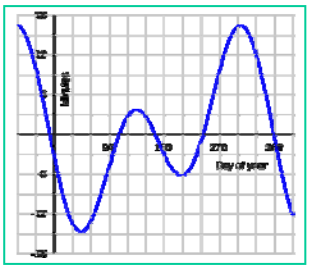
Gnomon Knowledge - Sundials Are A Global Activity

- Larry Krumenaker

Question: Where did the term "clockwise" come from? Here are some clues for finding the answer.

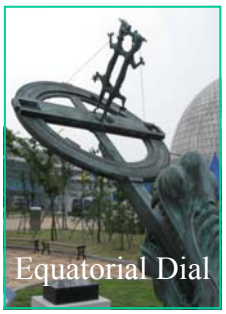
What is guaranteed to work for another 4-5 billion years, and can be built with no more than one part (but can have more) but has no moving parts? Need time to think? This machine will help you with that.

Yes, in a way, it is a time machine but not one that you travel in, it's one that helps you record your travel now. It's a sundial, and it can be as simple as a stick in the ground or the wall or as complicated as a topology math exercise There are multiple kinds of sundials but they all have a few things in common. They all have to be set for whatever latitude you are at. They all have to have some kind of gnomon which is the pointer that indicates the time and scales to indicate the hours. And one more thing…unfortunately, while the Earth may rotate steadily day in and day out, the Earth does not orbit the Sun at a constant speed. Thus, the sundial can run fast or slow compared to a steadier way of keeping time. Plotted, this is known as the Equation of Time. To be a more accurate sundial will require adjusting for the days, months, seasons of the year.



There are several things you have to decide when you want to build a sundial. You have to decide the type of sundial—for example, is the dial face vertical on a wall or horizontal on the ground? Somewhere in between, and is it flat or curved? Are you using a shadow or a point of line as your clock hand? How will you adjust for latitude (at least for the first time if the sundial is a permanent fixture)? Lastly, how will you adjust for Earth's varying orbital speed?

The type of sundial is the fun part, and there are so many kinds!

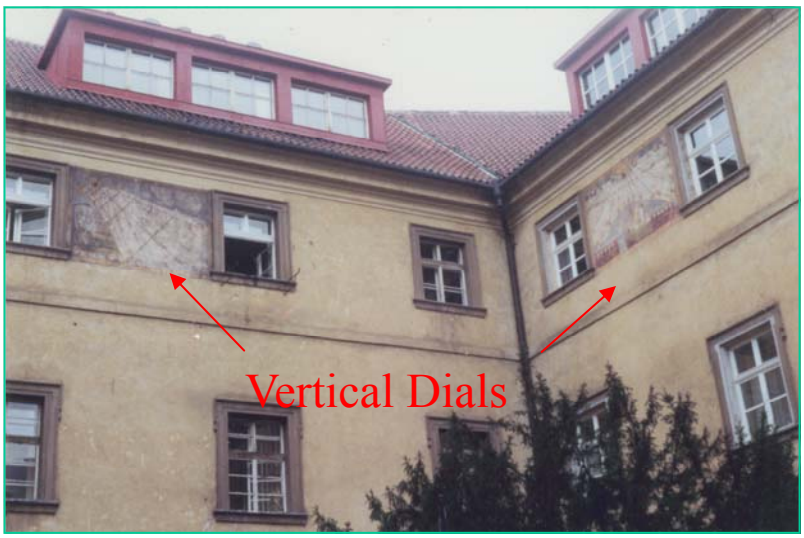

Equatorial Dial

- **Equatorial:** the dial face board is parallel to the Earth's (or celestial) equator in the sky so that the hour marks will be evenly spaced. The gnomon will be pointed at the North Star, tilted at an angle equal to your latitude.


Horizontal Dial

- **Horizontal:** This is the image of the common sundial—a horizontal plate with the hours marked and a triangular gnomon, again at an angle equal to your latitude and facing north. However, there are other, more complicated kinds of horizontal sundials.

- **Vertical:** These are on the sides of walls and seem quite common in Europe. It makes some difference if the vertical side faces due South, where you can get all the hours of the day, East or West to get just the morning or afternoon hours, or somewhere in between. Illustrated are two at right angles to each other on two sides of some buildings in Prague, Czech Republic.



