-55	64 - 21 - 03	
V / VI	-00	66 - 10 - 56	
	-05	68 - 02 - 41	
	-10	69 - 56 - 12	
	-15	71 - 51 - 24	
	-20	73 - 48 - 08	
	-25	75 - 46 - 22	
	-30	77 - 45 - 46	
	-35	79 - 46 - 22	
	-40	81 - 47 - 54	81 - 47 - 56
	-45	83 - 50 - 14	83 - 50 - 19
	-50	85 - 53 - 09	
	-55	87 - 56 - 29	
VI / VI	-00	90 - 00 - 00	
Latitude		37.3739° =	37° 22' 26"

Notes About the Tables

- **Only those angles calculated by TJ that do NOT agree (to the second) are given in his list.**
- **The angles included with his letter are symmetric relative to Noon and increase both counterclockwise to 11,...,6AM and clockwise to 1,...,6PM, the latter equal to 90°.**

- **The angles presented in the accompanying table are given in conventional time with the AM times inverted to read in decreasing order, e.g. 11:55 AM is equivalent to 12:05 PM, etc.**
- **Nine (9) times differ by 1 second of angle, all of which are larger for the computer value. Given that there are six hours of 12 values per hour for a total of 72 entries then it is likely that 7 will have the least significant digit equal 5 and half of those will round up and half round down if rounding is performed, if it is not than 3 or 4 values could be expected to be in disagreement by one second, that there are more than twice that can't be accounted statistically!**
- **There are five slightly larger differences: one(1) difference of 2", one (1) of 4", one (1) of 5", and two (2) of 6" of angle, all of which are smaller for the computer value.**
- **There are four more significantly larger differences: one (1) of 37", one (1) of 46", and one (1) of exactly 4' 0" being a difference of 27'3" and 23'3" which inspection of the facsimile confirms it mostly likely a reproducing (copy) error and not a computational one.**
- **Finally there is one very large difference of 8' 58" at 1:00 o'clock. Since there is approximately 9 degrees difference between both 12 and 2 this largest error would introduce only a 1/60 (9'/9°) or one minute in time error at 1:00 PM.**



Construction of Jefferson's PF Dial

- **Associates (PhiAssoIrontO) of the Ebony Dungeon have sandblasted a 1 foot square 3/4" thick slate tile with the Hour lines given above. We had weathered it for two years and then hesitated to offer it to Poplar Forest because it was a "re-creation." Then a December 9, 2001 news story that Monticello spent $10000 to recreate another of Jefferson's sundial designs convinced us it was worth offering ours for free!**
- **By removing its four corners, the Sundial becomes an octogon corresponding to the perimeter design of the villa.**
- **Since the angles from Noon to 8AM and 4PM measure 46° 26' 5", their intersection at the foot of the gnomen forms a 93° angle which we have used to inscribe a square (almost perfect) whose corners further divide the dial into the four hexagons reflecting the floorplan of the villa.**
- **Thomas Jefferson gives no instructions for the design of the shadow casting gnomen. In our design of Suntiles®, we find that thin (3/32" diam.) brass rod makes a durable, easily fabricated and stoutly mounted gnomen.**
- **To further individualize the sundial, strengthen the gnomen, and make the shadow interesting, a style (vertical post) has been added with a twofold (front to back, bottom to top) design of a**

"P" sitting atop an "F".

- **It was our hope that Poplar Forest would accept a gift of the above pictured dial for display at the villa and that it will help to educate young and old on Mr. Jefferson's breadth, and his grasp and appreciation of science and mathematics. It is our pleasure to say that they accepted it on May 30, 2002.**

How Accurate Will The Sundial Be?

Apparent Solar Time

- **If we "set the clock" on the first days of Spring and Fall (Equinoxes) at 6AM when the sun rises and at 6 PM when the sun sets (on a clear horizon!) and every day take Noon to be when the sun is at its zenith, the time we keep is called "Apparent Solar Time." The accuracy of the Sundial then depends on how carefully we can observe the shadow.**
- **If it were square, the Sundial base would be 12 inches on a side. The minimum length (radius) of the shadow on the base would be 6 inches at 6 AM and 6 PM. But a practical length of the shadow would be at least 8 inches between 8 AM and 4 PM.**
- **At a distance of 8 inches from the foot of the shadow, it would take slightly more than a minute (67.67 seconds of time) for the shadow to move one millimeter. If we can watch the shadow move the thickness of a sheet of ordinary paper (500 sheets is about 25 millimeters (2 inches) thick then one sheet is one tenth of a millimeter) it would take just under 7 seconds.**
- **There are 90 degrees between 6 and 12 or 90 degrees x 60 minutes of arc per degree x 60 seconds of arc per minute of arc or 324,000 seconds of arc in 6 hours which means that there are 15 seconds of arc for each second of time.**
- **Thomas Jefferson calculated his lines to within one second of arc. If the lines could be drawn to his specifications they would be accurate to 1/15th of a second of time. With a shadow taking 7 seconds to move 0.1 millimeter than in 1/15th of a second it would move 0.1 millimeter per 7 seconds x 1/15 seconds or just about 1/100 of a millimeter.**
- **A fine human hair is 5/100ths of a millimeter, so we can conclude that this kind of precision is like splitting hairs.**

Mean Solar Time

- **After 1650 and the development of reliable mechanical clocks that kept constant time, every 24 hours lasted the same amount of time. Apparent Solar Time was found to run fast and slow over the year by a much as 16 minutes a day depending on the seasons.**
- **To smooth out these fluctations and keep agreement with mechanical clocks, Mean Solar Time was devised. To keep Mean Solar Time the sundial has to be corrected by adding or subtracting a given number of minutes (and seconds) for each given day of the year. This set of corrections is called "The Equation of Time," but it's not really an equation - it's a List which can be made into a Graph.**
- **The yearly list of numbers that make up the Equation of Time is actually approximate (to about one-quarter of a minute) because of leap year.**
- **The Sundial reads Mean Solar Time without correction (Equation of Time = 0) on April 15, June 14, September 1, and December 26.**
- **The Sundial runs fastest between April and June on May 14 and has to have 3min44sec subtracted, and between September and December on November 4 when16min23sec must be subtracted from its time.**
- **The Sundial runs slowest between December and June on February 12 when 14min20sec should be added to its time and between June and September on July 26 when 6min25sec must be added to give Mean Solar Time.**
- **In Jefferson's day these corrections could have been made to give a sundial accuracy to within**

1/4th of a minute anywhere in Virginia (or anyplace else) and a graph could be made by connecting these points on a timeline with a smooth rounded wave curve.

Standard Time

- **Had Mr. Jefferson lived another 50 years to the mid-1870's then his Dial and Mr. Clay's Dial would each have to have a different correction made to give correct "clock" time. Up until then, Mean Solar Time still measured the corrected Noon locally when the sun was at its zenith.**
- **Since the sun appears to travel east to west, Noon in Williamsburg at 76.75 degrees compared to Poplar Forest at 79.25 degrees west longitude had its Noon 2.5 degrees x (24 hours / 360 degrees) x (60 minutes / hour) or 10 minutes earlier.**
- **By the 1880's with the development of railroads and their time schedules it became necessary to adapt local time to regional time. Ultimately a clock system was adopted with 24 regions running east to west around the world between north-south lines of longitude 15 degrees apart. This time system is called Standard Time.**
- **For a Sundial to be corrected to Standard Time then its longitude had to be compared to the 15 degree intervals starting at the Prime Meridian at Greenwich England. For Virginia, the reference longitude was at 75 degrees. Then given Poplar Forest's longitude of 79.25 degrees or 4.25 degrees x 4 minutes / degree or 17 minutes later than Eastern Standard Time at 75 degrees. Thus when the sun is at its zenith and Noon on the Sundial on April 15 (zero equation of time correction) it will be 12:17 on the clock, but on July 26 (+6:25 equation of time correction) it would be 12:23:25.**

- Return to Ebony Dungeon's Art&Arch
- OR
- Go to Poplar Forest Sundial page

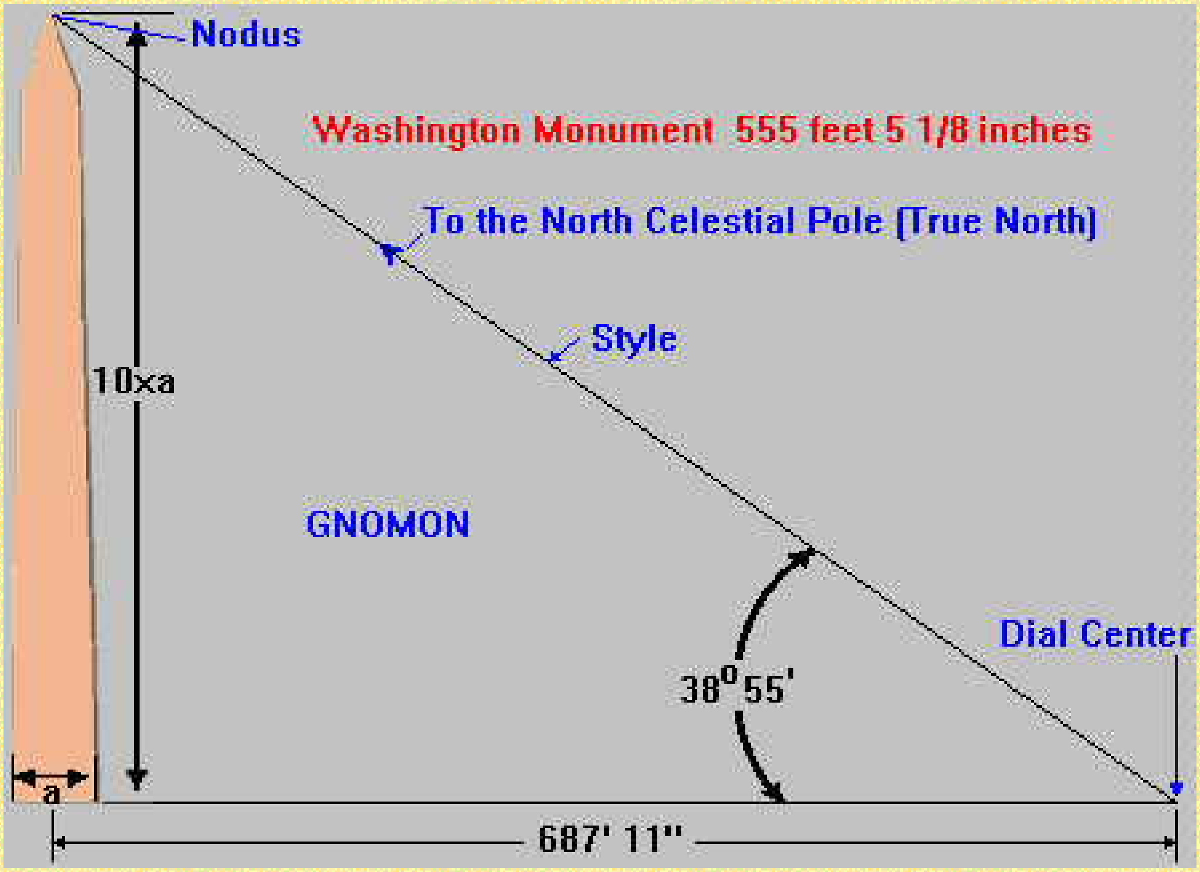
The Washington Monument as a Sundial

The above photo shows the Sun just behind the apex of the Washington Monument on the Spring Equinox (c) P.Field 1998

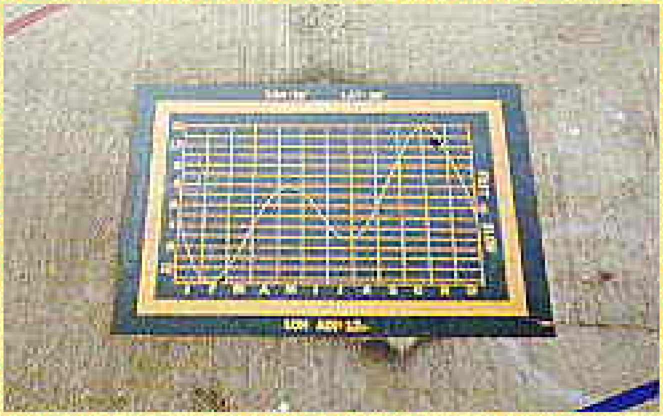
A nodus is a specific point along the *Gnomon* of a sundial. This specific point is usually used to show the declination of the sun on a sundial, or the zodiac lines. However the nodus can be used as the style of the dial.

