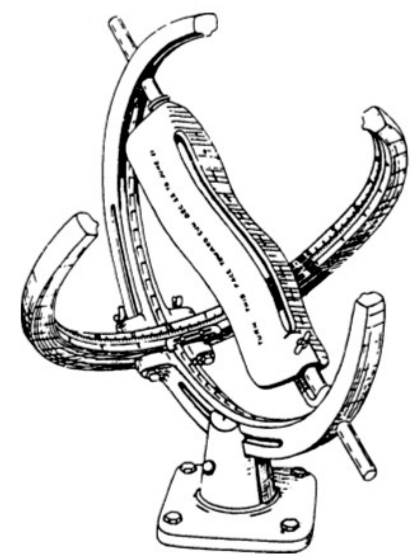
Assembly and Operation of the Scale Model Schmoyer Sunquest Sundial



Drawing by R.L. Schmoyer

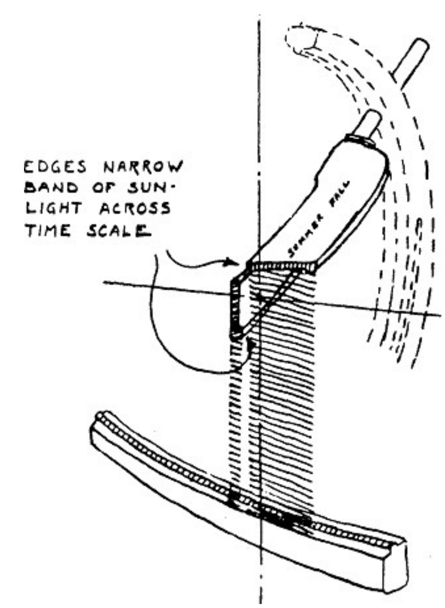
The Sunquest Sundial was invented in 1958 by Richard L. Schmoyer as a sundial that unlike other sundials, tells civil clock time rather than local solar time. His dial appeared in *The Amateur Scientist* of Scientific American in October, 1959, stating its advantages: "With only a few simple settings during two seasons of the year the sundial can be made to indicate accurate clock time. It can be adjusted to the latitude and longitude of any point in the world, including those areas where clocks are changed for daylight saving time. Clock time can be read from it to an accuracy of about one minute..."

From Schmoyer's description in 1983, "The design of the Sunquest sundial is derived from the traditional armillary, with an axis parallel to the axis of the earth...."

"As shown in the [figure at right] the Sunquest sundial consists of a gnomon or shadow casting device, an equatorial or time-scale crescent... [and] a latitude crescent that is made in two parts with a flange at the inner end of each half. Bolts pass through the flanges and through a slot in the equatorial crescent, and when tightened clamp the crescents into a rigid assembly. When loosened, the equatorial crescent and time-scale can be rotated to a position which the sun then shows a time later or earlier than the sun time of the sundial location, adjusting thereby for longitude [difference to the time zone meridian]."

"The latitude crescent similarly is clamped between the jaws of a split pedestal...loosening a single bolt allows the whole assembly to be rotated in the plane of the latitude crescent...This setting, depending upon the latitude, puts the gnomon axis parallel to the true north-south axis of the earth...." The base can be rotated to point the gnomon axis toward true north.

"Time is shown, not by a shadow, or by one edge of the [gnomon] shadow as in the familiar garden sundial, but rather by a band of sunlight between two shadows cast by the gnomon onto the [equatorial crescent] time scale." [Figure at right]



