A SUNDIAL WHICH KEEPS ACCURATE TIME

"The sun moves faster at some times than others (being eight days longer in the northern half of the ecliptic than in the southern)"

- so quoted Brewster in his "Lectures by James Ferguson" published in 1823

Sundials, to be accurate, must be designed for or adjusted to the particular latitude and longitude of the location. Necessary too is a correction for the daily irregularities of the sun's apparent motion if the dial is to read the very uniform, average, or mean hours and minutes by which clocks divide our lives. Due to the combined eccentricity of the earth's elliptical orbit and the tilt of the earth's axis, Sun-time throughout the year may vary from 14 minutes earlier to 16 minutes later than the Mean-time. James Ferguson did not have to correct for Standard time zones or for Daylight Saving time.

This sundial is similar to the traditional armillary with an axis parallel to the axis of the earth. The Time-scale is on the equatorial crescent, which is parallel to the plane of the earth's equator. The gnomon axis is pivoted within the latitude crescent, graduated with 5° intervals of latitude. Open crescents, instead of rings, avoid the shadow which some parts of an armillary cast upon the Time-scale. This occurs at noon and almost continuously during the seasons of the equinoxes (March 21 and September 23).

Nesting of the crescents with bolts in a circular slot allows the Time-scale crescent to be rotated for adjustment. A small indicator, adjustable along the Time-scale, is set initially according to the longitude. Once set, stop-hooks position the Time-crescent for either Standard Clock Time or Daylight Saving Time, one hour later.

Time is shown, not by a shadow, but rather by a band of sunlight between two shadows cast by the gnomon on the Time-scale. The gnomon can be turned on its axis to sharply define, to broaden, or to narrow the band of light. A broad band is an indication of the "local" Sun-time, and covers plus or minus 5 minutes on the Time-scale. But in reading the sundial, when either the winter-spring (Dec. 22 to June 21) face, or the summer-fall (June 21 to Dec. 22) face is turned toward the sun, and gradually is brought to a position at right angles to the direction of the sun's rays, two things happen.

(1) The effective slot width is reduced or pinched down, making a narrow line of light fall across the Time-scale; as fine as you care to see and use to interpolate between the 5-minute graduations on the Time-scale.

(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. The edges of the gnomon have curvatures, similar to the curves of an analemma, laid out in accordance with the Equation-of-Time irregularities of the sun's (or earth's) motion. Turning the other face of the gnomon toward the sun applies the correction for the other half of the year.

The portion of the curved slot through which the rays pass to the Time-scale depends upon the declination of the sun. In summer, the sun is high and shines through the upper 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 to offset the necessary number of minutes on the Time-scale.

This sundial, therefore, corrects automatically for the early or late sun - except for two periods of the year. From about December 1 to January 15, the path of the sun remains without much change very close to its lowest observed path across the sky on December 22. During this period it is as much as 11 minutes later to 9 minutes earlier than the mean or clock time. Correction is made by another scheme. The gnomon slot curve has been "stretched out" at the southern end. The proper portion is brought into play by moving the entire gnomon axially, and set by matching a mark on the gnomon adjuster to date marks on the underside of the gnomon. The north end of the gnomon has the same feature for the high sun path period several weeks before and after June 21.

Except for the date-setting during these two periods, telling time with this sundial requires no mental calculations, reference to charts, or selection of scales. The spectroscope-like line of light between shadows is noticeable even on slightly overcast days. It is a pleasant duty in the sunshine to make the date setting during the solstice periods, and twice per year to shift the equatorial crescent along with the Daylight Saving changing of timepieces, all by loosening one or two wing-nuts.

The location of a sundial should invite its use, and let it add to the interest of its surroundings. A place in the sunlight for a large portion of the day or season provides many moments of time-telling pleasure, but other locations may be studied. Trees often let fleeting rays of sunlight pass through to the dial and spend many months with no leaves at all. A house or building, however, has a fixed pattern of shadows. Perhaps the side and time favored by either the morning or afternoon sun may be also your favorite side and time to use the sundial. The high and low paths across the sky should be remembered, and also the extremes at sunrise and sunset.