Consider using an existing monolith (or obelisk) as the gnomon of a sundial. I believe that the Washington Monument (an obelisk) would make an excellent pointer for a sundial.

The diagram below shows how the Washington Monument could be utilized as the nodus of a **large** horizontal sundial.


Nodus
Washington Monument 555 feet 5 1/8 inches
To the North Celestial Pole (True North)
Style
10xa
GNOMON
Dial Center
38° 55'
a
687' 11"


Nodus



The dial pictured above is a horizontal dial which is painted on my patio. The nodus (labled) lies along a vertical support column. Let us imagine that the pictured brick column is the vertical Washington monument. As seen a dial can be constructed which will show the time.

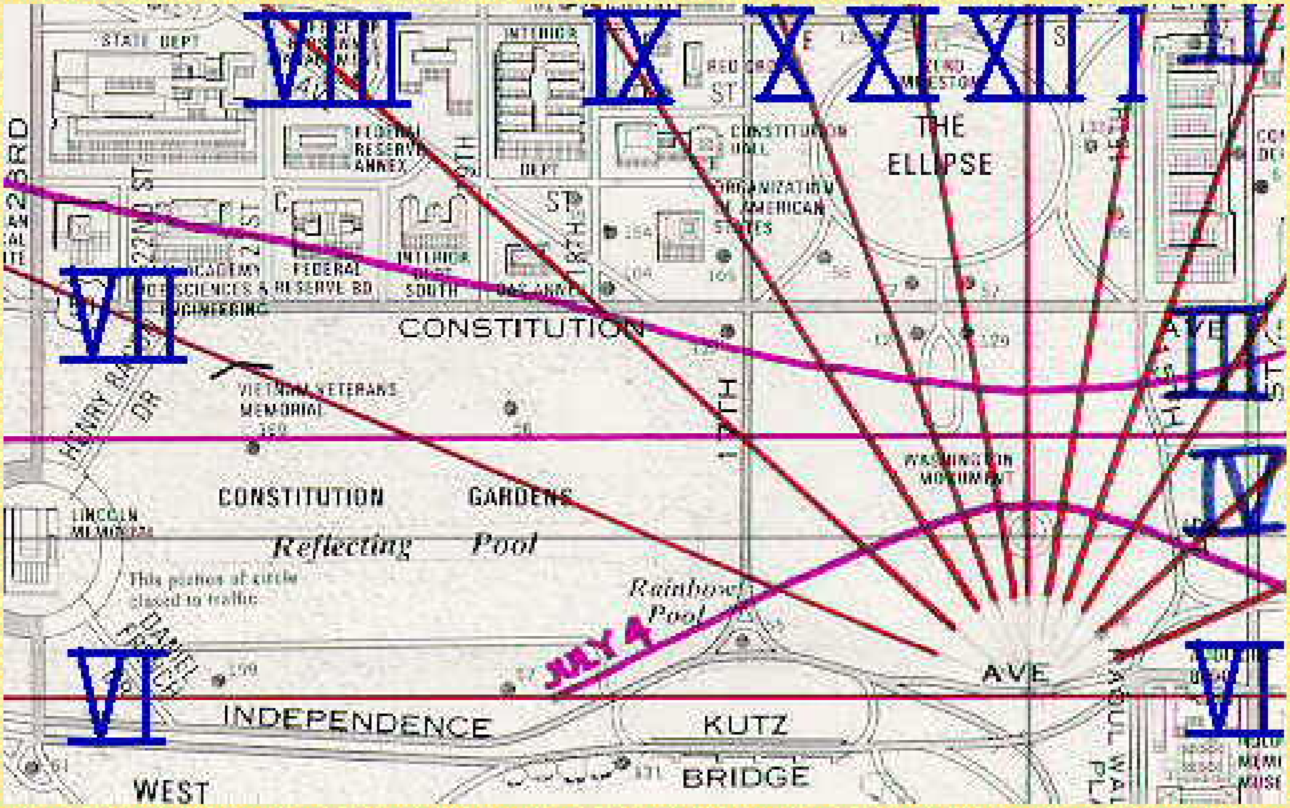
The picture below the dial is a close-up of the Equation of Time graph.

How Big will the Sundial be?

Let us calculate the distances from the base of the Monument to the maximum and minimum (and midpoint). If we use the Noon line, which would lie due North of the base of the Monument we find that on the Winter Solstice (the shortest "day" of the year) that the shadow would be 1060 feet, 1 3/4" from the base. On the longest "day" of the year (the Summer solstice) the shadow would be 153 feet, 10" inches and on the equinox(s) the length of the shadow would be 442 feet.

The Monument is about 687 feet from the dial center.

The map below shows the layout of the Washington Monument dial to scale. The declination lines are for the Fourth of July and February 22 and the Spring/Fall Equinox.



(c) 1998 P. Field I/O Asso.

What is an *Umbra*

A shadow has two parts, an *Umbra* in which the Sun is totally obscured and a *Penumbra* where the obscuration is only partial. We found that the Washington Monument has a *penumbra* that is rather large, thus detracting from the accuracy.

Page created by: abraxas2@ix.netcom.com
Changes last made on: *July 5, 1998*

die sonnenuhr für reutte

The Sundial for Reutte

latitude: 47°29'n longitude: 10°43'e

We propose a horizontal dial in the Isserplatz which uses an obelisk as the gnomon. The dial lines will be constructed by laying stone in a similar manner to that present in the Isserplatz. Granite will make up the hour lines and the date lines. Porphyry will be used as a background fill. The obelisk will be decorated with custom designed tiles that show various functions of the sundial.

For detailed information about the Horizontal dial click here.

For detailed information about the Obelisk click here.

For general information about Sundials click here.

This page accessed 1957 times.

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Page created by: Paul E. Field

Changes last made on: *August 6, 1998*

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sundial links

This page gives a comprehensive list of links to sundial related pages in the WWW. Usually new links are added on top.

Keywords: sundial (English), Sonwyser (Afrikaans), sa'a shamsiyya (Arabian[1]), Eguzki-erloju (Basque), slanchev chasovnik (Bulgarian[2]), rellotge de sol (Catalan), ri gui (Chinese[3]), slunecní hodiny (Czech), solur (Danish), zonnewijzer (Dutch), Sunhorlogho (Esperanto[4]), päikesekell (Estonian), aurinkokello (Finnish), cadran solaire / gnomon (French), Sonnenuhr (German), Heliako roloi / Heliako oroloio (Greek, modern[5]), dhupghadi (Hindi), napóra (Hungarian), Meridian (Indonesian), orologio solare / meridiana (Italian), hidokei (Japanese[6]), haesigye (Korean[7]), Eura da Suredl (Ladin), saules pulkstenis (Latvian), saul s laikrodis (Lithuanian), jam matahari (Malaysian), solskive / solur (Norwegian), sA'ate AftAbiy / sA'ate churschiydiy (Persian), zegar sloneczny (Polish), relógio de sol / quadrante solar (Portuguese), Sulagl (Rhaeto-Romanic), Cadran solar (Romanian), solnecnye casy (Russian), reloj de sol / cuadrante solar (Spanish), solur / solvisare (Swedish), suriya kadiharam (Tamil), günes saati (Turkish), suncani (Yugoslavian).

- Orologio Solare Equatoriale Armillare a Pisa (Italian and English version)
- SUNDI - sundial design program by Ivan Krastev
- Sonnenuhren - Ihre eigene Sonnenuhr für Haus und Garten (von Wolfgang Frolik)
- Stained Glass Sundials From Around The World (by David Bell and John Carmichael)
- Dasypodius - Association pour la Sauvegarde et le Renouveau des Cadrans Solaires en Alsace
- Sundial built using blacksmithing techniques (by David Cureton)
- Sundial with Mirror (by Gustav Biriell)
- Torreón Jardín Analemmatic sundial
- Da quando le meridiane? (by Giuseppe Ferlenga)
- Asociación de Amigos de los Relojes de Sol
- Meridiane in Friuli V. G. di Leonardo Comini
- Le meridiane di Giorgio Mesturini
- Astronomie und Sonnenuhren (page in German by Johannes Peters)
- Relojes de sol en Cádiz (España) por Paquita Vecina
- Precision sundials by Martin Bernhardt (german page, commercial)
- Photo albums of Hungarian sundials
- Relojes de Sol de Mallorca (page in Spanish by Juan Serra Busquets)
- El mundo de los Relojes de Sol en una página (page in Spanish by Juan Serra Busquets)
- 'sundial' at Wikipedia - The Free Encyclopedia
- Sundial Projects 1998 and 1989 (by Todor Todorov)

- L'arte della Gnomonica (page in Italian; incl. list of sundial mottoes)
- Paul Fieguth's custom sundial generator
- Meridia net (commercial)
- "Paper Plate Education" (includes sundials)
- Meridiane in Piemonte: le province di Biella e Vercelli (page in Italian by Gian Piero Ottavis)
- Accurate Sundials (commercial)
- The Time and Date Sundial - a simple, inexpensive, customised kit.
- Sundials by David Brown
- Analemma: Beautifully designed commercial site (in Dutch by H J Hollander)
- The Spectra Sundial by Artisan Industrials (commercial)
- Make your own Sundial (sundial in South Africa)
- Gnomonika Ltd.
- Phil's Sundial Webpages (by Phil Walker)
- Felix Solis Tempus (famous sundial shop in Basle, Switzerland by R. Felix)
- Buy a sundial (commercial)
- Relojes de Sol de Mallorca (by Juan Serra)
- Pagine di gnomonica di Michele Ferrarini (page in Italian)
- Bu te vítáni ve sv t slune ních hodin (page in Czech by Pavel Marek)
- La Nef Solaire de Tavel (one of the biggest sundials; page in French)
- Wie baue ich eine Sonnenuhr? (page in german by Klaus Strutzberg)
- Bestimmung der Tageszeit - Sonnenuhren (page in German by Kurt Scheuerer)
- 800 devises de cadrans solaires de Charles Boursier – 1936 (sundial mottoes, page in French)
- Cadrans solaires (French page by Jean-Yves Durand)
- Sonnenuhrenfreunde der Region Basel
- Construccion de relojes de sol (page in Spanish)
- Sundial by Christian Renonciat (1991) situated on the 'Place des Loges Coquault' (Reims, France)
- Sundial design by Simon and Roland Moroder
- Carte solari (page in Italian by Giuseppe Devito)
- Orologi Solari - Osservatorio Astronomico Serafino Zani incl. results of the contest "Shadows of time" (page in Italian)
- Cycloid Polar Book Sundial (by Edley McKnight)
- The Sundial - Metal has proven itself indispensible in telling the time...even before the invention of the watch
- Sundialman (by Nick Canfield, commercial)