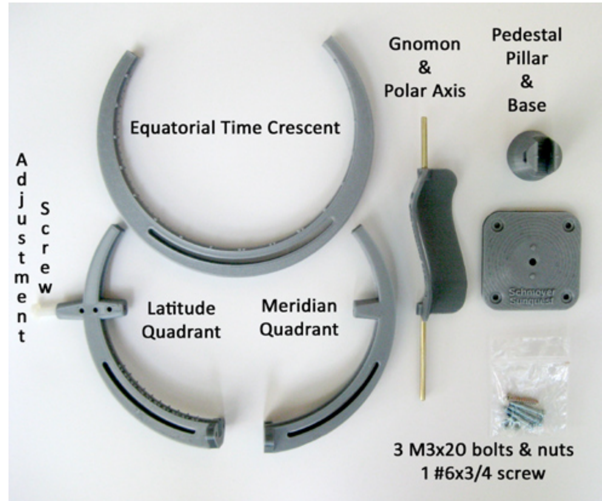
Drawing by R.L. Schmoyer

"The portion of the curved slot passing the sun's rays that meet the time scale changes from day to day and depends upon the declination [north and south excursion] of the sun. In summer the sun is high in the sky [in the Northern Hemisphere] and shines through the upper, or north end, part of the slot. The reverse is true in the winter when the sun selects an appropriate portion of the lower end of the gnomon slot, and offsets the necessary number of minutes on the time scale."

"The gnomon slot curve has been 'stretched out' axially at both the northern and southern end, allowing it to show a more accurate departure on the time scale from the gnomon.... The effective portion of the enlarged curve is brought into play by manually moving the entire gnomon axially north or south."

Sundial Assembly

Unpack & Check Parts

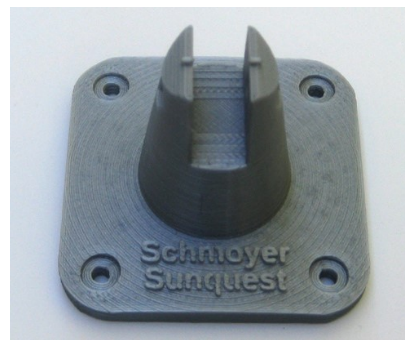


The model of the Schmoyer Sunquest sundial measures 5-1/2 inches in diameter. The dial is 3D printed using PLA thermoplastic and should wear well outside. It is an accurate timepiece showing clock civil time.

The kit contains a base & pillar, equatorial time crescent, two meridian quadrants (with one containing embossed latitudes and #10-24-1½ nylon adjustment screw), and a gnomon with two brass rods (32mm & 54mm) glued in to form the polar axis. The parts bag has 3 metric nuts & bolts (M3x20mm), and one #6-3/4 base screw.

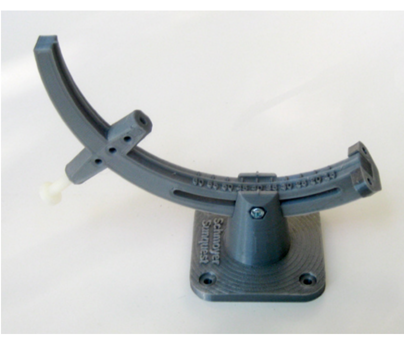
Take a look at all the parts and insure that there are no missing parts and that the equatorial crescent and upper meridian quadrant are correct for your hemisphere. The upper meridian quadrant has an embossed "N" or "S" for the hemisphere and the equatorial crescent hours read left to right in the Northern Hemisphere and right to left in the Southern Hemisphere. For missing or damaged parts, contact First Principles at rkellogg@comcast.net

Sundial Pedestal



First, assemble the base and base pillar using the Phillips-head #6 screw. Insert the screw from the bottom of the base into the top pillar. As you tighten, align the bumps on the top of the base with the indentations on the bottom of the pillar. Tighten firmly. This assembly is the sundial pedestal.

Latitude Meridian



Find the meridian quadrant that has embossed latitude numbers on the inner arc and the adjustment screw. Insert it into the top of the pedestal and adjust it to your sundial latitude (North or South) aligning to the pedestal's top ridge mark. Push one of the enclosed machine bolts into the pillar, through the latitude meridian quadrant's open slot and out the other side. Fasten with a nut and tighten.

