If you will ever visit the Greenwich Royal Observatory[1], you'll probably want the Prime Meridian right between your feet.

https://www.google.nl/maps/place/Royal+Observatory+Greenwich/@51.4779161,-0.001458,49m/data=!3m1!1e3!4m5!3m4!1s0x47d8a82a8ca9dca7:0x31abb25f451c8402!8m2!3d51.476853!4d-0.0005587

[1] see http://www.royalobservatorygreenwich.org/; non-native speakers: Greenwich is pronounced: Grennitch.

You'll probably use your smartphone to take a picture of your two feet on each side of the Prime Meridian.

https://en.wikipedia.org/wiki/Prime_meridian_(Greenwich)#/media/File:Greenwichmer1.jpg

And of course you want to check if they put that line on the correct spot, so you'll open a satellite navigation app.

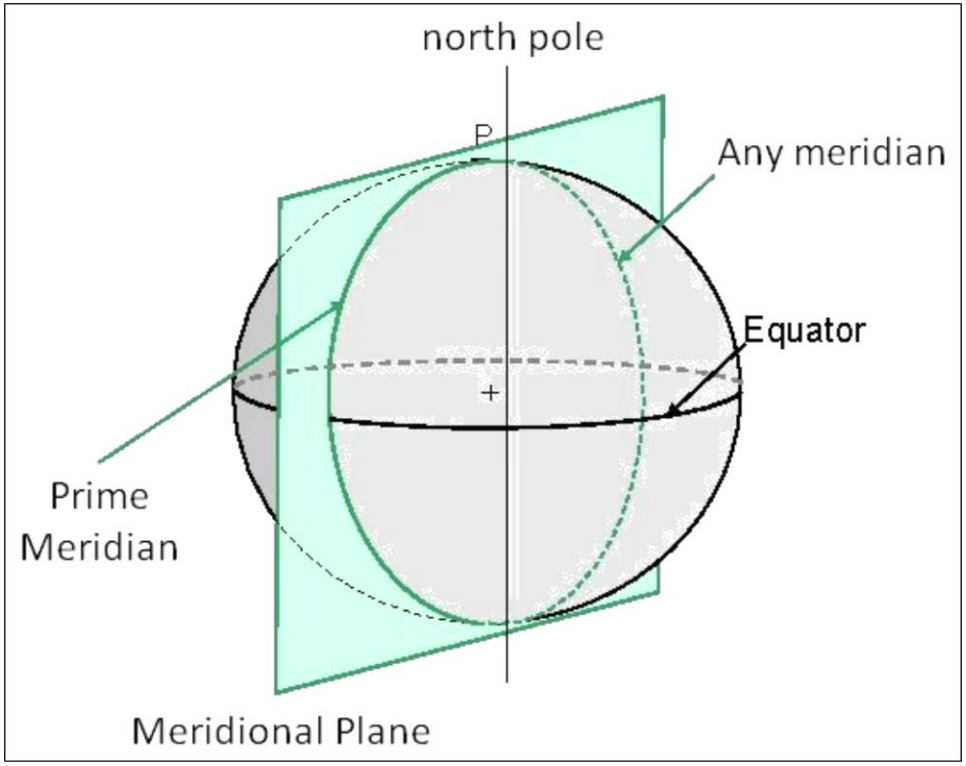
However, it says that you are roughly 100 metres on the western hemisphere

(i.e. the W000.00149° in the image tot the left).

How on Earth is that possible?

Did they make a clumsy mistake?

Well, you shouldn't think of the meridian as just a line on the Earth's surface, but as a vertical plane perpendicular to it. It is called the **Meridional Plane**.



It is fixed to the earth, so it rotates with it. Right between sunrise and sunset, the sun will pass this Meridional Plane. This event is called the **solar transit**. The moment at which this transit occurs is called *noon*.