- The Analemmatic Sundial at Keppel Henge
- M.J.Harley's Homepage for Sundials in Ireland
- Sundials of Distinction Inc. (commercial)
- Meine Sonnenuhren (page in German by Friedhelm Dietz)
- Almagest
- Mike Shaw's Sundial Page
- Newsgroup about metalworking (maybe useful for gnomonists making sundials on metal plates)
- Designing Sundials by MATLAB and MAPLE, by Keijo Ruohonen (download PDF or PS files)
- Lumbutts Sundial Photos Page
- Two attempts at a sundial
- Find sundial images with Google
- Sundial artist donates heliochronometer to Flandrau Science Center
- Sundials for the Connoisseur
- Artelitho - Sonnenuhren, sundials, Zonnewijzer (commercial)
- Sol Invictus - Faszination Sonnenuhr (commercial, page in German)
- Arno Ruckes Sonnenuhrengestaltung (commercial, page in German)
- Tragbare Sonnenuhren, Schmuck-Sonnenuhren etc. (commercial, page in German)
- Sundial at Griffith Observatory (Los Angeles)
- Perranzabuloe Millenium Sundial
- Sundials (by Brooke Clarke)
- Sundial Page (by David M.F. Chapman)
- Garden Expressions (commercial, by Steve Bradley)
- Sunlit Design - The Sun API, a DLL for calculating astronomical data concerning sundials (by David Pratten)
- Helios - Astronomische Uhren (high precision sundials by Carlo Heller, page in German)
- Orologi Solari & Meridiane (page in Italian by Enio Vanzin)
- Solaria (page in Italian by L.M. Morra e Fabio Garnero)
- Meridiane ed Orologi Solari di Giovanni Paltrinieri (page in Italian)
- artesolare: meridiane, orologi solari, quadranti, gnomonica (page in Italian by Roberto Finozzi)
- Orologi Solari (by Ugo Beccheroni, page in Italian)
- Almost 200 pictures of sundials & other astronomical clocks (by Peter Lindner)
- The inequalities of sundial time (A book on sundial theory, by Eilon Soroka)
- Ray's Page - sundials n stuff

- Sundial Construction using Mathematica
- Cadrans solaires en Queyras
- Sundial Sculptures (by John L. Carmichael Jr.)
- Quadranti Solari (page by Franco Martinelli, in Italian)
- Sundial in Bad Bevensen, Germany (page in german)
- SON Manufacturing Company (sundial compass etc., commercial)
- www.cadrans-solaires.org
- The first mirror-sundial in Bremen (by Reinhold Kriegler)
- The Spot-On Sundial - A new concept in garden sundials (commercial)
- Print Your Solar Noon Calendar
- Sundial site of Frans Maes
- Digital Sundials International (commercial)
- Gaffarel's Description of The Dial of Achaz, after R. Chomer (by James Eason)
- Präzisions-Sonnenuhr in Tholey (page in German)
- geometrische Sonnenuhren-Konstruktionen (page in German, by T. Gebhardt)
- Introduction into sundials (page in German)
- Epact: Scientific Instruments of Medieval and Renaissance Europe
- Collection of Sun Maps / Sun Clocks in 2 and 3 dimensions (Java applets), showing day and night on earth
- Arachne - Die Sonnenuhr am Untermarkt in Görlitz (1550) (page in German)
- Inscription in Pompei concerning a sundial built by Sandilianus and Epidianus
- Accurate Standard-Time Sundials (by Roy Maltby)
- Sonnenuhren - Zeitmessung mit Hilfe der Sonne (page in German by Andreas Hänel)
- Augustonemetum (sundial mottoes in Latin and French)
- Heavenly Mathematics: Highlights of Cultural Astronomy (by Helmer Aslaksen)
- Vermont Sculpture (sundials and sun-aligned sculptures of Kate Pond)
- Flowton Dials - Sundials and reproduction scientific instruments (by John Davis)
- Summaries of the journal of De Zonnewijzerkring (Dutch Sundial Society)
- AstroMedia
- The Astrolabe - An instrument with a past and a future
- Precision Sundials LLC (by Bill Gottesman)
- Reloj Andalusi (page in Spanish)
- Sundial Park in Genk, Belgium (page in Dutch)

- Derbyshire Sundials (by Peter Daykin)
- Analemmatic sundial at EcoSuperior in Thunder Bay, Ontario, Canada
- Le Mont Solaire
- Cadrans Solaires du Queyras (by Olivier Thizy)
- Perl script to generate a sundial drawing in PostScript
- Fabriquer un cadrans solaire (page in French)
- Cadrans Solaires (incl. link to download the software CadSol)
- Hand-carved stone sundials by Harriet James
- Sundial on the Atelier Acacia, at the old casern buildings in Mont-Dauphin (Haute Alpes, France)
- Merdienne on the front of the school of Serres (Hautes Alpes, France)
- Relojes de Sol de la Región de Murcia (España)
- European Navicula Sundial, 15th Century
- Cadrans Solaire (lycée de Mulhouse)
- Official page of SUNWATCH3D and to the world of the design of the sundials
- sundial at State University of New York, Binghamton
- Penn State University armillary sundial
- large sundial in Pekin, Illinois
- memorial sundial at Drake University
- how to use a heliochronometer
- shepherd's dial
- University of Kentucky sundial
- archaic Celtic cross in the cemetary area near the Gallarus oratory near Kilmalkedar, Ireland
- Paul Manship sculpture "Cycle of Life -Armillary Sphere"
- sundials on NASS tour, Hartford Connecticut, 1999
- armillary dial at Heritage Plantation, Sandwich MA
- elegant equatorial dial at the planetarium, University of Nevada, Reno
- another picture of equatorial dial at University of Nevada, Reno
- Sundial of the Dow's Planetarium in Montreal
- sundial on the site of the former Quebec Astronomical Observatory
- Sundial on Terrasse of Quebec Parliament
- Professor Sanchez's sundial on the campus of Laval University, Quebec
- Sundial in the Interior walls of the Séminaire de Québec
- Norlin Sundial at the University of Colorado, Boulder.

- Sundial in the Forbidden City, in Beijing.
- About the Measure of Time -- two dials pictured, one with Italian hours
- dial by Thomas Tompion, at Hampton Court Palace in London
- multiple dial, now located in the carpark of a hotel near Ironbridge, Shropshire, England
- cubical dial, Italian hours
- German string-gnomon sundial, circa 1680
- Horologium in Smith's Dictionary of Greek and Roman Antiquities (pages by Bill Thayer)
- Sonnenuhren - Software und LINKs (by Helmut Sonderegger)
- Sundial at Branford day care center
- Interior Sundials (commercial)
- Java-animation of a sundial designed for a house in Damongo, Ghana
- Meridiane in Canavese (by Mauro Basiglio)
- Gnomonics - The history, art and science of sundials (by Riccardo Anselmi, pages in English and Italian)
- Solis et Artis Opus (page by Mario Arnaldi)
- Gnomonica (by Marco Rossi)
- Gnomonica - Meridiane e Orologi Solari (page by Rosa Casanova)
- ArsGnomonica - Orologi Solari - Progettazione e Restauro (page by Antonio Giorgi)
- Gianni Ferrari's Meridi@ne
- Quadranti Solari (by Diego Bonata)
- La Gnomonica (by Fabio Garnero)
- The Nova Scotia Sundial Trail (by Steve Lelievre)
- The equinoxes and solstices
- Making a sun clock
- Building a simple sundial
- horizontal sundial design for Fairbanks, Alaska
- sundial at New Mexico State University, Las Cruces, NM, USA
- pillar dial (formerly) in garden of Nelson House, Virginia
- memorial sundial for scoutmaster Mike Mitchell, Troop 14, Newport News, VA
- horizontal sundial (and motto) at University of Virginia
- armillary sphere at University of Virginia
- The Saxon sundial at St. Gregory's Minster, Kirkdale (~AD 1055)
- The Aldbrough Sundial (East Yorkshire)

- statue "Pan with Sundial" (restoration), University of Pennsylvania, Philadelphia
- Sundial at the Washington State Capitol, Olympia
- Sundial at Mount Vernon, Virginia (home of George Washington)
- Jan Oort Next to a Sundial modeled after a radio telescope
- equatorial Sundial in Forbidden City, Beijing
- Prince of Dials Sundial at Jantar Mantar Observatory
- 1753 Sundial (two faces) Colonial Centre, Santo Domingo, Dominican Republic
- Sundial at Fortaleza, the Governor's Mansion in Old San Juan, Puerto Rico
- Sundial at Butchart Gardens, Victoria, BC
- Swedish polar sundial
- column dial at Princeton University
- dial in Paris
- sundial at Tai Mo Shan Rotary Park, Hong Kong
- sundial overlooking Althing,Thingvellir National Park, Iceland
- Class of 1911 sundial, Mediterranean Garden, San Diego State University, CA
- sundial at Colorado Rocky Mountain School, Carbondale CO
- bronze and granite sundial, Vancouver, BC
- 1580 sundial, Town Hall, Wroclaw, Poland
- Physics Department, University of the Pacific, Stockton, CA
- The Pinawa Heritage Sundial
- Simulation du cadran solaire (by Gérard Baillet)
- Mean values of declination and equation of time of the sun over the period 2000-2099 (by Thibaud Taudin-Chabot)
- Sundials (an introduction about sundials, by Frans W. Maes;
- Search the MacTutor History Archive (e.g. sundial)
- Calendrical and Astronomical Links
- Time Standards
- JavaScript calculator to obtain equation of time, horizontal coordinates of the sun, local sidereal time etc.
- Sonnenuhren - Unterrichtshilfen (pages in german, by Ludwig Engelhardt)
- Sundial site by 'Colors of India'
- A place where larger files from the sundial mailing list are stored (thanks to Dave Bell)
- sundials (by Giuseppe Viara)
- Marble Times

- The Universal Pocket Sundial (commercial)
- SunVial (commercial page)
- Different types of sundials as PostScript files (by John Hoy)
- Sundials (Field Navigation, Jaipur Observatory, Saint-Syr Sur Loire)
- La grande meridiana di Santa Maria degli Angeli
- Garden Expressions - Sundials (commercial)
- Public sundial sculptures in Philadelphia
- 2 monumental meridians and 1 polar dial as sculptures by Stephen Luecking
- Sonne, Zeit und Ewigkeit (page in German, by Johann Jindra, Austria)
- Sonnenuhren by Malermeister Christian Kumhofer (page in German)
- Sundials in Umbrian
- Korean celadon Sundial (sundials in Korea)
- Equatorial and Capuchin Sundial as PostScript files
- Eclissi e meridiane (observation of an partial eclipse at S. Maria degli Angeli in Rome)
- The National Millennium Sundial - Te Ra Tu (The Standing Sundial)
- Armillary sphere at Mystic Seaport, CT
- sundial with three satyrs, S. Mary Grace Burns Arboretum, Lakewood NJ
- Hours and Unequal Hours (by Nicholas Whyte)
- "Child sundial" at Missouri Botanical Garden
- sundial at Toronto City Hall
- Sundials in Berlin and Around (English)
- Vertical dial in San Carlos CA
- class of 1877 dial on campus of U. C. Berkeley CA (last photo)
- An original Russel Porter SunClock
- Cadrans solaires de Bretagne (by Jean Paul Cornec, page in French)
- Histoire de la mesure du temps (by Francis Lagardesse, page in French)
- NASS on the Net - The North American Sundial Society
- Lindisfarne Sundials (by Tony Moss)
- Almost 200 pictures of sundials & other astronomical clocks (by Peter Lindner)
- Saunders & Cooke - Fine Hand Crafted Antique Re-Creations (commercial)
- sundial page by Angelo Brazzi (in Italian)
- The revenge of the altitude solar
- Gunning Sundials

- 7+1 Sundials at the Robert Doisneau lycée in Vaulx-en-Velin
- "SUNCLOCKS" - Human Sundials
- Analemma - an extensive explanation (by Bob Urschel)
- Obeliscus Augusti (pages by Bill Thayer)
- Horologium Augusti (Geodätisches Institut der Universität Karlsruhe TH)
- Le Champ de Mars: l'Horologium Augusti
- Théorie sur le cadran solaire bifilaire vertical déclinant (par D. Collin)
- Harris Morrison's web site for Shepherdswatch portable sundials
- Gnomonica - Meridiane e Orologi Solari (page in Italian)
- Sundial on a chip
- Of Analemmas, Mean Time, and the Analemmatic Sundial (by Frederick W. Sawyer III)
- A sundial page (by Patrick Powers)
- Zonnewijzer (by H. van Winkel, page in dutch)
- Sonnenuhren von Wolfgang Frolik
- Another link to the Mars sundial
- Sundials for the Connoisseur (by Silas Higgon)
- Sundial Sculptures of Stone and Brass (by John L. Carmichael Jr.)
- sundial cannon
- Sundial Building, New Bedford, MA
- clay sculptured sundials
- the great sundial of Santa Maria degli Angeli
- church sundial, Jausiers
- Sundials at Augsburg (Germany)
- East Tytherton sundial
- Arkansas Sesquicentennial Sundial
- second picture
- Sun tower at Gullett Elementary School, Austin, TX
- Sundials (in China, India, South Tirol) at the AstroGallery
- Sundial at Justice Center, Hunterdon County NJ
- Vertical dials at Palladio's Villa Barbaro at Maser, Italy
- Vertical dial on church in Cornwall
- Sundial at University of Limerick
- Build A Pennsic Sundial