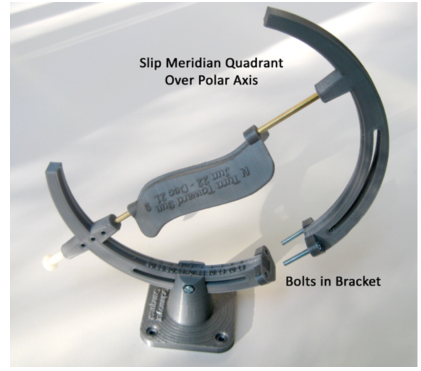
Insert Gnomon into Meridian Quadrant

The gnomon has a short and long brass rod protruding from each end forming the polar axis. The gnomon should be pre-assembled for the correct hemisphere with the long rod on the gnomon pointing upward.

Push the gnomon's short rod into the adjustment screw assembly. The nylon adjustment screw is pre-set such that the gnomon will be midway between meridian quadrants, its normal operating position. The adjustment screw and brass rod should be visible in the middle of the three adjustment sight holes.

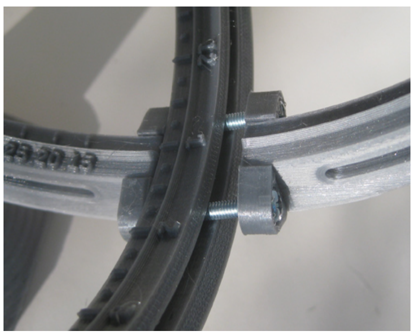
Slip Meridian Quadrant onto Polar Axis

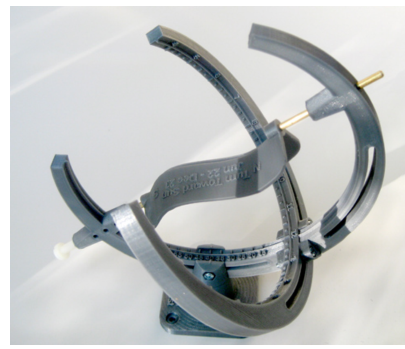
Then take the remaining meridian quadrant and slip its axis hole over the tip of the long polar axis rod. Insert two bolts into the meridian quadrant brace where the two quadrants join. Leave plenty of space between the two quadrants for the Equatorial Time Crescent.



Insert Equatorial Crescent

Insert the equatorial crescent between the two quadrant braces. Insure the hour numbers are above the time marks. For those in the Northern Hemisphere the time marks increase left to right. For those in the Southern Hemisphere the time marks increase right to left.





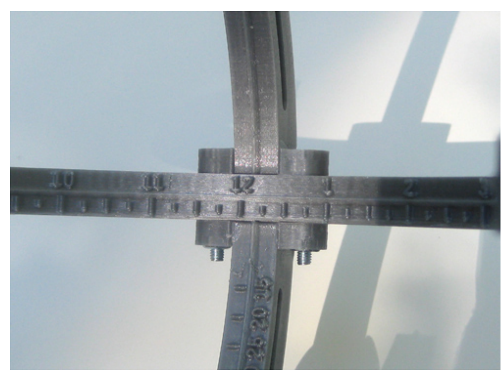
Gently move the meridian quadrant down the polar axis and fit the two bolts through the equatorial crescent and into the lower latitude quadrant brace holes. Use the two nuts to fasten the assembly together. Do not fully tighten.

Make Longitude Adjustment

If the dial location were exactly on a time zone meridian, say Eastern Time at 75° W, the equatorial crescent would have the noon 12 hour mark exactly in line with the latitude crescent's central ridge line. If the dial is not on a time zone meridian (the most likely case), compute the longitude correction as follows. Here we use an example of a sundial site at 77° W in the eastern time zone:

Site Longitude	77° W
Subtract Site Time Zone	-75° W
	2 ° W

This is your longitude with respect to the zone meridian.