- **Analemmic or Analemmatic** sundials: While some of the above three types have ways to accommodate the Equation of Time issue, this type of sundial has the adjustment explicitly visible and requires that you make the adjustment.

This last form of sundial seems to break down into two kinds. The first kind has a stationary point where the gnomon, which could be you, is located. Then, you read the time on different hourly lines all of which have a Figure 8 pattern called the analemma that is the Equation of Time joined with the sun's north-south motions. This sundial uses a hole in an intricate artwork as the nodis or time-indicating point. To read the clock, look for where the shadow or light spot crosses each hour mark for that particular month. This is illustrated in the upper set of photos from Mississippi's Rainwater Observatory, an astronomy education center along the Natchez Trace Parkway.

Analemma — stand on the date for the correct time.

The second kind has the hour marks stationary and linear but you adjust the position of the gnomon on an analemmic pattern. The Hermograph Press T-shirt is a vertical, south-facing analemmic sundial. At Rainwater Observatory, this lower set of photos shows brick tiles indicating the hours; the observer has to position himself on the correct date on the analemma. This, of course, is also a hori-

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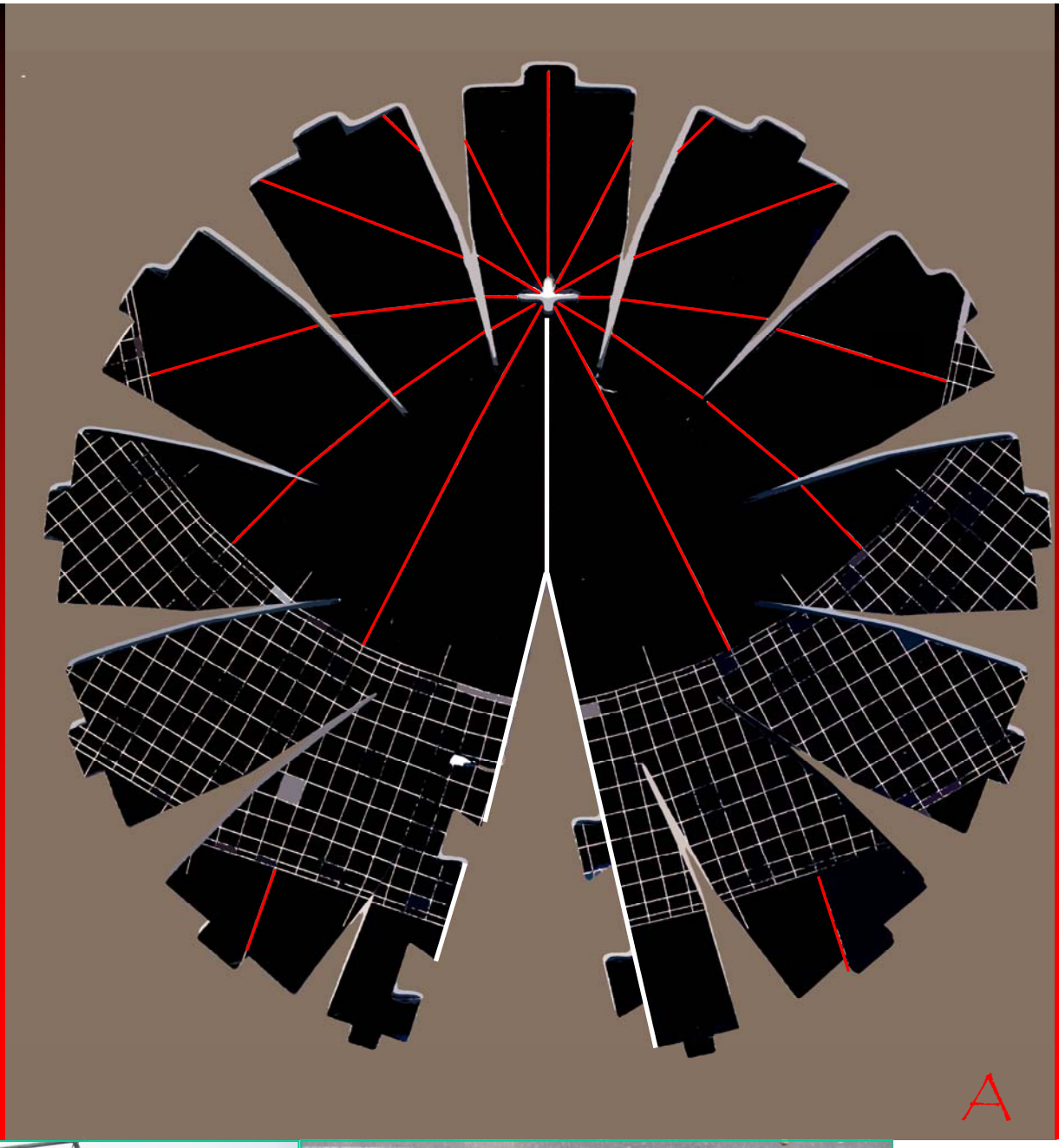
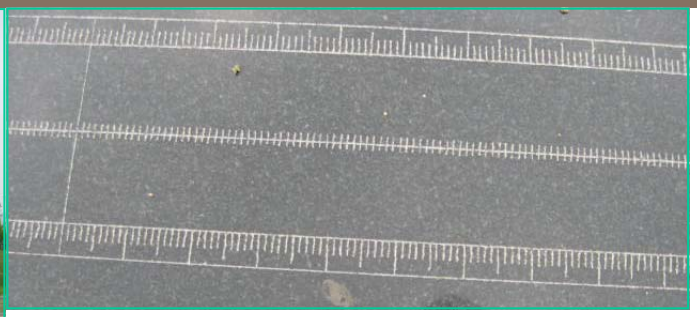
Make Your Own Korean Hemisphere Sundial