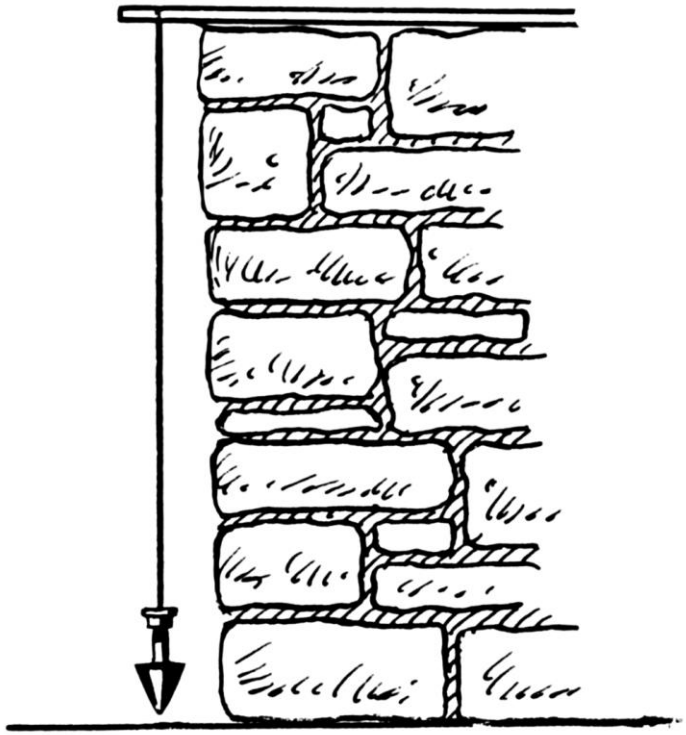
The solar transit actually occurs when the sun's *centre* passes the Meridional Plane, but that is hard to measure. Instead, we measure both the left and right edge of the sun and take their average.

There is a telescope in the building from which the Prime Meridian marker emerges. It was used to accurately measure the solar transit. Since the sun's height above the horizon (called **altitude**) varies throughout the year, this telescope must be adjustable to this altitude. Therefore it can rotate around a horizontal east-west aligned axis, but definitely not around any other. It *must* of course remain in the north-south-vertical Meridional Plane. Such a construction is called a **transit circle**. Since it was installed by George Airy, the seventh Astronomer Royal, it is named the **Airy Transit Circle**.

http://www.royalobservatorygreenwich.org/articles.php?article=1234

As said, a transit circle *must* remain in the Meridional Plane.
Obviously, it should then be **perfectly levelled**.

For that purpose we
can use a spirit level:



or a **plumb line**, which
yields a greater accuracy.

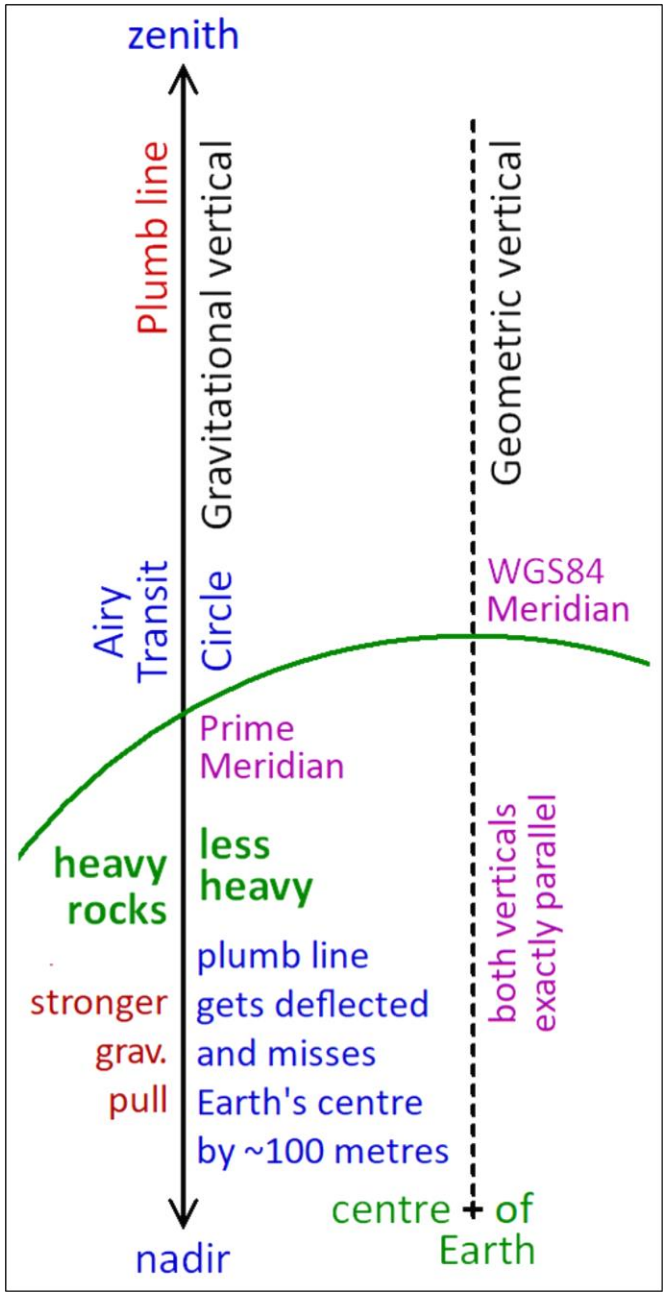
https://picclick.co.uk/Antique-Circa-1880-Brass-Ebony-Spirit-Level-142689099160.html