- Sonnenuhren in Österreich / Sundials in Austria
- Richard D. Swensen Sundial (now with web cam!)
- Deutsche Gesellschaft für Chronometrie e.V. (German society for chronometry, includes a link to sundials/Sonnenuhren, page in German)
- The Mars Sundial
- Burmingham Friends sundial
- Live cam on sundial at Pembroke College, UK
- Wenger Sundial
- Il tempo vero degli iblei (sundials of Sicily, page in Italian by G. Bellina)
- Great Circle Studio's Sundial Generator
- Great Circle Studio's Solar Calculator
- The sundial for Reutte
- high precision sundial at Technisches Gymnasium in Kirchheim/Teck, Germany (page in German)
- St. Peter's Cathedral, Geneva; German dyptich dial
- curriculum unit -- "science and the sun"
- Urbana IL high school "Merging Science and Art" sundial project
- Harvard School of Education: observation-based curriculum project
- Harvard School of Education: sun and sundial resource page
- "old quadrant" in Museum of the History of Science, Oxford
- The Team Disney Sundial and the Florida Solar Energy Center
- Download 'The Dialist's Companion'
- article about Jaipur - Jantar Mantar (both in English and in
- Swiss Society of Chronometry, SSC (including an english version)
- "Sundial of Human Involvement", Wellington NZ
- Sundial in front of the planetarium in Berlin (page in German)
- Haym Kruglak Sundial at Western Michigan University
- Portable Sundials at the Manor House Museum, Bury St Edmunds
- Kentucky Vietnam Veterans Memorial Sundial
- Sundials at the Deutsches Museum, Munich
- Societat Catalana de Gnomònica
- Sundial pages by K.P. Cheung (Hong Kong)
- Armillary Sundials by New England Garden Ornaments
- Sun dial plate (London) found at York Factory, Canada

- Some sundials by Piers Nicholson
- Universal Ring Dial by Ames Instrument Company
- The Event Inventor - Sun Fun
- Production of the Richard Swenson Sundial
- Sundial at Fort Oranje, St. Eustatius (Dutch Caribbean)
- Books, Photos & Sundials, Ireland
- Antique Pocket Sun Dials and Pocket Watches
- Sample Worksheet: Sundials (Project: Primary Physics)
- Schoolyard Human Sundial (Needham, Massachusetts)
- Analemmatic sundial, Riverwalk, Augusta, Georgia
- Grand Army of the Republic Sundial, Des Moines Iowa
- A "Sun Clock" at Kochi Castle, Japan
- Travelsundial for Europe: for hiking and beach (page in German/English-commercial)
- Gothic Gardening: Potpourri - Moondials and Nocturnals
- Relógios de Sol
- Queens' College Dial (includes a virtual dial as a Java applet)
- Sundials at Radnor Forge
- Welcome in the world of the sundials - Philippe Langlet
- Colonial Brass SUNDIALS (commercial)
- Suntiles
- Moon Calendar
- Startime Sundial
- Bob's Sundial Page
- L'orologio di Augusto
- Merlin Design - Etchers in Brass (commercial)
- East Harima Hidokei no Oka
- L'Osservatorio Astronomico di Monte Porzio Catone
- GNOMONICA - Meridiane e Orologi Solari - sundial
- Gruppo Astrofili Piceni: Orologi solari
- Les excursion d'un Grand Optimiste - Cadrans solaires
- Digital Sundial by Scharstein et al., U.S. patent 5,590,093
- Gnomonique par Yvon MASSE (French)
- Some Early Dutch Sundials

- Startime sundial
- Reproduction 1750 Sundial Compass (commercial)
- Sunwatch Uhri (commercial)
- Arbeitsgruppe Sonnenuhren des Österreichischen Astronomischen Vereins (page in German)
- The Kirkdale Sun-Dial
- Kenneth Lynch & Sons
- Sundials & Moon Discs
- SunPath Designs: construction of outdoor sundials as functional works of art
- De Zonnewijzerkring (The Dutch Sundial Society)
- The famous software ZONWVLAK for download!
- Method to compute flat sundials
- Construction of hemispherium
- Pictures of Sundials in the Netherlands
- UAI - Sezione Quadranti Solari
- Sonnenuhren in Bremen und umzu (sundials in Bremen, Germany)
- La Commission des Cadrans solaires du Québec
- Mass dials
- Sundial Computations (by Slawomir K. Grzechnik)
- The equation of time (scientific approach)
- Sundials on the Internet
- Introduction to sundials
- Types of sundials
- How to set up a horizontal sundial
- The Equation of Time
- How to join your national sundial society
- *Books in print
- *Bibliography of journal articles on sundials
- Sundial mottoes
- Sundial designers and makers
- Robert Terwilliger's Homepage
- Sun Canon Club
- The Geometry of War, 1500-1750
- Basic program to design a vertical sundial

- Sundial - TBM Solutions
- Sundial Astronomical Calculations (SAC) - Optimal Solutions
- "About Time" - engravings from computer-generated files for sundials etc.
- Sundial at Hong Kong University
- sundial in StarTrek TNG episode (page in German)
- sundial in the bible, 2 Kings, Chapter 20 (literal in German part only)
- sundial at the public observatory in Mainz (page in German)
- Gnomonica: La Lunga Vicenda Degli Orologi Solari (page in Italian)
- Compass with pocket string sundial
- Augustus' sundial
- The sundial of Sheikh Bahai
- Musee des arts et metiers (list of 174 sundials, page in French)
- History of Astronomy (University of Bonn)
- Sundials in Berlin
- Sundial at the University of Washington
- Jack Aubert's Sundial Page
- The College of Engineering at Cornell University
- CLOCKS and TIME by Gordon Uber
- Sundials
- Sundial Organizations
- Sundial Mailing List
- Sundials by F. J. Britten
- A Brief History of Time - From Thales to Callippus
- Wholesale Nutrition - Sundials
- The Sundial Building
- The Adler Planetarium & Astronomy Museum (General)
- Mount Laguna Observatory Sundial
- Bob's Sundial Page
- Sundial by Bernard Droege
- Horology - The Index
- NAWCC - National Association of Watch and Clock Collectors
- catalog about sundials in Germany and Switzerland (page in German)

edit

---

[1] Graphics by Peter Herkenrath (Cologne)

[2] Graphics by Todor Todorov

[3] Graphics by K P Cheung (Hong Kong University), please also visit his page.

[4] Graphics by Yvon Massé (Pontoise)

[5] Graphics by Angelo Valtzis (Cologne)

[6] Graphics scanned from the cover of Vol. 1, No. 1 of the Journal of the Japan Sundial Society

[7] Graphics by D H Kim (Seoul)

Thanks to all the contributors for the links (especially to Steven Woodbury, Frederick W. Sawyer III, and Bill Thayer for their continuing submissions)!

If you know of other interesting links to pages in the WWW concerning sundials, please send a mail to roth@infraroth.de (Daniel Roth). Then I can include it here.

---

to the homepage

The Universal Ring

A WebRing for sites that promote Sundials, Astrolabes and other ancient scientific instruments.

A WebRing is a collection of sites that share a common interest. When you are a member of a ring "surfers" can easily find other sites that share the same topic. For more information about WebRings Click Here!

Sites qualifying for membership into the Universal Ring should have content related to astronomy, sundials, astrolabes or other ancient scientific instruments. If your site contains more than just links on one or more of these topics, please apply!

To be accepted into the Universal Ring there are a few things that you will have to do:

1: Apply for admittance!

2: Download the 2 graphic files (RINGLOGO.JPG [8158 bytes], and NEXTUNI. JPG [5888 bytes]) and add these files to your homepage directory. DO NOT attempt to link to the Universal Dial homepage for these graphics.

3: Add the below HTML code to your homepage, make changes where they apply (addresses et al).

4: E-Mail me to let me know that the above has been completed.

Below is the HTML code that you must add to your page: (Copy/Paste/Edit):

<center> <font size=3> <img src="_THE_RINGLOGO_GRAPHIC_HERE_" align="left" width=136 height=67> <a

```
href="http://www.webring.org/cgi-bin/webring?ring=universalring;id=_SITE_ID_HERE_;next"
target="_top"> <img src="_THE_NEXTUNI_GRAPHIC_HERE_" align="right" width=70
height=70></a> This <a href="http://www2.netcom.com/~abraxas2/univrsal.htm" target="_top">
Universal Ring</a> site is owned by <a href="mailto:_SITE_OWNER_EMAIL_"><font
size="2">_YOUR_NAME_HERE_</font></a>. <br><br> <font size="3"> Want to join the <a
href="http://www2.netcom.com/~abraxas2/univrsal.htm" target="_top">Universal
Ring</A>?</font> <br><br> <font size=3> <b> [<a
href="http://www.webring.org/cgi-bin/webring?ring=universalring;id=_SITE_ID_HERE_;sprev"
target="_top">Skip Prev</a>] [<a
href="http://www.webring.org/cgi-bin/webring?ring=universalring;id=_SITE_ID_HERE_;prev"
target="_top">Prev</a>] [<a
href="http://www.webring.org/cgi-bin/webring?ring=universalring;id=_SITE_ID_HERE_;next"
target="_top">Next</a>] [<a
href="http://www.webring.org/cgi-bin/webring?ring=universalring;id=_SITE_ID_HERE_;skip"
target="_top">Skip Next</a>] [<a
href="http://www.webring.org/cgi-bin/webring?random;ring=universalring"
target="_top">Random</a>] [<a
href="http://www.webring.org/cgi-bin/webring?ring=universalring;id=_SITE_ID_HERE_;next5"
target="_top">Next 5</a>] [<a
href="http://www.webring.org/cgi-bin/webring?ring=universalring;list" target="_top">List
Sites</a>] </b> </font> </center>
```

The editing required in the above HTML code is:

- Change _THE_RINGLOGO_GRAPHIC_HERE_ to the address (and name) of the ringlogo graphic (Example http:// . . . /ringlogo.jpg).
- Change _THE_NEXTUNI_GRAPHIC_HERE_ to the address (and name) of the NextUni graphic (Example http:// . . . /nextuni.jpg).
- Change _SITE_OWNER_EMAIL_ to your E-mail address.
- Change _YOUR_NAME_HERE_ to your name.
- Change the six _SITE_ID_HERE_ to your site ID number (see below).

After you apply you will receive E-mail from WebRing.org. This E-Mail will have enclosed your URL data and your site ID number. Use this in the above listed HTML code where you are asked for id=**_SITE_ID_HERE_**.

Here are the two graphics you will need:

Right click, save image, DO NOT RENAME, then upload to your homepage.

Since this WebRing is addressed to Sundials,Astrolabes et al, I feel it is neccessary to use the Universal Ring dial as a name, logo and pun.

The above HTML code and graphic images will show on you page as shown below.

This Universal Ring site is owned by P.R. Field.

Want to join the Universal Ring?

[Skip Prev] [Prev] [Next] [Skip Next] [Random] [Next 5] [List Sites]

Page created by: abraxas2@ix.netcom.com

Changes last made on: *January 30, 1998*

WebRing News

- Be a Supporting Member
  - Surf ad-free!
  - Create a WebRing homepage!
- News 7 January, 2004
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more...

