Timekeeping: The 10,000 Year Clock

"Time is the wisest counselor of all." - Pericles

By Amos Kwon on 11.20.12 | Photo by Long Now

When I was a child, people used to talk about what would happen by the year 02000. For the next thirty years they kept talking about what would happen by the year 02000, and now no one mentions a future date at all. The future has been shrinking by one year per year for my entire life. I think it is time for us to start a long-term project that gets people thinking past the mental barrier of an ever-shortening future.
- Daniel Hillis

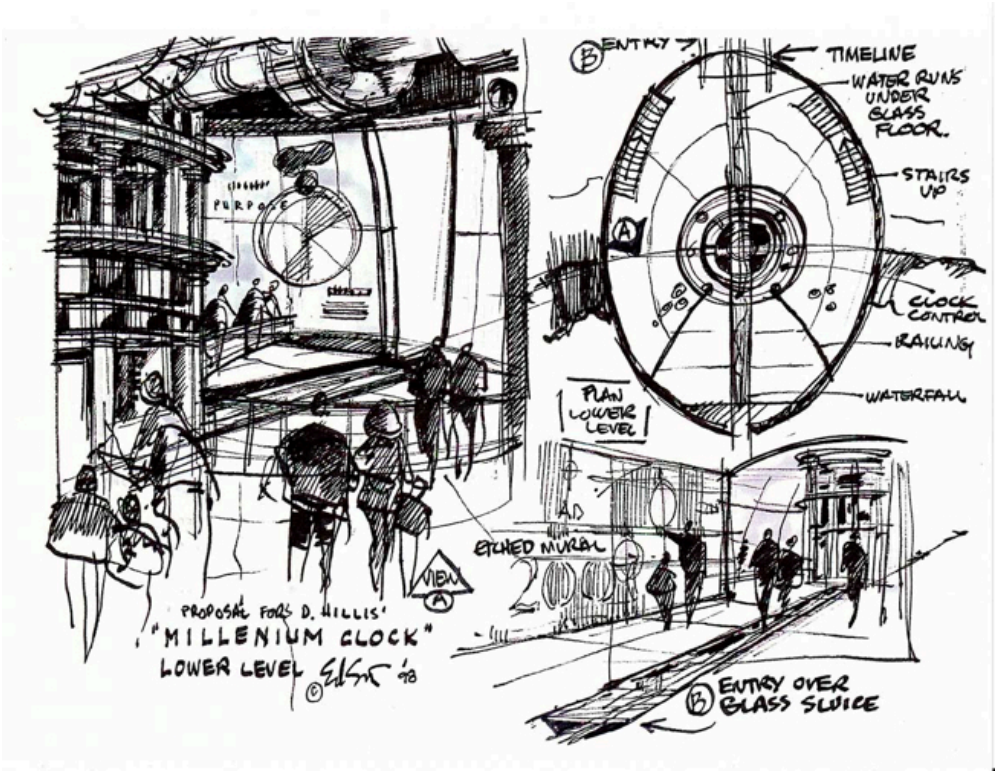
"Time and tide wait for no man", wrote Geoffrey Chaucer. We spend our days clamoring after bigger homes, nicer cars, the ultimate vacation spot — and time keeps ticking, someday getting the better of us. Death and taxes, as they say. Every so often, in the stillness of the night, we think about the legacy we're leaving, about what will remain that has our name stamped on it long after we're food for worms. Discomfortingly, it seems little will. Even in the world of architecture, with varied and vast creations across the globe, it's a constant struggle to keep many historic buildings intact or to actually restore them to their original glory. Some survive, and many of those buildings aren't even a century old. Others fall, their legacy continued only in photographs or history books.

But what if someone were to add to the list of man-made wonders, something that would outlive them all — the Great Pyramid of Giza, or even the Great Wall of China? What if there were a way to build something so unique and lasting, something that might also track time for generations to come; something to make those in our place thousands of years from now gaze in wonder, all the while involving those future generations in the process itself? The notion seems ludicrous, grandiose and completely fascinating all at once. Such a creation was birthed in the brain of a single man —

computer engineer, polymath inventor, and designer Danny Hillis — in his quest to create the 10,000 Year Clock, a project of positively monumental proportions both in size and duration, and one that is currently underway in a remote location in the hills of Texas.

Find out more after the jump.