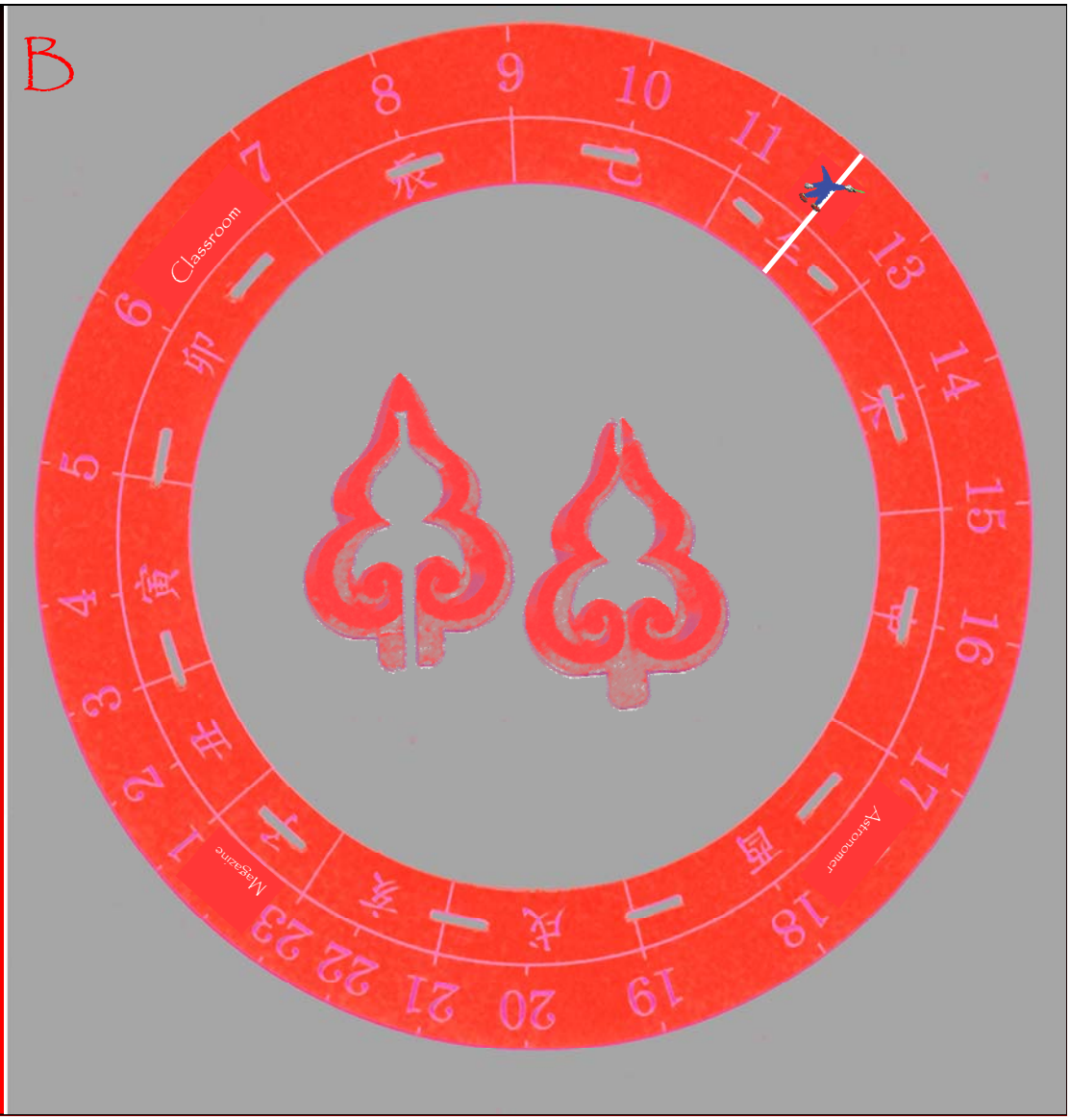


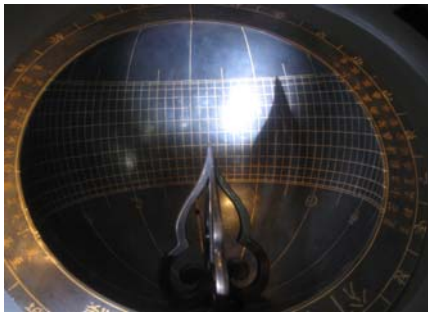
zontal sundial.

Two different kinds of sundials were observed in Korea. One is a gnomon with a single long time indicator. It doesn't indicate the hours. It indicates the day of the year. We all know that our shadows are shorter in summer than in winter (if we observe them at the same hour each day). This sundial is, in effect, a solar powered calendar.

The second kind is a form of analemmic sundial…in a mirror image of the sky overhead, a bowl. Called a Angbuilgu, a Hemispherical Sundial, the time surface is round, not flat. Inside it are inscribed both horizontal and vertical lines. The latter indicate the hours, the for-

I. Print Patterns A and B on bendable but fairly stiff material, like heavy manila folder paper.
II. Cut both patterns and the two gnomon pieces out.
III. Cut the rectangular inner holes out in B, and the cross in A's "center."
IV. Fold A into a bowl shape, connecting the two tabs on the white line. Tape it together.
V. Put B on the bowl, with A's tabs going into B's 'horizontal' slots. The white line at 12 o'clock joins the white line in A's bowl.
VI. Cut out the two gnomon pieces, insert one into the other (there is only one way) and the insert in A.
VII. Put the dial into a 2-3 inch deep bow, 12 (Clastro) to the South, and use!





mer the days of the years. We've included a template to make one though you'll have to provide your own supports to make the bowl level. Invented in 1434, they are found all over Korea and were especially prominent in the royal and governmental gardens of the Joseon Dynasty.

A more modern version of this, inverted, is having a small mirror reflect the sun as a spot on a clear dome, rather a shadow down into a bowl. (See Page 24 for this and a plastic soda bottle as a SunTracker.) A more interesting and much safer variant is projecting the beam onto a ceiling that has tiles or drop ceiling panels, which you can then use as a grid to make your own hour marks and analemma!

There are many other more complicated kinds of sundials. The mathematics, while relatively straightforward for the simplest kinds, gets truly trigonometrically migraine-inducing for the more unusual kinds, or the one you want to build on that NNW side of your garage. There are some computer programs out there to help you design sundials for your latitude and type of interest. They are listed on pages belonging to two large sundial societies on opposite sides of 'the pond' (i.e. the Atlantic Ocean). The URLs are listed below and on the Hermograph and *Classroom Astronomer* websites.