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Howard Dean
George Bush
Wesley Clark
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- [www.artpromote.co.uk]
- [Pauline Brothers and Sisters]
- [WebRing Minions]
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more...

Top Rings

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- Yu-Gi-Oh ! Webring
- The KiSS DollRing
- Acclaim's Re-Volt WebRing
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- DOS Games Ring
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- The Live WebCams Ring
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View system traffic here.

Health & Wellness

Fitness, Support

Science

Astronomy, Biology, Pets

Sex & Romance

Singles, Relationships

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View WebRing's Adult Content Policy

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Notice: We collect personal information on this site.

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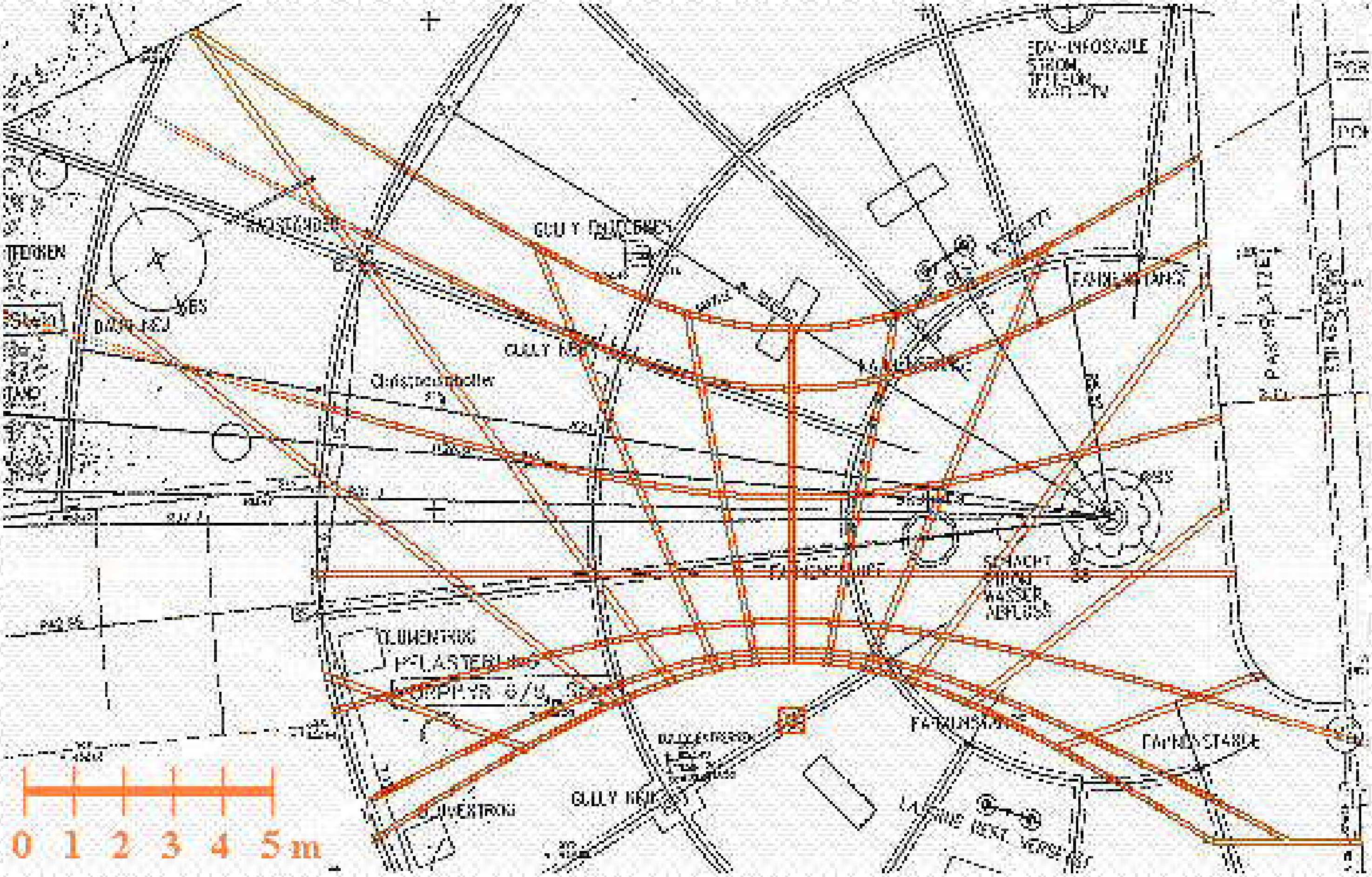
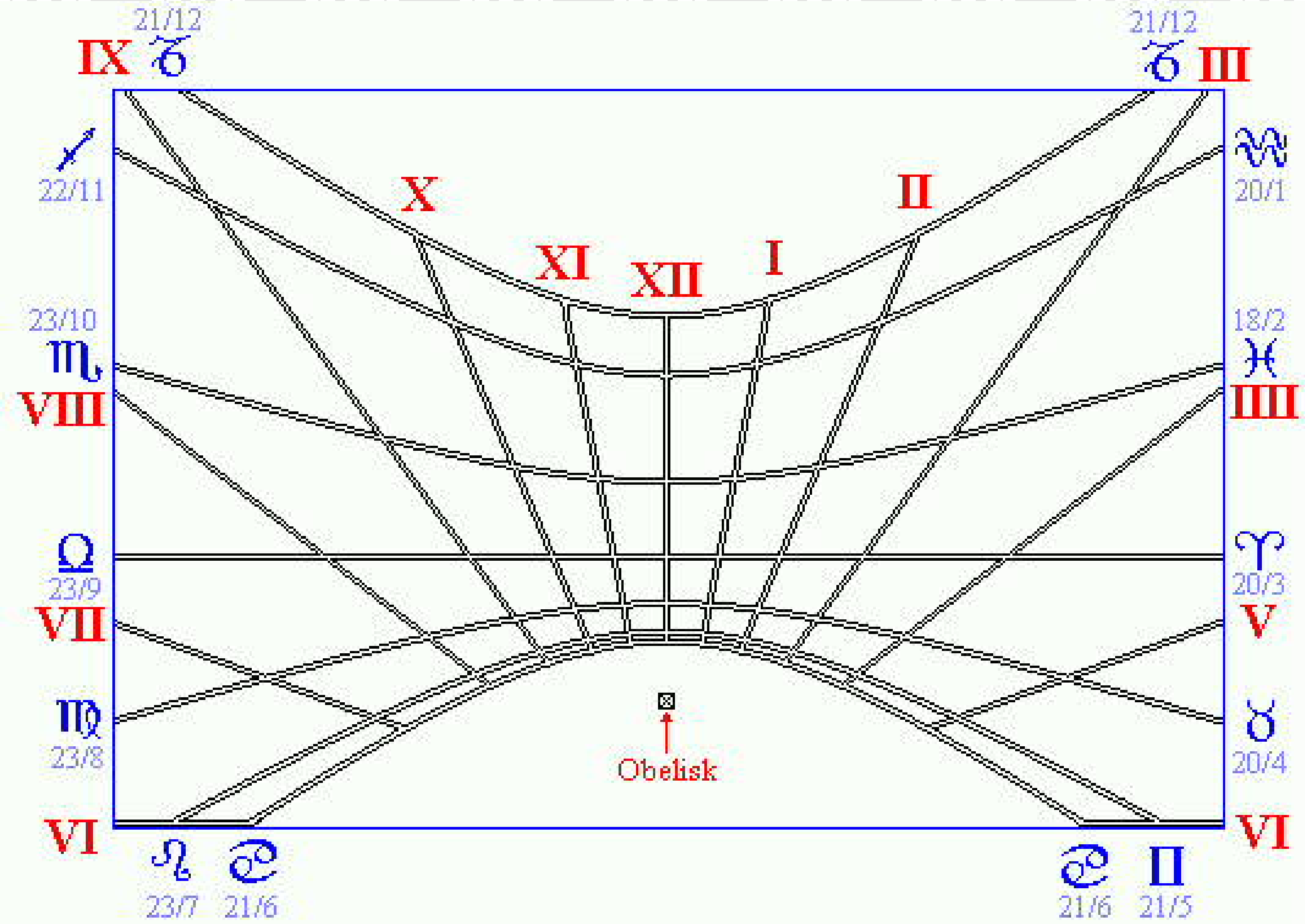
The Horizontal Dial for the Isserplatz

The detailed map of the Isserplatz shows how the proposed Horizontal Dial would be laid out using the 25 x 6 cm Granite stones to form the white hour and zodiac lines and relaying the 8 x 8 cm Porphyry stones to form the red field. The position of the 2.73 m tall tiled Obelisk to be constructed as the perpendicular Style having a 13 cm sphere mounted as the Nodus of the Dial is shown in both figures on this page. It is described in detail on the accompanying page.



The Dial in Detail

The labeling of the hour lines and monthly (solar declination or zodiac) lines are shown in the following diagram.



For information about the obelisk click here.

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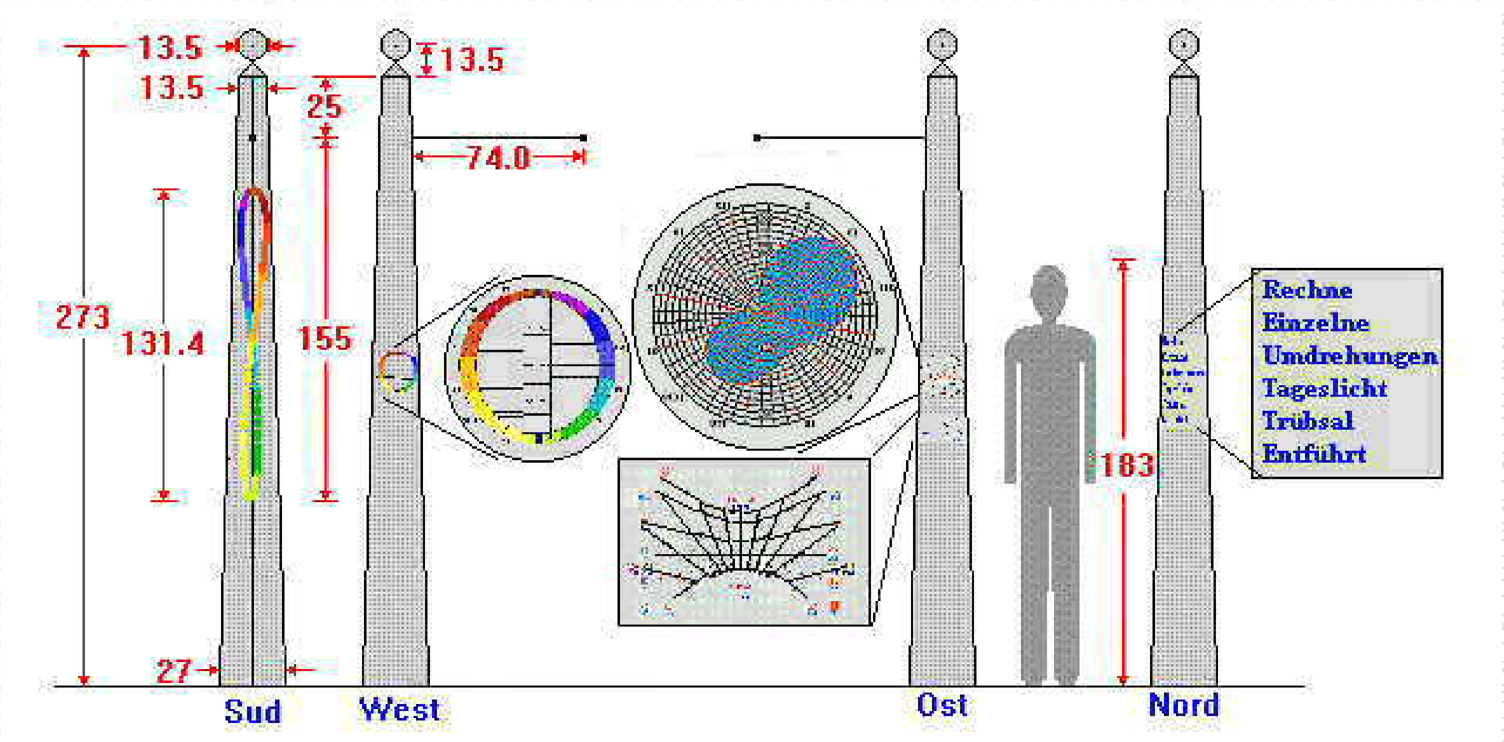
Changes last made on: *September 2, 1998*

The Obelisk for the Horizontal Dial



Dimensions are given in centimeters.