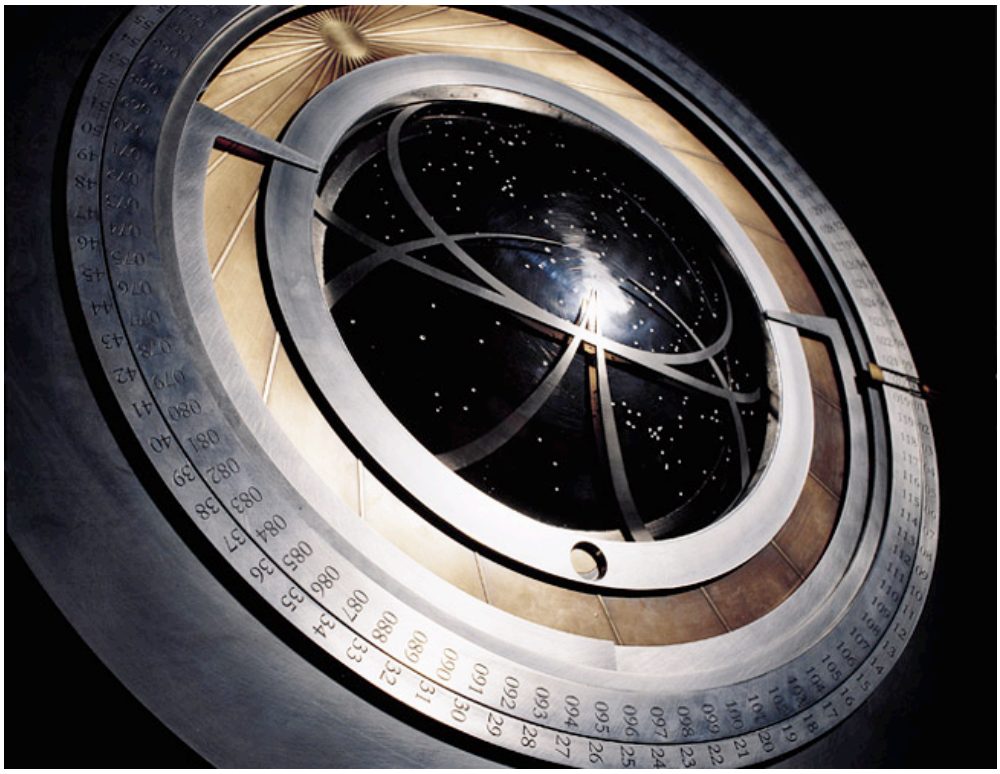
Planting Acorns



Before wrapping our collective brains around this landmark project, it's imperative to understand a little bit about the mind behind it all. Certainly, your less-than-progressive thinker, asleep on top of a half-eaten package of dry Ramen noodles, doesn't just wake up and say "Eureka! I'm building a 10,000 year clock!" It takes a tad more gray matter than that. So, who's responsible for this beast of a project? William Daniel "Danny" Hillis is a Maryland-born inventor, renowned author in the field of computer science and mathematics and a full-blown entrepreneur — so he happens to know a little bit about how to get such a project off the ground.

A graduate of MIT in mathematics with a masters and a PhD in Electrical Engineering and Computer Science (with a specialty in robotics), Hillis comes from a seriously underachieving family. His father was an epidemiologist for the U.S. Air Force and his mother was a biostatistician. Hillis's younger brother is a professor of evolutionary biology at the University of Texas at Austin and his sister is a professor of neurology at Johns Hopkins. Talk about a group of knuckle draggers.

Hillis isn't some boring math guy, though. His multi-faceted work at MIT involved developing hardware and software for children, as well as creating computer-based toys and games for Milton Bradley. Also, during his doctoral studies at MIT, Hillis co-founded Thinking Machines Corporation, where he developed his major work in parallel computing and marketed a product called the Connection Machine (which broke down larger problems into smaller ones to solve them in parallel, mimicking the human brain). Despite his fascinating work at Thinking Machines, the company filed for bankruptcy and Hillis ended up working at, of all places, Disney. Starting in 1996 as VP of Research and Development of Walt Disney Imagineering, Hillis worked on technology and business strategy for Disney movies, TV shows, theme parks and consumer products. He even put his stamp on full-sized robotic dinosaurs and other robotic devices for the entertainment company.



THE NOTION OF THE HILLIS'S CLOCK IS BRILLIANT AND INCREDIBLY COMPLICATED; WHAT IT FOSTERS IS BRILLIANTLY SIMPLE.