Next, convert degrees to time. It takes the sun 4 minutes to move one degree in the sky, so the time displacement is:

Minutes Off Noon: 4 min/deg x 2° = 8 minutes

Set the equatorial crescent time 12:08 in line with the meridian's central ridge line as shown in the figure at right. (Shown for Northern Hemisphere)

If the sundial site were at 72° W, then the degree difference from the Eastern Time zone meridian is -3° or -12 minutes. The time setting on the latitude ridge line would be 11:48.

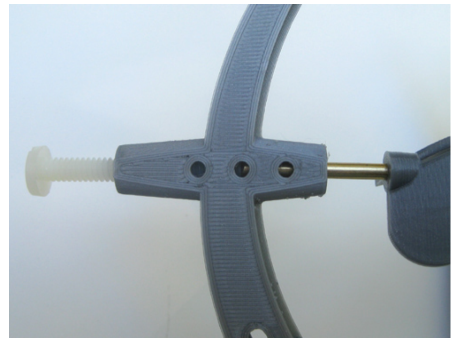
With the time offset made, tighten the two brace nuts & bolts, locking the equatorial crescent in place. For daylight savings time, loosen the nuts & bolts and move the equatorial crescent to read exactly one hour later than the standard time setting.

Operation

Alignment - North or South

In the Northern Hemisphere with "N" on the upper meridian quadrant, upper polar axis should be aligned to true north. In the Southern Hemisphere with "S" on the upper meridian quadrant, the upper polar axis should be aligned to true south.

Solstice Adjustments



This model of the Sunquest Schmoyer sundial uses a adjustment screw to move the gnomon during the period 7 June - 5 July around the summer solstice and 7 December - 5 January for the winter solstice. The gnomon resides for most of the year in the center of the meridian quadrants. To account for the gnomon's elongation near the solstices, in the Northern Hemisphere before summer solstice starting on 7 June, the adjustment screw is retracted from its central position 1/2 turn each day until solstice, when the screw and brass rod should be visible in the lower alignment hole. Then after summer solstice the screw is advanced 1/2 turn each day until 5 July returning to the central position. Before winter solstice starting on 1 December, the screw is advanced ½ turn each day until solstice, when the screw and brass rod should be visible in the upper alignment hole. Then after winter solstice the screw is retracted ½ turn each day until 5 January, returning to the central position once again. Make sure that the gnomon polar axis rod sets firmly on the screw.

The adjustment screw holder is embossed with <Win - Sum>, *referring to the Hemisphere's season* (not the solstice) reminding you of the direction of advancing or retracting the screw. For those in the Southern Hemisphere, the advance and retract motion of the screw operate during the same 14 days before and after each solstice, but in opposite directions.

Reading Civil Time

The gnomon should be able to swing stiffly, holding whatever angle is set. Use the appropriate side facing toward the sun, create a narrow slot of sunlight onto the ridge of the equatorial time crescent. A broad band is an indication of the local sun time, and covers about 15 minutes on the time scale. But by turning the gnomon face toward the sun, choosing either the winter to summer (December 22 to June 21) or summer to winter (June 22 to December 21) face, and gradually bring it to a position at right angles to the sun's rays, two things happen as explained by Richard Schmoyer:

(1) "The effective slot width is reduced or pinched down, making a more narrow line of light fall across the time scale. Turning beyond a right-angle shuts out the direct sunlight entirely, but just short of a position squarely facing the sun, the band can be as fine as you care to see and use to interpolate between the [15-minute] graduations."

(2) "The band of sunlight is shifted from the gnomon axis to fall earlier or later on the time scale by an interval necessary to show standard clock time instead of local sun time. This correction is known as the 'Equation of Time' and is made by the curve of the Sunquest gnomon."

Enjoy this accurate timepiece.