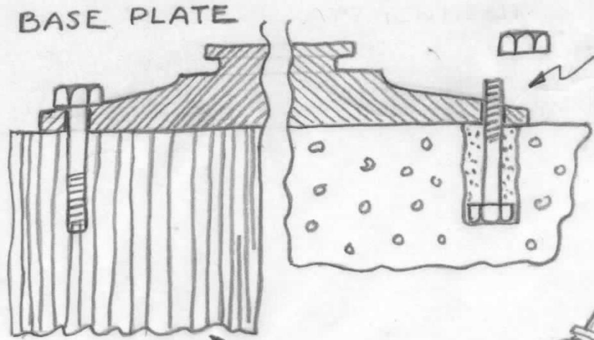
A position from which Polaris, the North Star, can be seen permits an easy, accurate, and interesting initial adjustment of the sundial to its latitude and position, but since there are other means to orient the dial properly, a view of Polaris should not be taken as a requirement in finding the most pleasant location.

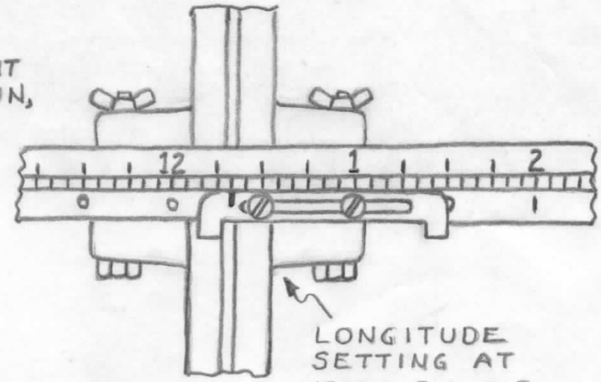
Attachment to the top of a fence post, a masonry pedestal, a wall, or the edge of a stairway all are suitable. The surface should be approximately level. The base plate can be oriented in any direction. Four 5/16" x 2 1/2" bolts are provided for the 4" x 4" pattern of holes. If mounted on wood, drill 5/16" holes 1" deep, and then continue with 1/4" holes to a depth of 2 1/4". The bolts nicely form their own thread as they are turned down.

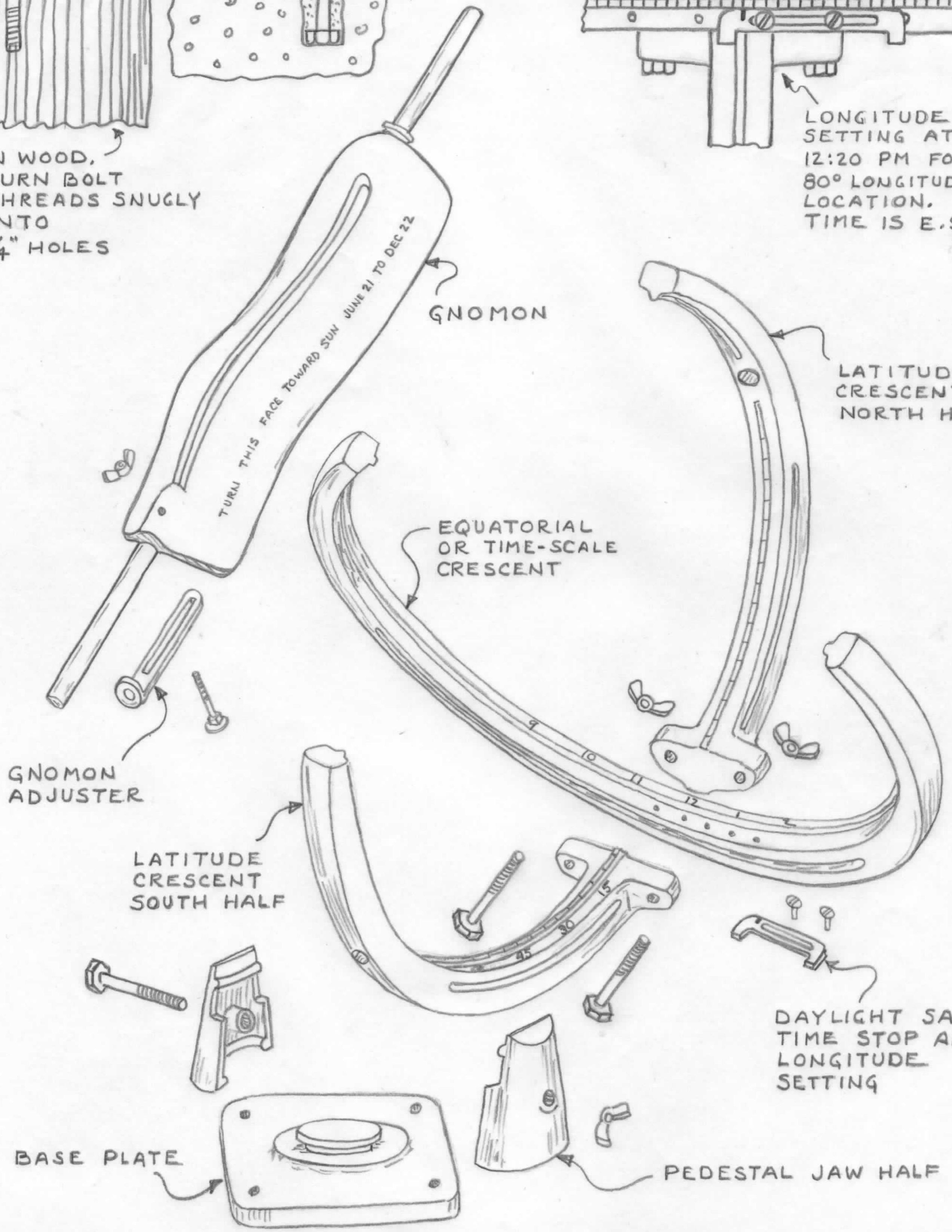
In masonry, use the same bolts in the inverted position, but first dip all but the tip of the threaded end in paint or varnish and let dry before cementing into place. Leave only enough projection above the baseplate to take the hex nuts. Set and level the base plate at this time. Tighten down the nuts after the cement has cured.