Each side of the Obelisk faces one of the principal compass directions and is designed with a unique time-related function, to be made from custom ceramic tiles adhered to the monument.

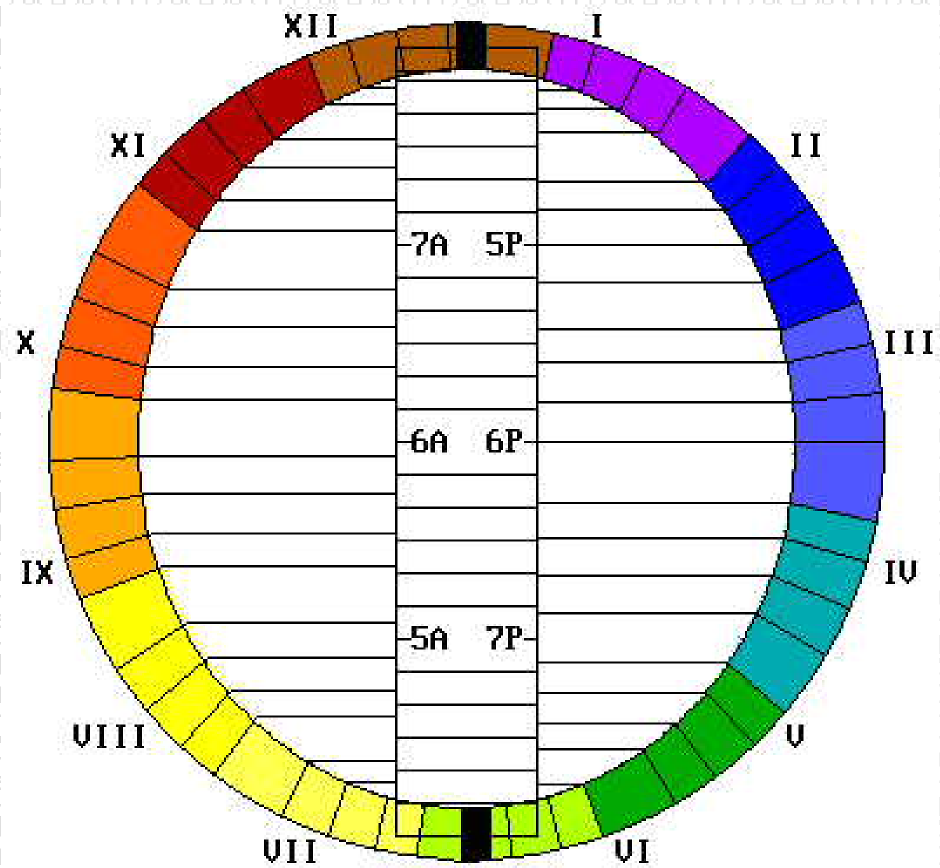
The South Face

has a vertical reclining Noon Analemma to show the correction for the Equation of Time or how many minutes the Sun is ahead or behind the Mean Time. When the shadow of the tip of the style (Nodus) aligns with the appropriate seasonal line-segment of the figure Mean Time Noon may be noted on the Horizontal Dial from the shadow of the Obelisk. A model obelisk of the same dimensions but with a Noon Analemma for 37.25 degrees latitude is shown.

[Return to Obelisk Views]

The West Face

has an original I/O (Greek letter PHI) design from which the A.M. time of Sunrise and the P.M. time of Sunset can be read for each day of the year with marks for the first four weeks of each month (1st, 7th, 14th, and 21st). The months are distributed around a circle like the hours of a clock. The inner ellipse gives the length of daylight to an accuracy commensurate within a few minutes/day by doubling the time of sunset. Each space on the center scale marks a 10 minute interval. On March 21st (Spring Equinox) the sun rises and sets exactly at 6:00 o'clock. On March 31st, one might estimate Sunrise at 5:42 A.M. and Sunset at 6:18 P.M. The length of day would be 12 hours and 36 minutes.



[Return to Obelisk Views](#)

The North Face

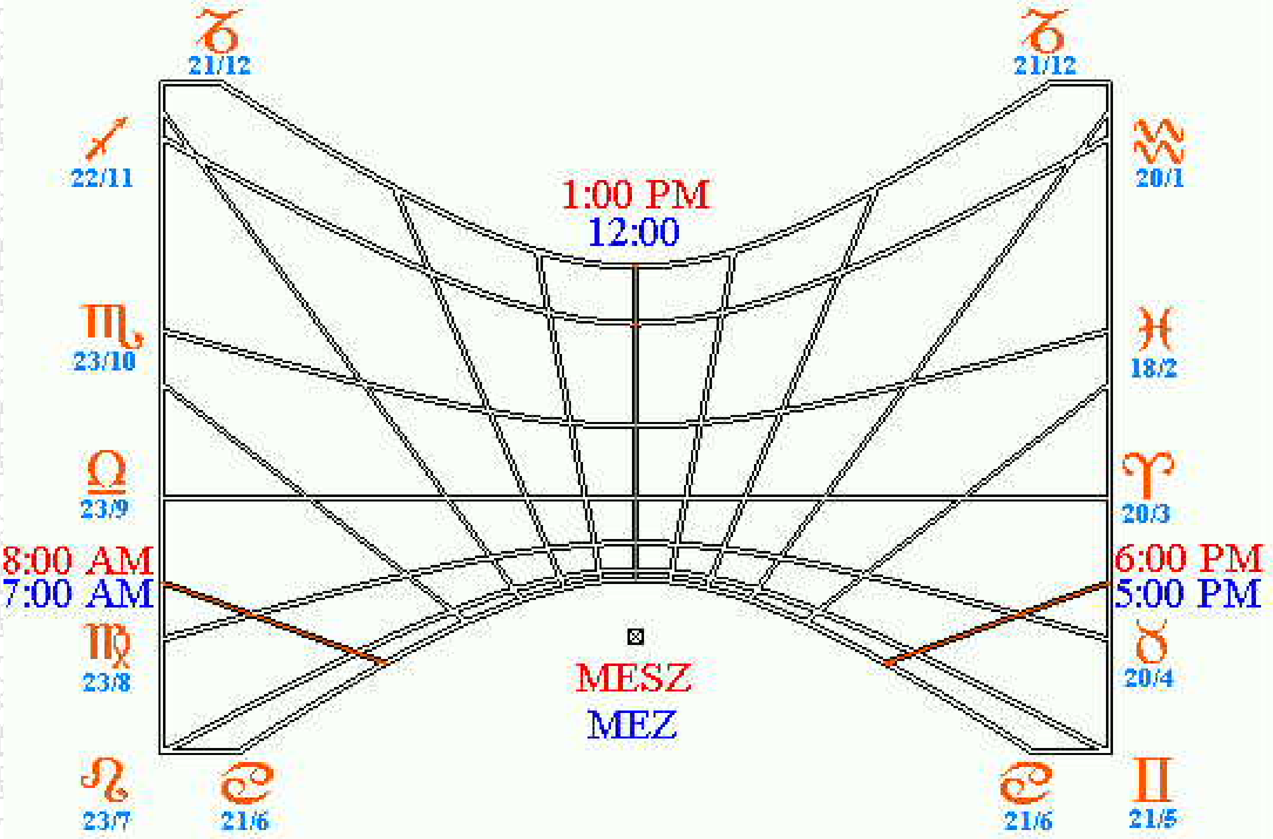
bears a Sundial Epigram on Time in the form of an acrostic (the initial letter of each line) spelling the name of the town.
REUTTE ACROSTIC

- Rechne
- Einzelne
- Umdrehungen;
- Tageslicht
- Trübsal
- Entführt.
- A free translation in English would be:
  - Count rotations one by one;
  - Daylight carries off gloom.

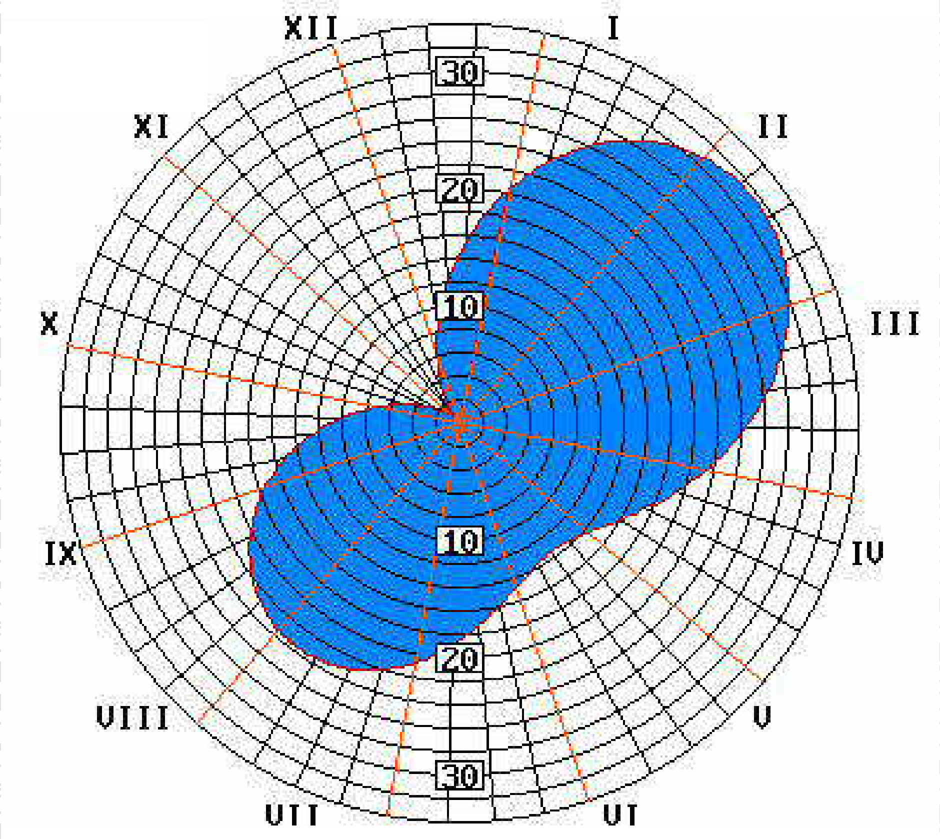
[Return to Obelisk Views](#)

The East Face

illustrates how to read the hour lines and the month (zodiac) lines of the sundial laid out on the Isserplatz. It also shows the observer the adjustment between Middle European Time and Middle European Summer Time.



In addition, this face includes information on the Longitude adjustment and the correction for the Equation of Time presented on an I/O original graph designed especially for Reutte. The graph can be read for each day of the year with marks for the first four weeks of each month (1st, 7th, 14th, and 21st). The months are distributed around a circle like the hours of a clock. The vertical scale gives the number of minutes where the date radius intersects the figure which are added to the sundial time (Sun time) to convert to the Local time (Earth time). For example, on April 14, 17 minutes would be added to Sun time to determine the correct Earth time, while on October 14, an addition of 3 minutes is required to correct the Sundial reading to the proper local time.



