SCIENCE

JERRY OLTION

FUN IN THE SUN

SPRINGTIME IS one of my favorite seasons. The dreary gray blanket of winter clouds that covers the sky in my part of the world (the Pacific Northwest) gives way to clear blue sky. Flowers bloom, trees leaf out, birds return from their migrations, and people start planting gardens.

In those gardens, many people will place a sundial. Sundials make interesting, often beautiful, and sometimes even useful ornaments, but it's fair to say that probably 90% of the sundials in gardens around the world don't actually work the way they're supposed to. And even the ones that are set up correctly are seldom used properly. Which is a shame, because when they're set up and used right, sundials can be the coolest part of the garden.

How do you adjust a sundial — or make your own — so it actually tells time?

Let's dive into the science of sundials.

AT THE NORTH POLE

Let's start with a thought experiment: Imagine you're at the Earth's North Pole sometime after March 21st, when the Sun peeks above the horizon and starts circling around and around for the next six months without setting. Imagine that swirly red and white candy pole sticking up at the gate to Santa's workshop. Think about the shadow it casts. That shadow will move around in a circle, pointing directly away from the Sun all day long, making a full 360° sweep in 24 hours.

If you were to make 24 evenly spaced marks in the snow out there at the end of the shadow's reach, you could tell time with that shadow.

The pole has to be straight up

and down in order for the shadow to be accurate. If it tilts off to one side or the other, the shadow will reach some marks too soon and others too late. The ground also needs to be flat. If the shadow is cast upon a snowbank, it falls closer to the pole than it would otherwise. That means the hour marks would have to be closer together there, because the closer shadow wouldn't move as far in an hour as it does when it's stretched all the way out.

In the Garden

With that image in mind, shrink the candy pole down to a rod sticking up out of a plate-sized disk. Put hour marks around the perimeter of the disk. Now click your heels three times and magically transport yourself back home.

Let's say home is at 40° north latitude, which runs across the middle of the United States. You're standing on flat ground, but your candy pole isn't pointing in the same direction as it was a moment ago. It's pointing 50° away from there, because to reach your latitude you moved around 50° of the globe. (The North Pole is at 90° north latitude. 90 – 50 = 40.)

So tilt the whole works, plate, candy pole and all, 50° toward the north. Now it's doing the same thing it did at the North Pole. It won't work for 24 hours anymore because the bulk of the Earth gets in the way and hides the Sun for half the day, but it will work fine during the sunlit hours.

Flatten It Out

If sundial makers had stuck with that design, all would be well. Any sundial could be used anywhere on Earth and it would tell time. But garden sundials don't have tilted plates. The plates are flat to the ground, and the pole, which is technically called the "gnomon," does the tilting.

Remember our snowbank? That's what we're dealing with here. Because the shadow is effectively riding up on a hillside (from the perspective of someone at the North Pole), the lines marking the hours can't be evenly spaced. They have to get closer together around noon than they are in the morning or the evening.

And sure enough, that spacing is dependent upon the tilt of the gnomon.

Custom Made

That means a flat garden-style sundial has to be custom made for its latitude. Any sundial made for

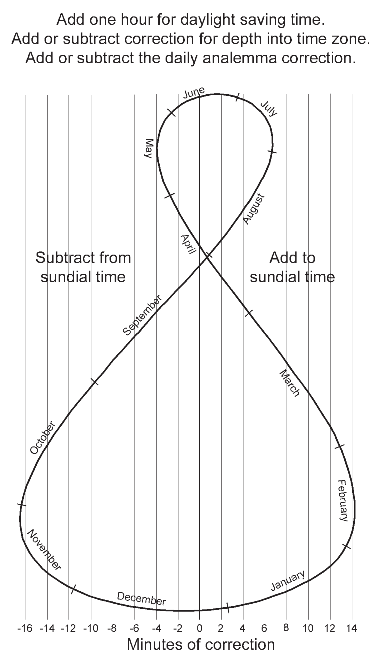
40° will work for any place along the 40° parallel (northern or southern hemisphere — you just have to aim the gnomon south in the southern hemisphere [and reverse the numbers!]), but it won't work — at least not very well — at any other latitude. You get maybe five degrees of leeway before it becomes noticeable, so you can still use a 40° sundial at 45° latitude; it just won't be quite as precise. Which is a shame, because a good sundial can be precise down to a minute when it's set up right. And used right. Which brings us to...

The Analemma

Remember back in the July/August 2020 issue when I wrote about the analemma? That figure-eight thing you see on a globe? One of its major functions is that it can be used to correct a sundial. That's-because the Sun doesn't actually keep accurate time.

What? The source of our entire timekeeping system, the one most constant-seeming thing in the universe, isn't constant? Not even close. It's not the Sun's fault; it's the tilt of the Earth's axis, plus the eccentricity of our orbit around the Sun that's the culprit. Without going into the details (read my Jul/Aug 2020 column for that), I'll just point out that compared to a clock, the Sun runs fast for half the year and runs slow for the other half of the year. So to convert solar time (which is what you get with a sundial) to clock time, you have to add or subtract the analemma correction for that particular date.

The correction can be as much as 16 minutes, so it's important to do.



But Wait, There's More

Alas, that's not the only correction factor. There's a separate correction for where you're located in your time zone. Think of how solar noon sweeps steadily across the planet from east to west. The Sun moves across the sky at a rate of 15° per hour (360° in 24 hours), so if it's straight south in Denver, Colorado, it won't reach Gunnison, which is 2° farther west, for another 8 minutes. Yet both Denver and Gunnison are in the same time zone, so a person in Gunnison has to add 8 minutes to his sundial time to match Denver.