https://en.wiktionary.org/wiki/plumb_line#/media/File:Plumb_(PSF).png

But the rocks deep below our feet exert *non-symmetrical gravitational forces*, causing a small but surely relevant *deflection of the plumb line*,

so the gravitational vertical does not point to the exact centre of the earth!

The mass distribution of the rocks in the ground below us is of course a ***local*** *circumstance* which is nowhere the same, yielding a wobbly *plumb line deflection* along the meridian. Would one calibrate the "*plumb line meridian*" to synchronous transits along its length, it would become a bit tortuous at ground level.



For accurate calculations, a database would be required containing all those local circumstances, which is rather capacious and disallows fast & easy computations.

Instead, satnav[2] uses the WGS84 reference system[3] which is tied to a geometric vertical which *does* point to the centre of the earth, independent of local circumstances.

WGS84 simply ignores the Prime Meridian marker.

It uses another meridian that is way easier to calculate with.

Its geometric vertical is parallel to the gravitational vertical of the Airy Transit Circle at Greenwich. Because of this purposely chosen point of reference, this geometric meridian does not necessarily coincide with the exact average of the slightly tortuous "*plumb line meridian*". It's close, but no ~~cigar~~ ~~broccoli~~ ice cream.

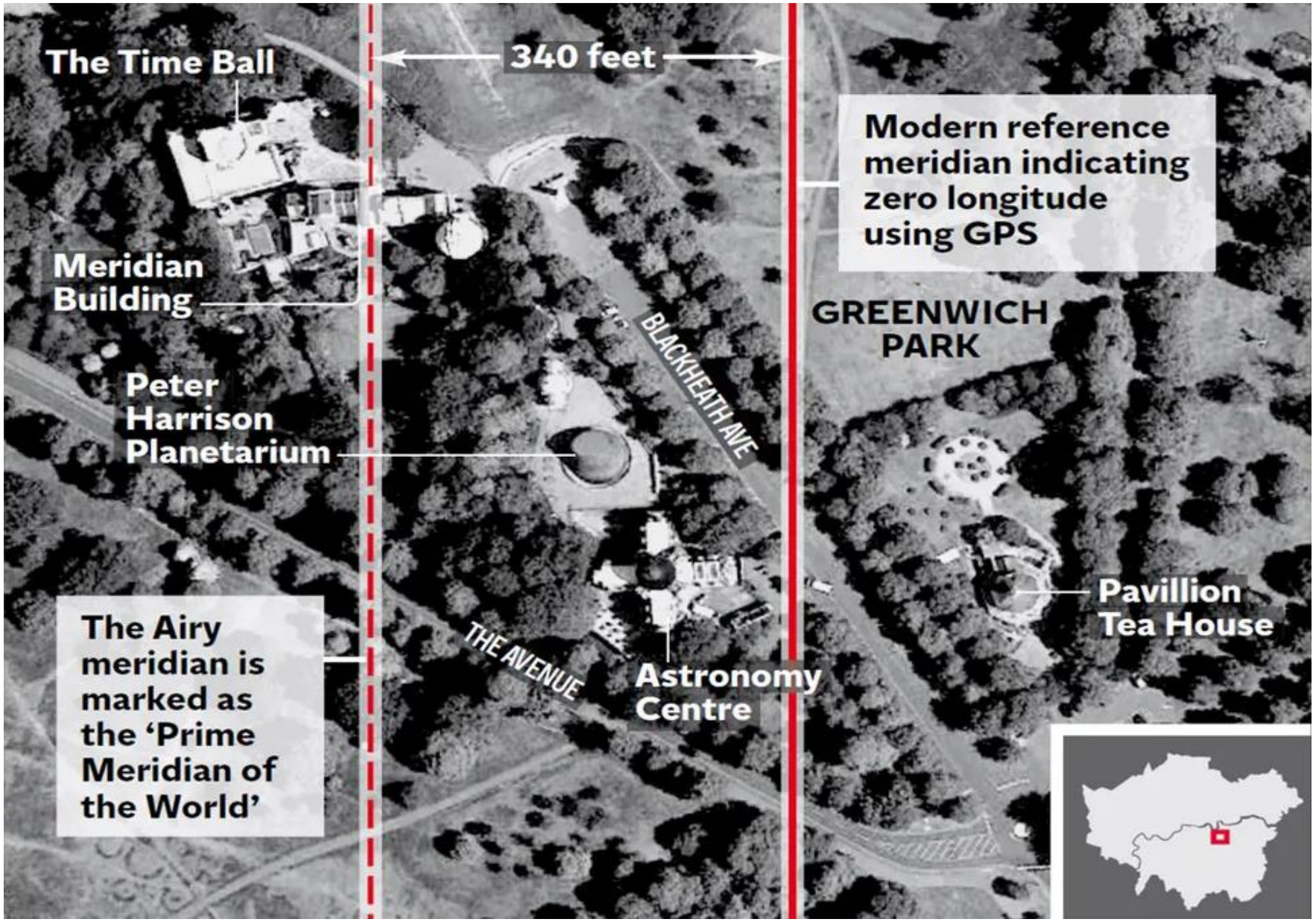
[2] Satnav accuracy: in 95% of open field measurements, i.e. without any buildings etc., the error is less than 8 metres.
[3] https://en.wikipedia.org/wiki/World_Geodetic_System

WGS84 was calibrated by measuring the transits of many distant "clock" stars. These observations were made all around the world.