The south latitude crescent half is joined to the baseplate by the pedestal jaws, bolt and wing-nut. If loose, the assembly may be turned to any direction on the base, and the latitude crescent may be tilted by sliding in its grooved sides. The south latitude crescent half is the one with numerals representing degrees latitude.

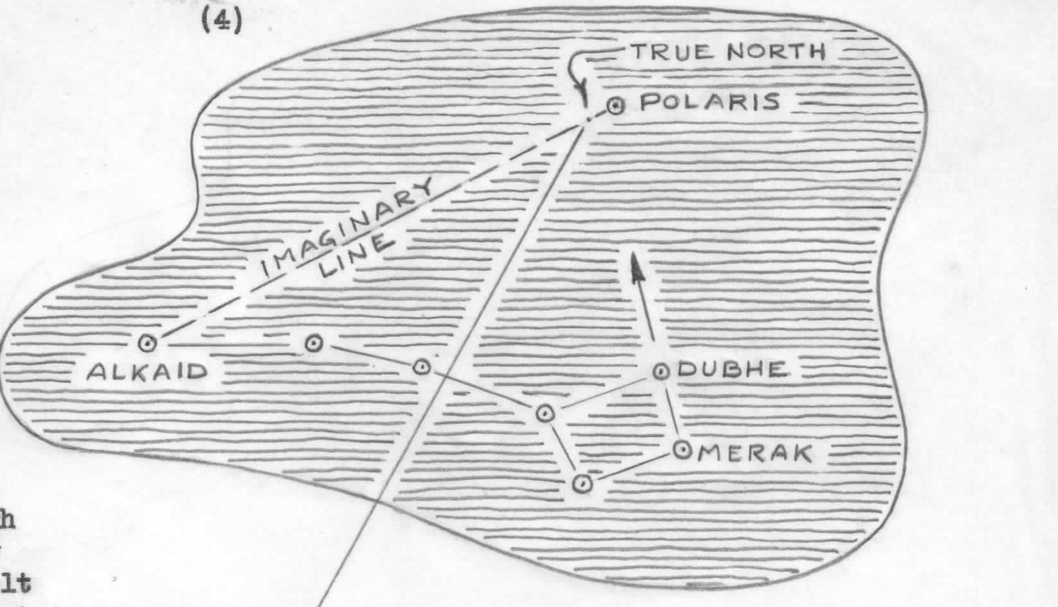
If the North Star, Polaris, is visible, direction and angular elevation can be set at night. The entire sundial, except for the gnomon, is assembled and oriented by







SUNDIAL - RICHARD L. SCHMOYER - LANDISVILLE, PA.