I chose Denver because it's right in the center of its time zone, so it requires no correction. But unless you're also in the very center of your time zone, which would be 75° longitude for Eastern, 90° for Central, 105° for Mountain, 120° Pacific, etc., you have to add a correction. That correction is +4 minutes for every degree west of center, and -4 minutes for every degree east of center. It can be as much as half an hour if you're on the very edge of your time zone. Fortunately, once you know your correction, that never changes. (Unless you move.)

Plus there's daylight saving time. You have to add an hour for that when it's in effect.

Unfortunately you can't just move the sundial an hour ahead plus or minus your longitude correction. That would be the same as tilting the pole away from true north. Your dial would run fast before noon and slow after noon.

Reading a Sundial

With all that under our belts, let's take a run through a typical sundial reading. This is the May/June issue, so let's pick May 31st, late morning. The gnomon is casting a shadow off to the left (if you're facing north). Let's say we're in Gunnison, Colorado.

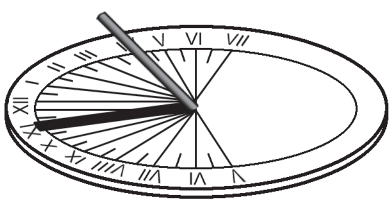
We immediately see our first potential stumbling block: The gnomon's shadow is fat as a finger! Which side of the shadow do we read?*

Don't think of it as a choice between one side or the other. Think of it as reading the top of the gnomon. That means before noon, you read the left-hand side of the shadow (in the northern hemisphere, anyway; in the southern, you read the right side in the morning), and in the afternoon you read the opposite side.

*Many garden-style sundials avoid this problem by making the gnomon triangular, leaving only one edge to the shadow

That brings us to another common design flaw of mass-produced garden sundials: They don't have a noon gap. A good sundial will have a gap the width of the gnomon between two separate marks for noon. Because at noon (solar time) you switch over from reading one side of the shadow to the other.

Okay, back to reading the dial. Let's say the shadow just kisses the 10:45 line. So it's 10:45 solar time. Daylight saving time is in effect in May, so it's 11:45 clock time. But the Sun is 8 minutes behind in Gunnison, so you have to add 8, giving you 11:53. Now you look at the analemma and find that the correction for May 31st is -2 minutes and change, so call it -2, so we're back to 11:51. That's clock time derived from a garden sundial.



A garden sundial reading 10:45 solar time. North is to the left.

Whew!

That might seem incredibly complicated, but until the invention of the clock, that was how time was told. And you didn't have to do all that correcting for daylight saving time or time zones or even the analemma, because for millennia nobody cared about any of that. The world ran on solar time, and that was plenty good enough.

A Better Sundial

There's another type of sundial that allows you to read clock time directly. That's the equatorial sundial. Let's go back up to the North Pole again and look at our big candy pole sticking up out of the snow. Instead of making marks on the snow, imagine a picket fence encircling the candy pole. The pole's shadow would move along from picket to picket just as readily as it did the marks in the snow. You could label the pickets with the time, and if you had just the right number of pickets (1440 of them) you could have one for each minute.

Now get this: When daylight saving time strikes, you just rotate the picket fence an hour backward, so the shadow falls one hour ahead. (Okay, it's on a toy railroad track.) And if your time zone correction is +8 minutes, you rotate the picket fence another 8 minutes. And on May 31st you move it -2 minutes for the analemma correction. From that point onward, you can read clock time directly off the picket fence.

Every few days you have to nudge the fence around to account for the increasing or decreasing analemma correction, but the daylight saving correction and the time zone correction stay put.

Now miniaturize the fence and move it, along with the central pole, to your garden. You've got a sundial that anyone can read, provided you set it up properly. As with the flat sundial, angle the gnomon toward the north celestial pole (the star Polaris makes a handy target) and set the correction factor for the day.

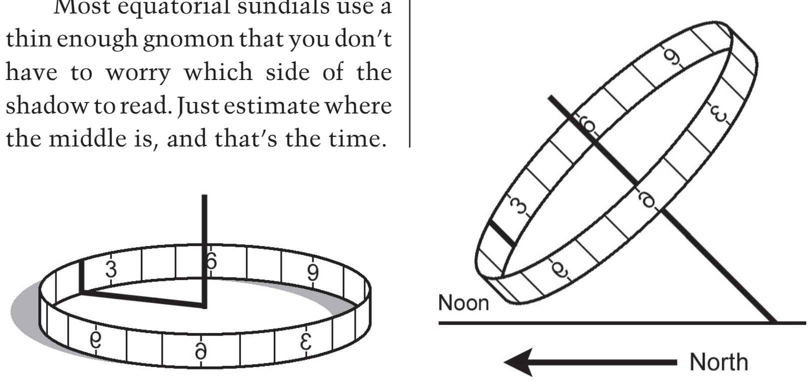
Most equatorial sundials use a thin enough gnomon that you don't have to worry which side of the shadow to read. Just estimate where the middle is, and that's the time.

Make Your Own Sundial

Most garden sundials are the flat-plate kind. And unfortunately most of them are just ornamental junk. The hour and minute lines aren't drawn for the right latitude, and sometimes don't even aim at the base of the gnomon. They often don't include the noon gap for the width of the gnomon. So don't feel discouraged if your sundial doesn't keep time. Instead, buy or build one that does!

I've put up plans for how to build your own sundials, both garden style and equatorial, on my website at www.jerryoltion.com.

Have Sun, have fun!



An equatorial sundial on the ground at the North Pole (left) and tilted upward at 45° latitude (right). Both sundials are reading 2:00. Note that the upper numbers on the sundial at right are superfluous: At night the Earth is in the way of the gnomon's shadow!