[Return to Obelisk Views](#)

Construction Recommendations

- Position and stability of the base of the obelisk are critical. Reinforced steel rods embedded in the foundation base to rise the height of the obelisk should be considered. Concrete casting of the obelisk in place should precede relayment of the pavement for precise positioning of the hour and declination lines. A bolt to mount the sphere to the top of the pyramid should be encased in the top of the obelisk shaft. The pyramid itself can be free formed around the bolt. Note that the height of the pyramid is one-half of its base width: this so-called *golden pyramid* having the ratio of the sides for the triangle intersecting the corner edge equal to the the square roots of 1(height) : 2(base) : 3(edge).
- Custom-made tiles can be produced from molds carved in dampened plaster of Paris forms which when dry are filled with clay slip. On hardening, the (greenware) tile must be biscuit fired in a kiln. The bisque tile can then be painted with glaze and refired. The glazed tiles can be mounted with commercial adhesive and grouted with any other commercial tiles in any design configuration desired: standard rectangular, cut and patterned, or broken for a random free-form layout or any combination desired for an attractive, bright and colorful display. Tiles used in the graphical displays can have thin lead caning inserted in the grout lines to form black graph lines.

[*Return to Obelisk Views*]

For information about the Horizontal Dial click here.

To return to the Home page click here.

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- News 7 January, 2004
  - pop-up ads are gone!
  - User directory coming!
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January is Mars exploration month, Hot Tea month. The perfect thing to warm yourself after skiing or snowboarding.

Or, try Wine Tasting if the tea doesn't warm you up.

Hot Rings

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Jan 4th-10th

It's Football playoff time!
4th Trivia Day.
8th Postal Day.

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George Bush
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- The Panorama Format
- Pagan/Gothic/Wiccan Shops and ...
- Artists with Teddy Bears
- Frauen, die Webrings moderiere...
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- imaginings
- the kitty realm webring

more...

Top Rings

- Vacation Travel
- Yu-Gi-Oh ! Webring
- The KiSS DollRing
- Acclaim's Re-Volt WebRing
- Midi Ring
- DOS Games Ring
- PICmicro WebRing
- The Live WebCams Ring
- Original Writing WebRing
- The Corsetorium

more...

WebRing Numbers

December 2003:
2.8 million unique visitors
26 million hits
49,600 Rings
915,000 **active** Sites
575,000+ registered users
6,500+ contributing members .
View system traffic here.

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Investments, Industry

Computers & Internet
Internet, User Groups

Cultures & Community
Issues, Seniors, LGB

Entertainment & Arts
Movies, TV, Books

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Singles, Relationships

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making a sundial | sundial types | links 'n' stuff

sundial pictures

This is mainly a site about sundials............all the information you need to make a sundial that *works*,.....
.......pictures of sundials that I have seen and like, some that I've made,....
......an outline of some of the types of sundial that can be made,...... and some links to relevant pages,.......
.... and, in 'links 'n' stuff', maybe a few irrelevant 'indulgences' like pictures of places that I like to "be".
You're very welcome to email me on this 'sundials 'n' stuff' if you feel like it.

Click on any of the four topics above .

E-Mail me: *HERE*

Note:- Remove "SPAM" from email address for posting

Go to Home Page
Go to "Making a Sundial" page
Go to "Types of Sundials" page
Go to "Pictures of Sundials" page

On this page:

1 LINKS: Here're a few links to other sundial sites that I've found interesting. They, in turn, will lead you to many others if you're still 'fired up' about sundials.

2 OTHER STUFF: Well, I guess if you've waded through my site to this point, it's probably OK for you to see who wrote it, and some of the places that I find good to 'be'. There's a handful of photos here that I'll add to and change from time to time.
This constitutes the 'light entertainment' end to my site.... :)))) .... and good luck with your sundial.

Some links to sundial pages on the Internet

- **Sundials on the Internet**:A large site on sundials on the Internet. Start here!! .
- **L'atelier tournesol** : some good images of sundials...(French language!.
- **Sundials by Jack Aubert**:history,types and construction details
- **The equation of time**:an 'in depth' explanation'
- **Sundial links**: a lot of links on sundials.
- **Sonnenuhren**: a page in German by an active promoter of the sundials on the Internet, Daniel Roth.
- **Horology**: to learn more on the time and its measurement.
- **Greenwich 2000**: about the zero meridian and Greenwich history.
- **The time of the Internet**: the Time of any kind and in any place in the world.
- **Bob's Home Page**: Bob Berring gives facility to dial calculation and excellent explanations about sundials
- **Shadows Home Page**: "PC" download sundial creation programme
- **Making a Horizontal Sundial**:.
- **Cambridge Astronomy**:Some further reading on sundial theory and practice.
- **Montana Uni Solar Physics**:Sun related insights at high level

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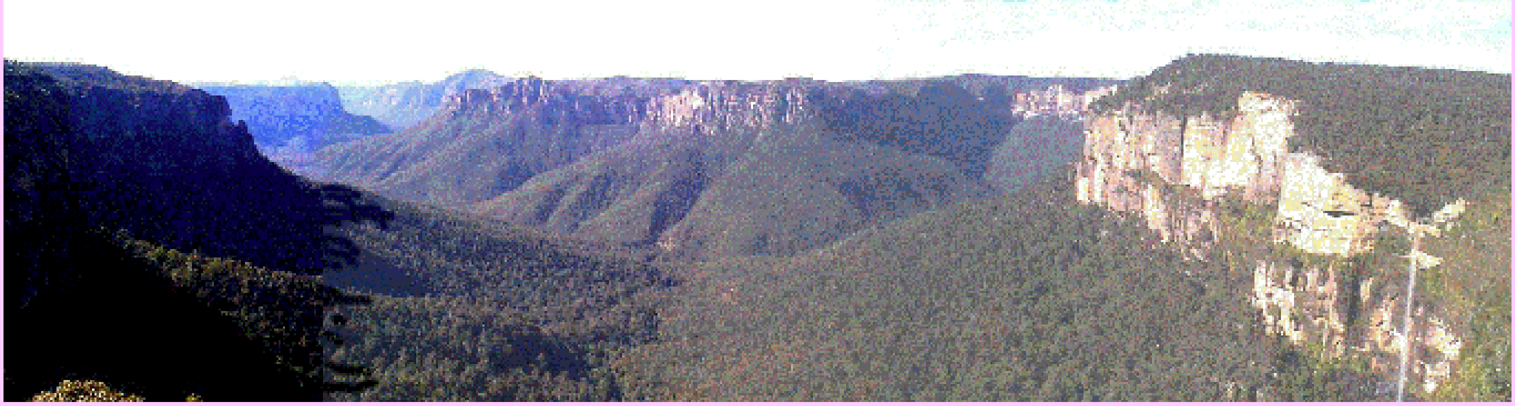
Other Stuff

The following are just a few 'snaps' that I thought I'd put in.....The 'self indulgent' bit, I guess!! :))..... Just some places and stuff that I like. Let me know if you like any and I'll show some more....... especially of the coasts and forests where I like to go....

This first picture is taken in the 'Blue Mountains' west of Sydney. The valleys of this dissected plateau are spectacular and there are innumerable bushwalks, at all levels, along tracks through the forests.

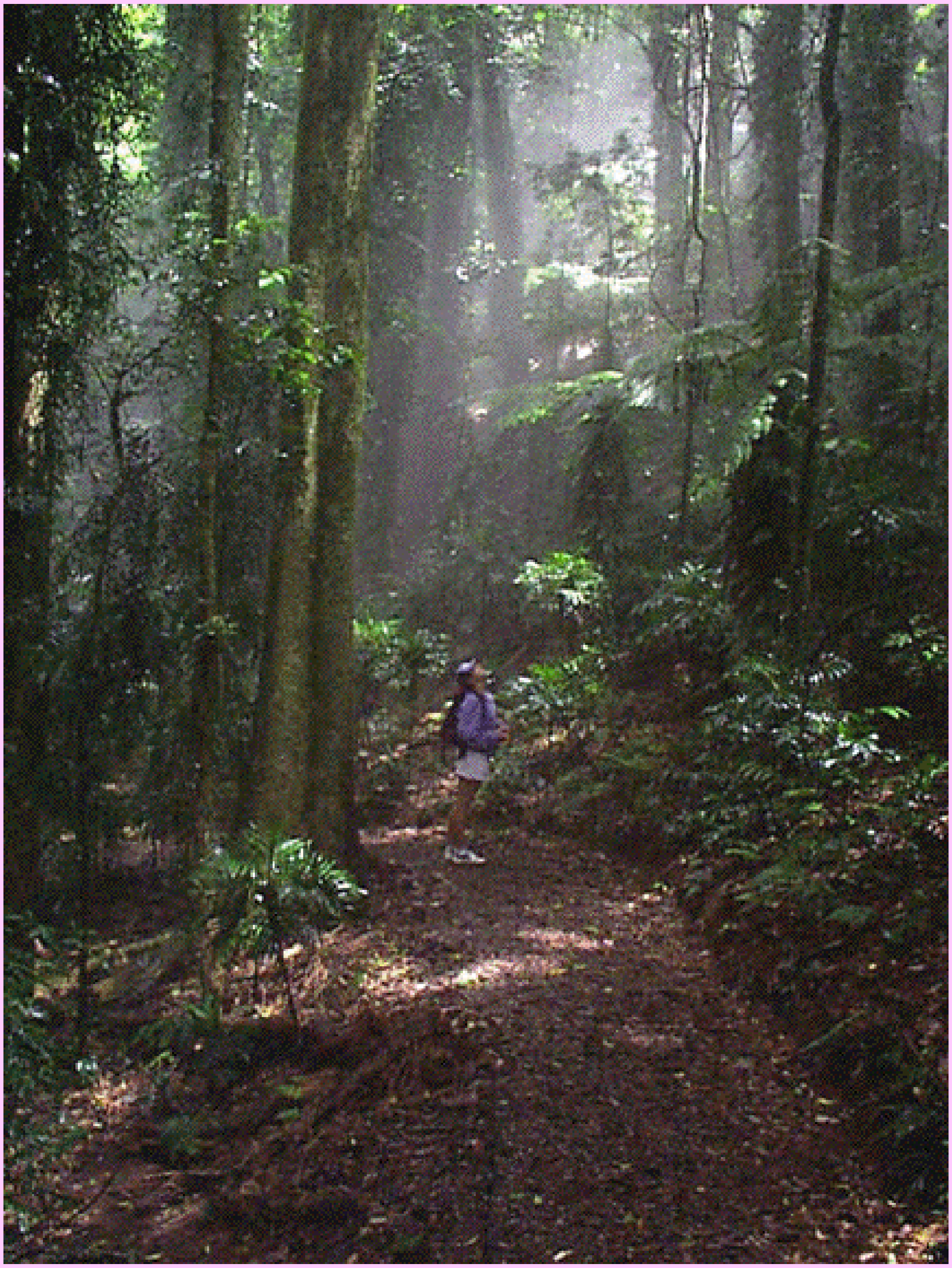
Blue Mountains, NSW... "Govett's Leap".



Dorrigo is on the eastern edge of the New England plateau, NSW. Well watered and forested, this is replete with scenery such as the next three photos show. It's one of my 'special' places.

Dorrigo , NSW. "Wonga Trail"

Dorrigo , NSW. "Wonga Trail"



Dorrigo , NSW. "Wonga Trail"

These are the "Crystal Falls" down in the valley where the Wonga Trail leads. There is an overhang and large cave behind the falls. .... Just _so_ good!

near Dorrigo , NSW. a little creek to rest along and " ... be !'

"Griffith Lookout", NSW

Not far from Dorrigo, looking south along the Eastern Highlands

Wollomombi Gorge , NSW.

This gorge is about 45kms east of Armidale, NSW

The next piccies are taken on the Central Coast of NSW.

Central Coast, NSW. "Waves"

When the sea is 'up', "wave watching" is OK!