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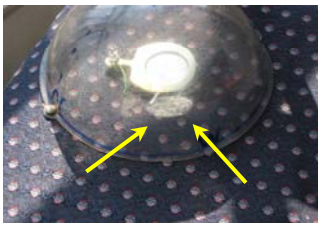
http://www.sundials.co.uk/comprogs.htm http://www.sundials.org/construction.php



We took a clear plastic dome, put it on the dark seat of a chair (this worked better than cardboard or light colored railings) with a small mirror (smaller the better), and placed it in the Sun. Lo, on the first clear morning, we could easily see in our inverted hemisphere a sun reflection on the dome! One could easily mark the hours (if you glued or nailed the mirror and dome down!) and have a sundial! As the picture to the right shows, one can also use the small mirror to make a solar spot on the wall (ceiling, etc.) and have a projection sundial!

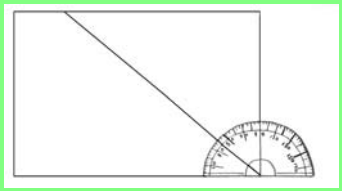
Below are instructions for a more educational clear plastic sun tracking device using materials that are commonly available.

All photos L. Krumenaker, except Equation of Time—Wikipedia Commons.

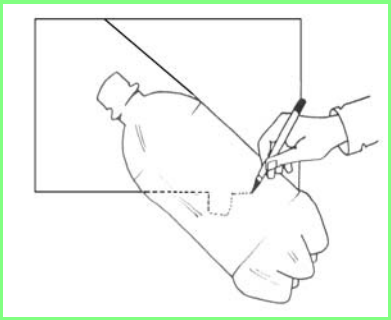
TO MAKE A SUNTRACKER—Eric Jackson, New Zealand

Items needed. A sheet of paper, a 20 cm x 20 cm square of heavy cardboard, fine tipped permanent marker pen, a clear soft drink bottle (one or two liters), protractor, sharp blade, scissors, your latitude.

1. To be accurate the Suntracker must be made for the latitude where it is to be used. Find your latitude.
2. Put a protractor on the bottom right hand corner of a sheet of paper. Mark the angle of your latitude and draw a line across the paper

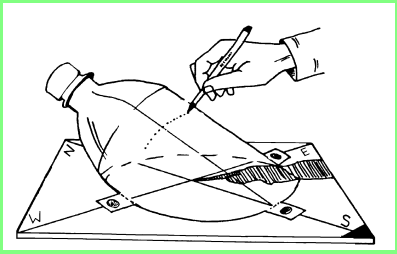


3. Lay a bottle along this line (as shown). With a marker draw a line around the bottle corresponding to the bottom of the sheet of paper. Include three 2cm by 2cm square tabs. Cut the bottle along this line with scissors. (Caution: you may need a sharp blade to start the cut). Bend out the tabs.



4. On a piece of board (or heavy card) 20cm by 20cm draw lines from corner to corner with a fine tipped marker. Mark one corner with an arrow head and **S** for south. Label the other corners **E, N,** and **W.**
5. Staple or glue the Suntracker on to the board through the tabs starting with the center one the N to S line near **S.** Then fix the other two Rule a line with a fine tipped marker from the front tab to the cap directly above the north/south line on the board. This is the meridian line.

6. On a sunny day just before solar noon take the Suntracker outside and set it down flat on the ground well clear of shadows with **S** pointing in the direction of the Sun. Move the base board so that at the time of solar noon the shadow of the meridian line on the bottle lies along the north/south line on the base.
7. Mark this position on the ground somehow so that each time the Suntracker is used it will be placed exactly on this same location.



8. At 9.30 a.m. on a day that is likely to be sunny all day place the Suntracker on its location. With a marker put a dot on the bottle where the shadow of the marker tip falls on the crossing point of the North/South, East/West base board lines. Do this at least every half hour throughout the school day. After the last dot is made join them up with a continuous line. Record the date.

This activity has recorded the elevation of the track that the Sun has appeared to make across the sky on that day. Repeat at weekly/monthly intervals. Note the movement of the tracks between December 21 and June 21 (the solstices) and back. Also note the positions on the equinoxes.

All photos by the author.