Dates of the Equinox and Solstice

	Spring Equinox EDT				Summer Solstice EDT				Fall Equinox EDT				Winter Solstice *EST*			
2019	Mar	20	Wed	5:58 PM	Jun	21	Fri	11:54 AM	Sep	23	Mon	3:50 AM	Dec	21	Sat	11:19 PM
2020	Mar	19	Thu	11:50 PM	Jun	20	Sat	5:44 PM	Sep	22	Tue	9:31 AM	Dec	21	Mon	5:02 AM
2021	Mar	20	Sat	5:37 AM	Jun	20	Sun	11:32 PM	Sep	22	Wed	3:21 PM	Dec	21	Tue	10:59 AM
2022	Mar	20	Sun	11:33 AM	Jun	21	Tue	5:14 AM	Sep	22	Thu	9:04 PM	Dec	21	Wed	4:48 PM
2023	Mar	20	Mon	5:24 PM	Jun	21	Wed	10:58 AM	Sep	23	Sat	2:50 AM	Dec	21	Thu	10:27 PM
2024	Mar	19	Tue	11:06 PM	Jun	20	Thu	4:51 PM	Sep	22	Sun	8:44 AM	Dec	21	Sat	4:21 AM
2025	Mar	20	Thu	5:01 AM	Jun	20	Fri	10:42 PM	Sep	22	Mon	2:19 PM	Dec	21	Sun	10:03 AM
2026	Mar	20	Fri	10:46 AM	Jun	21	Sun	4:24 AM	Sep	22	Tue	8:05 PM	Dec	21	Mon	3:50 PM
2027	Mar	20	Sat	4:25 PM	Jun	21	Mon	10:11 AM	Sep	23	Thu	2:02 AM	Dec	21	Tue	9:42 PM
2028	Mar	19	Sun	10:17 PM	Jun	20	Tue	4:02 PM	Sep	22	Fri	7:45 AM	Dec	21	Thu	3:20 AM
2029	Mar	20	Tue	4:02 AM	Jun	20	Wed	9:48 PM	Sep	22	Sat	1:38 PM	Dec	21	Fri	9:14 AM
2030	Mar	20	Wed	9:52 AM	Jun	21	Fri	3:31 AM	Sep	22	Sun	7:27 PM	Dec	21	Sat	3:10 PM
2031	Mar	20	Thu	3:41 PM	Jun	21	Sat	9:17 AM	Sep	23	Tue	1:15 AM	Dec	21	Sun	8:55 PM
2032	Mar	19	Fri	9:22 PM	Jun	20	Sun	3:09 PM	Sep	22	Wed	7:11 AM	Dec	21	Tue	2:56 AM
2033	Mar	20	Sun	3:23 AM	Jun	20	Mon	9:01 PM	Sep	22	Thu	12:52 PM	Dec	21	Wed	8:46 AM
2034	Mar	20	Mon	9:17 AM	Jun	21	Wed	2:44 AM	Sep	22	Fri	6:39 PM	Dec	21	Thu	2:34 PM
2035	Mar	20	Tue	3:03 PM	Jun	21	Thu	8:33 AM	Sep	23	Sun	12:39 AM	Dec	21	Fri	8:31 PM
2036	Mar	19	Wed	9:03 PM	Jun	20	Fri	2:32 PM	Sep	22	Mon	6:23 AM	Dec	21	Sun	2:13 AM
2037	Mar	20	Fri	2:50 AM	Jun	20	Sat	8:22 PM	Sep	22	Tue	12:13 PM	Dec	21	Mon	8:08 AM
2038	Mar	20	Sat	8:41 AM	Jun	21	Mon	2:09 AM	Sep	22	Wed	6:02 PM	Dec	21	Tue	2:02 PM
2039	Mar	20	Sun	2:32 PM	Jun	21	Tue	7:57 AM	Sep	22	Thu	11:49 PM	Dec	21	Wed	7:40 PM
2040	Mar	19	Mon	8:12 PM	Jun	20	Wed	1:46 PM	Sep	22	Sat	5:45 AM	Dec	21	Fri	1:33 AM
2041	Mar	20	Wed	2:07 AM	Jun	20	Thu	7:36 PM	Sep	22	Sun	11:26 AM	Dec	21	Sat	7:18 AM
2042	Mar	20	Thu	7:53 AM	Jun	21	Sat	1:16 AM	Sep	22	Mon	5:11 PM	Dec	21	Sun	1:04 PM
2043	Mar	20	Fri	1:28 PM	Jun	21	Sun	6:58 AM	Sep	22	Tue	11:07 PM	Dec	21	Mon	7:01 PM
2044	Mar	19	Sat	7:20 PM	Jun	20	Mon	12:51 PM	Sep	22	Thu	4:48 AM	Dec	21	Wed	12:43 AM
2045	Mar	20	Mon	1:07 AM	Jun	20	Tue	6:34 PM	Sep	22	Fri	10:33 AM	Dec	21	Thu	6:35 AM
2046	Mar	20	Tue	6:58 AM	Jun	21	Thu	12:15 AM	Sep	22	Sat	4:22 PM	Dec	21	Fri	12:28 PM
2047	Mar	20	Wed	12:53 PM	Jun	21	Fri	6:03 AM	Sep	22	Sun	10:08 PM	Dec	21	Sat	6:07 PM
2048	Mar	19	Thu	6:34 PM	Jun	20	Sat	11:54 AM	Sep	22	Tue	4:01 AM	Dec	21	Mon	12:02 AM
2049	Mar	20	Sat	12:29 AM	Jun	20	Sun	5:47 PM	Sep	22	Wed	9:43 AM	Dec	21	Tue	5:52 AM
2050	Mar	20	Sun	6:19 AM	Jun	20	Mon	11:33 PM	Sep	22	Thu	3:28 PM	Dec	21	Wed	11:39 AM