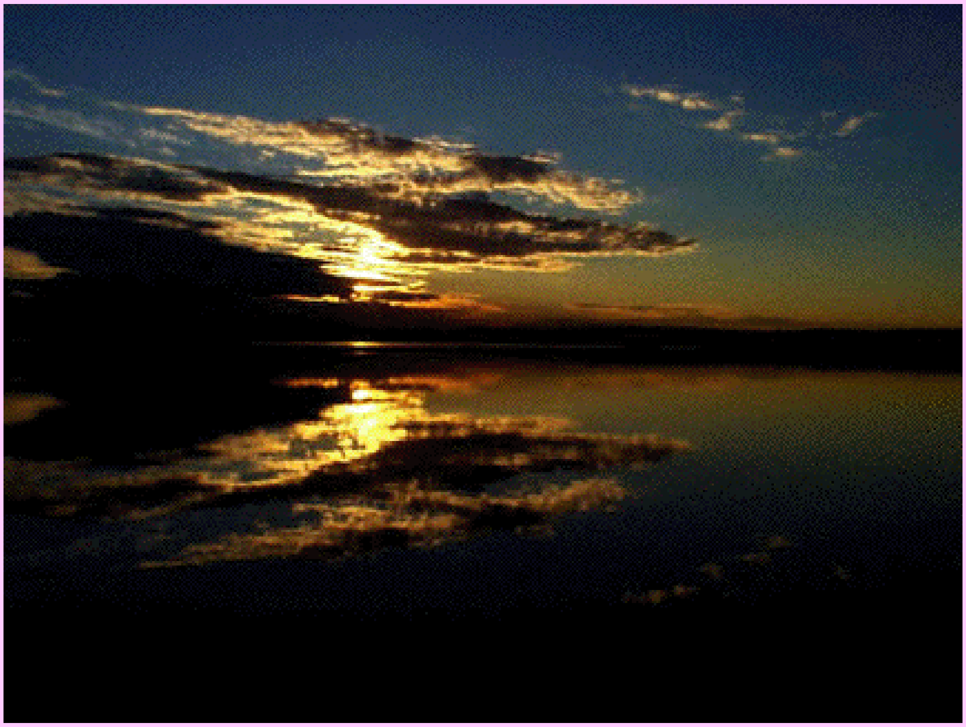
Looking North from Norah Head towards Wybung Pt.

Wybung Point. I ride a mountain bike to here, often. And , yeah, that's me!!! You could see this 'point' in the last piccie.

Wybung Point , NSW.

This is 'Sunset" over Tuggerah Lakes, Central Coast, NSW....... and the end of this little 'indulgence' of showing some piccies of places I like......... There are _so_ many. Maybe I'll show some taken in the Barrington Tops area later on..... and there're many others. But, for the moment, I'm running out of my ISP's allocated 'workspace' .... Hey, this started out as a Website giving some insights into Sundials........:)) ..... And then I go and get out the Photo's....... Happens all the time, doesn't it!!

'Sunset', Tuggerah Lakes, NSW.



"Work like you don't need money.......Love like you'll never be hurt.......

.................And dance like no one's watching.".......

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Go to "Pictures of Sundials" page

Types of Sundials.

This is just a very brief outline of some of the possibilities for sundials. Within just these, the scope for individual expression is infinite. You will find examples of all when you look through the links.

The noon mark sundial is perhaps the oldest. Examples go back thousands of years! The noon mark signified the time for events in the market square, religious ceremonies and time for dinner at old farmhouses. An extension of the noon mark is to mark out the sequence of noons, indicated by a shadow from a fixed object, on your floor or flat area that gets the daytime sun. You can start this today at your place! Over a year the pattern of dots so formed will display a figure of eight pattern ..i.e. ... an analemma. To this figure can be added dates, celestial phenomena, seasons.....and this will be accurate for the place for which it is made.

The horizontal dial(the construction of which I have given detailed instructions in "Making a Sundial") is perhaps the most ubiquitous. It can installed on a small column in a garden or engraved on the floor or patterned in the pavement. Its gnomon (style) faces toward the celestial pole. The straight lines radiating from the gnomon point give the hours and the half-hours.

A vertical direct north sundial is a vertical sundial which faces directly toward the North (replace with south for the northern hemisphere). This type of sundial is one of the most common types of sundials found on the walls of houses and churches. The end of the gnomon points toward the ground, the gnomon being parallel with the axis of the Earth.

Declining sundials are sundials whose orientation is not necessarily toward the south or north. Some of them face the east or west or even away from the sun. A vertical direct east sundial, for example, faces directly toward the East. The vertical direct east sundial can only show the morning hours from the sunrise until local noon and vice versa, the vertical direct west sundial faces directly towards the West. It can only show the afternoon hours from the local noon until sunset. There are also SW and SE decliners and NW and NE decliners nominating the general direction that the dial faces.

Then there are the reclining and inclining sundials that are placed on sloping surfaces.

My favourite, as maybe you found from my comments regarding the magnificient cast bronze sundial in Sydney's Botanic Gardens in the pictures of sundials,
is the Armillary Sphere, a sundial derived from the celestial globe frameworks

of ancient astronomers. There are photos of some of ones that I've made in the 'pictures of sundials'..... In its simplest form, it is simply a meridian ring aligned to the latitude and containing the gnomon which is parallel to the earth's axis and points to the celestial pole, and an equatorial ring which is parallel to the equator and contains the hour marks. The various abbreviations of these rings (as my own examples show) allows for an infinite variation of craft.

Lastly there are the portable dials which preceded pocket watches. There is a magnificent portable Universal Ring Dial shown in the pictures of sundials page.

More information and illustrations of all these dials can be found through the links page. And Albert Waugh's outstanding manual, " Sundials, their Theory and Construction" (ISBN 0-486-22947-5) discusses them all, too, together with construction details. If you're keen, this book is excellent! But there is also comprehensive instruction given on some of the linked pages.

Go to Home Page
Go to "Making a Sundial" page
Go to 'Links 'n' Stuff
Go to "Pictures of Sundials" page

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Pictures of Sundials

These pictures are added to give a few ideas...a bit of 'inspiration' for you to have a greater look at sundials. There are many more pictures in the links. Sundials from all over the world! The following are just a few that I thought I'd add, especially the first one....... and there's a few Armillary Spheres that I've made, too.

My Favourite Sundial

Royal Botanic Gardens, Sydney.

This sundial is an 'armillary sphere'. Sure , all the other dial types have a place, but the sheer 'presence' of this dial is awesome.
Whenever I go down to Sydney... one of the world's most
beautiful cities!... I always 'take a break' in the Royal Botanic Gardens. Here is
an "Oasis' of tranquility and immense pleasure right in the 'hub' of the city centre.
And, in the gardens, is just one of many ' special' areas. This part is the 'herb garden'.
One can sit and knock over a few 'munchies' and 'something ' to drink, escape from

the hustle and bustle of city life, soak in the fragrances of the myriad of herbs........ and ,
there, central to this part is this magnificent sundial cast in bronze.
The attached plaque tells that it was designed by Margaret Folkard and John Ward,
drawn by Marion Westmacott, sculpted by Karin Rumpf, and cast by David Mune's
"Art Foundry". Quite a team, eh? It stands about 8 feet high . It has examples of Australian flora
and fauna cast into the rings.......... and the 'feel'. .... One can't resist running one's
hands over the form of this oustanding piece of functional sculpture to 'soak in' the good 'vibes'.
And, functionally, it is 'spot on' with a plate showing the equation of time for people
who know what you know! If you ever go to Sydney......... see this!

---

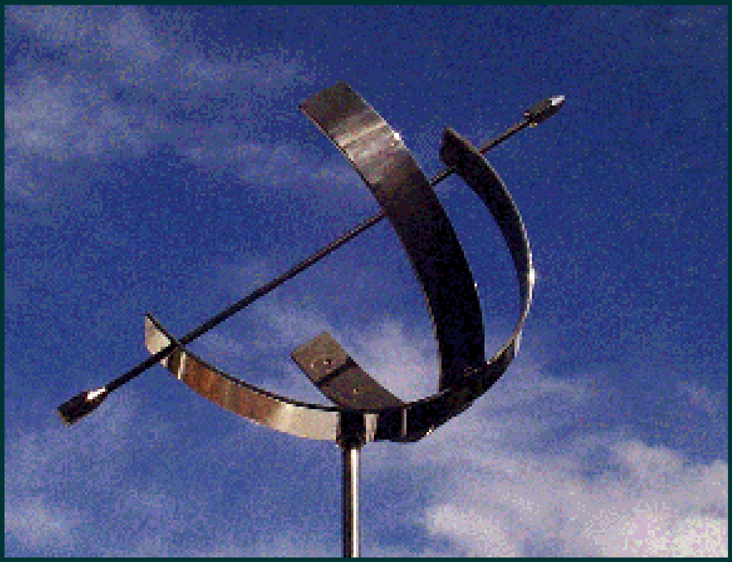
1. **Some of my Sundials**

These are a few of the 'armillary spheres' I've made.

Brass with time plate... 21cms diameter,

'Aged' Copper....23 cms diameter,

Stainless steel..24cms diameter,



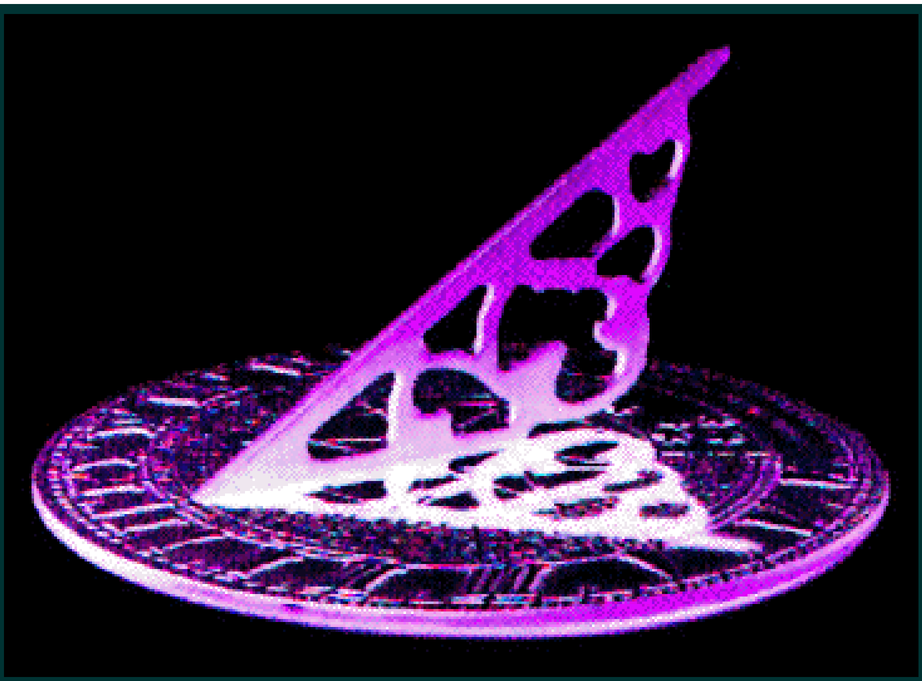
a Brass 'Desk Dial'....10cms diameter,

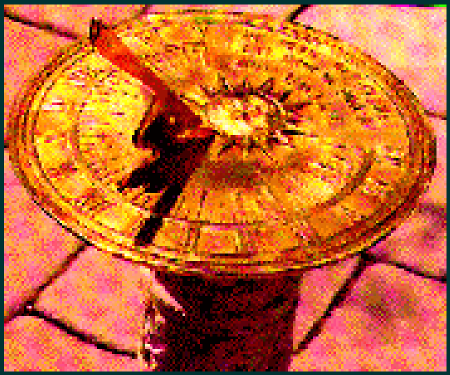
a copper 'Flat Dial'....26cms diameter.

This was constructed from the directions given in 'making a sundial'.

2, **Horizontal flat sundials**

These are just a few examles from my picture collection of horizontal dials that might give you some ideas for the construction I laid out in 'making a sundial'. As they are just 'clippings' I have collected, I can't say who or where.... but isn't the first one a beauty!.... Engraved brass set on green marble!





a Portable "Universal Ring Dial"

I'll add some more pictures as I get them, or make more dials. You'll find many more in the 'links' section.

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