technology review
Published by MIT

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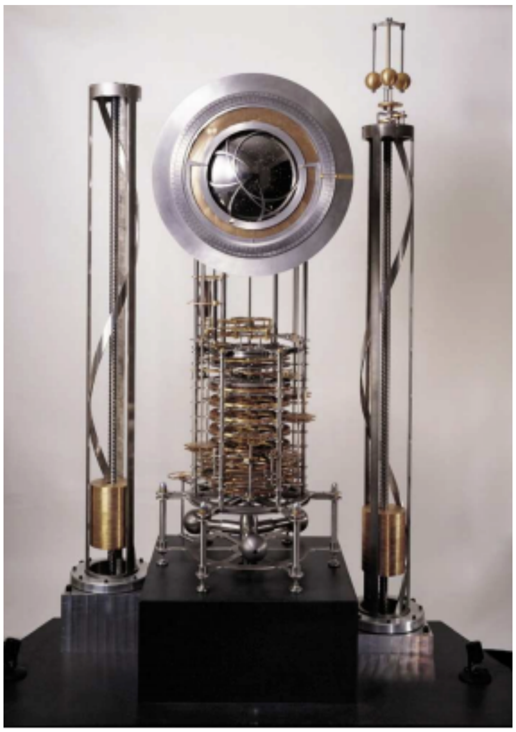
12/15/2011

How the 10,000-Year Clock Measures Time

The Earth's rotation is notoriously unpredictable. So how can a clock keep time for 10,000 years?
By kfc



Ten thousand years is about the age of civilisation. Archaeologists have a few relics that have spanned this period, mostly stone tools and works of art. But most evidence of the earliest civilisations has long crumbled into dust.

So the plan to build a mechanical clock that will keep time for the next ten thousand years is hugely ambitious. And yet that is exactly the goal of the Long Now Foundation, an organisation set up to promote long term thinking and responsibility.

These guys are currently building a prototype of their clock inside a mountain in Texas near the border with New Mexico. And today, Danny Hillis at the foundation and a few pals, outline the way in which it will keep time.

Keeping time over such a period generates numerous challenges. First is ensuring the mechanical integrity of the machinery, which they achieve with long-lasting materials such as titanium, ceramics, quartz and sapphire.

Just as important is the environment: a series of tunnels carved into a mountainside in the high desert. Inside the mountain, the conditions are dry and the temperature constant.

Outside, however, the temperature varies between dessert extremes of hot and freezing. Hillis and co plan to exploit this temperature difference to power the clock using metal rods that change in length as the temperature varies. Human visitors will also be able to wind it.

As for time, the heart of the clock is a titanium pendulum with a 10 second cycles. Pendulum Time advances one unit once every 30 cycles, in other words every five minutes.

The rest of the clock is a digital computer using Pendulum Time as an input and generating analogue outputs in the form of various displays of time.

The mechanism first calculates Uncorrected Solar Time using a straightforward equation of time, which has been precomputed for the next ten thousand years to within the accuracy of the Earth's variable rotation.

Next, the clock calculates Solar Time using a correction provided by a solar sychroniser: a vertical chamber that heats up when the sun is directly overhead and shines into it. This can add or take away a tick if the clock is out of sync. "The correction is positive if the Sun is detected before the just-before-noon tick, and negative if it is detected after the just after-noon tick," say Hillis and co.

An obvious problem occurs if the Sun is obscured for long periods of time, perhaps because of dust from a volcanic eruption. In that case, the clock will keep uncorrected solar time until the Sun becomes visible again. Then it can correct the time in 5 minutes steps each sunny day.

It is this mechanism that corrects for any changes in the Earth's rotation, caused by climate change, shifts in the Earth's crust and so on. An accumulation of ice at the poles will cause the rotation to speed up, for example.

But provided the clock does not drifted by more than 12 hours, it should return to the right time. "This allows the clock to successfully recover after more than a century of overcast skies," say Hillis and co.

The clocks uses Corrected Solar Time to generate a Displayed Solar Time that visitors will see. It also calculates Orrery Time, a display of the position and phase of the Moon, the tropical year, the sidereal day, orbits of the visible planets, and the precession of the Earth's axis.

The plan is to use the lessons from building this prototype to create another clock in a mountain in Nevada. After that, the creators hope that other groups around the world will make their own millennium clocks, thereby spreading the pattern of long term thinking.

A profoundly impressive project.

Ref: arxiv.org/abs/1112.3004: Time In The 10,000-Year Clock