Together, they resulted in an average meridian which was then calibrated in order to have a geometric vertical that is parallel to the gravitational vertical of the Airy Transit Circle at Greenwich.

In this way, the Greenwich Prime Meridian still is a reference point, but as far as WGS84 is concerned, it has simply been *deprecated as the zero longitude meridian*.

Please read 338 feet instead of 340:



https://static.independent.co.uk/s3fs-public/thumbnails/image/2015/08/12/19/pg-6-greenwich-graphic.jpg

http://www.thegreenwichmeridian.org/tgm/articles.php?article=7
(near the page bottom, under "Continental drift and plate tectonics"):

> The International Reference Meridian and Poles, hence the WGS84 datum, are stationary with respect to the average motion of the Earth's crustal plates. As a consequence, all individual locations are in motion relative to them. In the UK, WGS84 latitudes and longitudes are changing at about 2.5 cm per year in a north-easterly direction. In 1989, the International Reference Meridian passed an estimated 102.478 m to the east of the Airy Transit Circle at Greenwich.

With a change of 2.5 cm/year (which I think was rounded to an inch and then converted to metric), the ±0.5 mm accuracy suggested by the estimated(!) 102.478 m seems slightly exaggerated. By now (Dec. 2021), the year 1989 is ~ 32.5 years ago. Assuming the change is exactly north-east, we find: $102.48 + \frac{0.025}{\sqrt{2}} \times 32.5 \approx 103.05$ metres ≈ 338.1 feet.

Please note: on the astronomical and geological time scales, ***any*** non-zero change rate will (unless it's *really* small) ultimately yield a significant result.

As said, due to continental drift (of which Mr. Airy had no knowledge at all), WGS84 positions in the UK move by about one inch per year to the north-easth. This means that you'll have to travel at that velocity and in that direction if you want your satnav coordinates to remain unchanged[4].