This data is from the
U.S. Naval Observatory
Multiyear Interactive Computer Almanac
1800-2050

Schmoyer Sundial 3D Printed by Dr. Robert Kellogg
Spreadsheet Data by John Sibenac (Northern Hemisphere)

Except for the following dates, the declination screw is set with the brass rod end to be visible in the middle adjustment hole

SUMMER SOLSTICE

Use this for the year 2020, etc., see chart, left column

				Days Different
From June 6	To Jun 20	CCW	1/2 turn/day	14
From June 21	To July 5	Clockwise	1/2 turn/day	14

June 20 Screw and brass rod are both visible in the <u>lower</u> hole

<Win - Sum> Printing on the dial is consistent with

Counter Clock Wise (CCW) and Clockwise

SUMMER SOLSTICE

Use this for the year 2019, etc., see chart right column

				Days Different
From June 7	to June 21	CCW	1/2 turn/day	14
From June 22	to July 6	Clockwise	1/2 turn/day	14

June 21 Screw and brass rod are both visible in the <u>lower</u> hole

WINTER SOLSTICE

Use this for all years 2019 - 2050

				Days Different
From Dec 7	To Dec 21	Clockwise	1/2 turn/day	14
From Dec 22	To Jan 5	Counter-clockwise	1/2 turn/day	14

December 21 Screw and brass rod are both visible in the <u>upper</u> hole

Summer Solstice

June 20	**June 21**
2020	2019
2021	2022
2024	2023
2025	2026
2028	2027
2029	2030
2032	2031
2033	2034
2036	2035
2037	2038
2040	2039
2041	2042
2044	2043
2045	2046
2048	2047
2049	
2050	

Year		**DST Starts**	**DST Ends**
2019		March 10, Sun	Nov 3, Sun
2020		March 8, Sun	Nov 1, Sun
2021		March 14, Sun	Nov 7, Sun
2022		March 13, Sun	Nov 6, Sun
2023		March 12, Sun	Nov 5, Sun
2024		March 10, Sun	Nov 3, Sun
2025		March 9, Sun	Nov 2, Sun

Reference

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