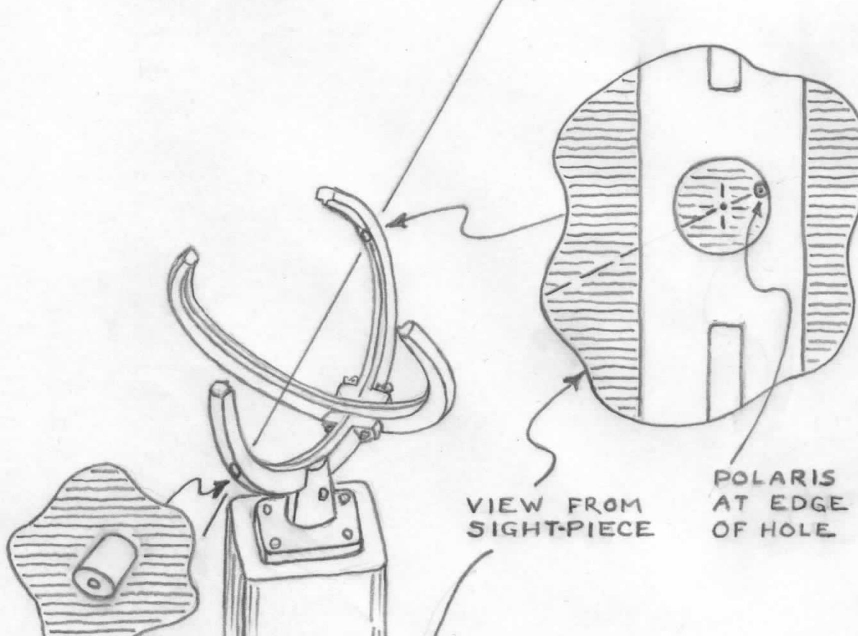
sighting through the empty gnomon pivot holes, aligning them upon the star. The North Star is located after finding the Big Dipper, by following a line from the two stars forming the pouring end of the dipper; Dubhe and Merak. With your eye at the southern or lower pivot hole, turn and tilt the sundial to bring the North Star into view through the upper pivot hole. Now tighten the pedestal jaw bolt just a little to hold the setting for further refinement. Meanwhile the two bolts holding the latitude and equatorial nested crescents should be tight.

Sighting accuracy is better if your eye is looking through the center of the pivot hole. Insert the wooden sight-piece (dowel with small hole) temporarily into the southern gnomon pivot hole to narrow the view and the chance for error.

Further, since the North Star is so-called only because it is a bright star near the true axis (extended) of the earth, the sundial should not be firmly tightened up until its axis also follows into space to true north, the point about which all the stars, including Polaris, appear to rotate. Polaris is less than one degree from true north and is in a direction approximately opposite to the direction (from north) of Alkaid, which is the star at the handle end of the Big Dipper.

The pattern of Polaris, true north, and Alkaid, in whichever position it appears in the sky according to the hour or season, can be used to position the sundial axis for the degree of accuracy needed in telling time.

With your eye centered at the lower pivot hole, and Polaris visible at the center of the upper hole, adjust further to make the upper hole center appear to move along an imaginary line between Polaris and Alkaid, toward Alkaid, but just enough to put Polaris almost out of sight at the edge of the hole. Tightening the pedestal bolt now fixes the axis of the sundial.



This setting need not be disturbed in removing the two bolts holding the equatorial crescent and the latitude crescent halves together to re-insert the gnomon.

The latitude numbers on the south latitude crescent half, or interpolation between the 5° divisions, at the center mark on the pedestal jaws now show the latitude of the place at which the sundial is located.

If the North Star is not visible because of an obstruction, the dial can be set for latitude to the center mark on the pedestal after determining the latitude of the locality from a map, atlas, or local bench mark. In addition, then, to the angular elevation or latitude setting, the latitude crescent (and the entire sundial) must be rotated about the vertical axis of the base until it is in the plane of true north. A magnetic compass can be used if corrected for the magnetic declination or local error. If the local compass error is not known, it can be determined at a point nearby where the North Star and Alkaid are visible and in a manner similar to that described above.