It should then be obvious that the UK itself is moving in the exact opposite direction, as compared to the average of all continents on earth. This average yields the actual zero meridian for WGS84. Therefore its geometric vertical cannot forever be kept parallel to the gravitational vertical at the Airy Transit Circle. The latter will go astray.

The Prime Meridian marker is to be considered obsolete. It has no other use than to attract tourists (and *squeeze* all money out of their pockets ☺).

[4] But the standard satnav uncertainty is roughly 8 metres...

The meridian is important for keeping solar noon at 12 o'clock.

If two (meridional) planes are parallel, they yield
the same transit time of *very distant* objects.

Therefore the WGS84 meridian was chosen such that
its geometric vertical is parallel to the gravitational vertical
at the Airy Transit Circle.

Because of Earth's axial rotation, the sun *seems* to travel each day from east to west. At the sun's distance from Earth (which is called an **a**stronomical **u**nit), this corresponds to an *apparent* velocity of circa 2π au / 1 day ≈ 10879 km/s.

103 metres then corresponds to about 9.5 microseconds
(which is ***not*** really negligible).

For the transit of a star however, this difference vanishes.
At a star's distance, 103 metres is completely irrelevant.

As the earth orbits the sun (on average at 29.78 km/s =
1 earth diameter in just 7 minutes and 8 seconds),
the sun seemingly moves through the 12 zodiac signs.
There's always one behind the sun & yours is that when you were born.

But because of Earth's axial tilt, the ellipticity of its orbit & the year not having an integral no. of days, this apparent movement varies. The **true sun** can deviate from the theoretical ***mean* sun** by over a quarter of an hour.

In most years, the earliest sunset (i.e. the longest evening) is on the **12**th of December, the **21**st is the shortest day & the latest sunrise occurs on the **30**st.
At the Prime Meridian, the transit occurs somewhere from 11:44 to 12:14.

Greenwich Mean Time keeps track of this theoretical *mean* sun, hence it is synchronised with the *mean* axial rotation of Earth w.r.t. the sun. 12:00 p.m. GMT marks the transit of the *mean* sun.

And then there is **C**oordinated **U**niversal **T**ime, abbreviated: **CUT.**
Mais non! Ça s'appelle **T**emps **U**niversel **C**oordonné, abrégé: **TUC!**

> *Since anglophones and francophones mutually reject any inferiority to each other, they did something weird:* **CUT** + **TUC** ⇒ **UTC**, *which is silly in both languages. Now everybody can consider the other one a moron.*
>
> (And, being a Dutchman, I think both are... ☺).

UTC is atomic time, which has nothing to do with Earth's rotation. Moreover, the latter is very moderately slowing down[5]. But they want **UTC** to keep pace with **GMT**, so the difference is kept below a second. Whenever it will exceed 0.9 s, a leap second is applied. The very last UTC minute of June or December then lasts 61 s.

It can also last 59 s, but that has not yet ever happened. A total of 27 leap seconds were added from 1970-01-01T00:00:00Z until 2016-12-31T23:59:60Z, i.e. over a period of $N \coloneqq 1\,483\,207\,200$ GMT seconds. Hence UTC (i.e. atomic time) ticked $(N + 27)/N = 1.000\,000\,0182$ times faster than GMT (earth rotation based), which is the same as ~ 1.57 milliseconds per day.

[5] Due to tidal effects, rotational energy of the earth is transferred to distance energy of the moon, which is moving away from us at 3.8 cm/year.

And did you know

that around the longest day of the year
sunrise is at about 4 AM[6] local solar time?

Of course that is the start of the first hour of daylight

(4AM ⇒ 1st; 5AM ⇒ 2nd; 6AM ⇒ 3rd; 7AM ⇒ 4th; 8AM ⇒ 5th; 9AM ⇒ 6th; 10AM ⇒ 7th; 11AM ⇒ 8th; 12PM ⇒ 9th),

so when the sun is in the south, reaching its greatest altitude of the day, the **ninth** hour of daylight starts.

Latin for "ninth" = **nonus**;

nonus ⇒ noon.

[6] at average European latitudes; Paris is a reasonably accurate example.