> The sundial itself can be used to determine latitude and direction from the sun. Start with an approximate north orientation and latitude setting. Early in the day, turn the gnomon on its axis until the sun shines broadly through the slot, falling upon the Time-scale between two shadows. Observe which portion of the gnomon slot permits the sunlight to reach the Time-scale. Now mask, with tape or paper on the gnomon slot, all but the small square of light reaching the Time-scale ridge. Watch this small light-patch as it progresses along the Time-scale at intervals during the day and toward late afternoon, turning the gnomon on its axis as necessary. If the light-patch wanders off the Time-scale the settings need correction.
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> Next sunny day repeat, but turn the entire sundial on its vertical axis about the base-plate (loosening the bolt through the pedestal halves) in a direction to cause the light-patch to return to the Time-scale ridge at equal time intervals before and after noon, even though it wanders off in mid-day. When this occurs, hold the orientation or direction but increase or decrease the angular elevation of the gnomon axis until the light-patch has a consistent path along the Time-scale ridge throughout any one day.
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> This procedure may take several days (not necessarily consecutive) with a new position of the mask for each day's observation. Then the plane of the latitude crescent (and the axis of the gnomon) serves as a direction marker to true north, and the latitude can be read on the latitude scale.

On March 21 and on September 22 the shadow of the equatorial or Time-scale crescent should fall on itself. At these times the sun crosses the equator of the earth, to which the equator of the sundial should be parallel. Observation of the shadow of the crescent ends (or a straight edge held across the crescent opening) on these dates serves as a check upon a previous determination of angular elevation or latitude setting.

Next is the setting for longitude. The sun, as it appears to travel around the earth, covers 1° of longitude in 4 minutes of time. It may pass the sundial before or after its crossing of the Standard Time Zone meridian which determines time for the zone. The Standard Time Zone meridians are 0° (Greenwich), or 75° (Eastern Standard Time), 90° (CST), 105° (Mountain Time), 120° (Pacific Time), etc. The meridian or longitude of the sundial location can be found from a map or atlas.

The two wing-nuts and bolts holding the crescents together must be loose to allow rotation of the Time-scale crescent between the latitude crescent halves. Loosen also the two small screws holding the Daylight Saving and longitude stop. Slide it along the Time-scale to a position where the mark coincides with a time 4 minutes later than noon for each degree of longitude the location of the sundial is west, or earlier if east, of the Standard Time meridian for the time observed in the community. For example: if the sundial is at:

Philadelphia	longitude = 75°	EST longitude = 75°	set 12:00 noon
Pittsburgh	longitude = 80°		set 12:20 PM
Barre, Vt.	longitude = 72°-30'		set 11:50 AM

Now tighten the two small screws. With the longitude indicator straddling the center ridge of the south latitude crescent, move the Time-scale crescent to put the early-end stop-hook against the latitude crescent ridge for Standard time, or the opposite stop-hook for Daylight Saving time. Tighten the crescents together.

All the preceeding initial adjustments need no further change in using the sundial to tell time except the shift from Daylight to Standard or the reverse when all the clocks are changed.

In reading the sundial during most of the year, sun time irregularities are corrected automatically by the curvatures of the gnomon. The gnomon is central within the latitude crescent, set by a mark on the gnomon adjuster to Dec. 1, June 1, (+) marks on the under-side of the gnomon. During the period for which dates are showing, the first reading on any day should be preceeded by the resetting of the gnomon adjuster mark to the proper date. The small wing-nut on the upper side of the gnomon loosens the adjuster. Approximate the position between the marks for days between the dates shown.

After the date setting, and with the gnomon wings down, turn the gnomon on its axis until the sun shines broadly through the slot, falling upon the Time-scale between two shadows and with the gnomon wings or faces flaring back away from the direction of the sun. Now turn the gnomon to bring one of the two faces squarely toward the sun. Select the face according to the dates marked on the face. Watch the band of sunlight across the Time-scale. Turn the gnomon until the band becomes narrow almost to the point of shut-off. Read the time on the Time-scale. Divisions on the Time-scale represent 5-minute intervals. With practice it is possible to approximate the individual minute intervals between the 5-minute marks. The narrower the band, the more accurate the reading depending upon the weather conditions and how good are your eyes. For a sporting comparison between sundial and watch, both should be set and read with the same care and skill.

Turn the gnomon for a casual or a more accurate reading. Visit with the sundial for neighborliness. Let the sun help you find an unhurried peace.