Even as far back as 1993, when Hillis was helming Thinking Machines Corporation, he began to think about a project that involved some seriously long-term pondering: some sort of extremely large clock that would last thousands of years. The spark that fostered his ultimate idea, though, was breaking through "limited thinking"; that is, going beyond the limits of pondering what might occur *only* a thousand years into the future. A mere 1,000 years seemed too short-sighted. Hillis wanted to create something that would live on, nearly in perpetuity — no small task, for even his mind to grasp.

But his idea was for something far more than just an ageless monument. Hillis's plan was for this massive clock to require mechanical winding by human means in order to fully operate. No doubt, as Hillis intends, the clock would foster thought about the past, the present and the future in generations to come. What can we do to ensure the continuation of the human race for the next 10,000 years? Is that length of time assured or are we, as a society, acting in such a way that will cut our time painfully short? What changes must we make? These are questions that the Pyramids or the Parthenon don't pull forth from our awed minds. The notion of the Hillis's clock is brilliant and incredibly complicated; what it fosters is brilliantly simple.

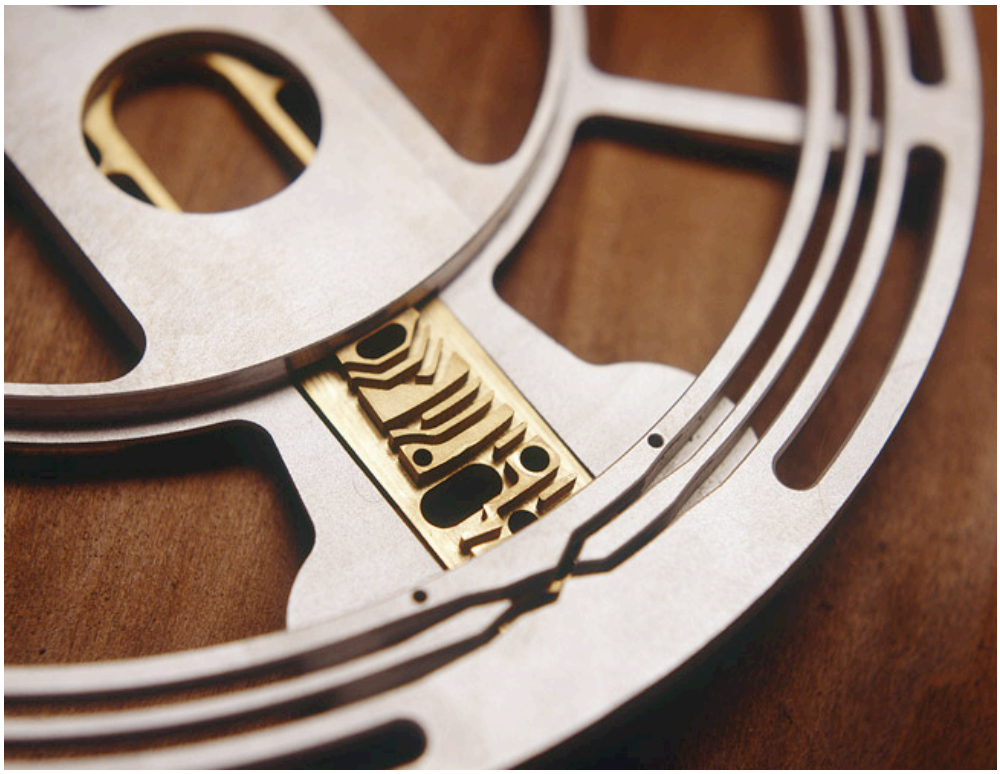
The 10,000 year (that's one hundred centuries) clock would be designed to make a small bell peal every day, tick once per year, chime once every hundred years and release one hell of a cuckoo every one thousand years. The mechanics involved in creating such a clock would be one massive obstacle — the sheer size and complication of the clock itself, in order to be able to capture 10,000 years of timekeeping, would dwarf just about anything the mind could conjure up. How would one even go about designing, much less even developing and building such a project? And how could one fathom to initiate something of such magnitude knowing that its completion would extend far beyond one's own lifetime? All these were questions Hillis had to address — and not simply theoretically, but practically. Hillis captured it brilliantly in just a few sentences:

I cannot imagine the future, but I care about it. I know I am a part of a story that starts long before I can remember and continues long beyond when anyone will remember me. I sense that I am alive at a time of important change, and I feel a responsibility to make sure that the change comes out well. I plant my acorns knowing that I will never live to harvest the oaks.

The Very Long Now

Actualized dreams, however, take serious details, and that's exactly what was required to even get out of the starting blocks on such an endeavor. You have to essentially reverse engineer something of this nature — and think about what actually could happen to the clock over such a large span of time. The problem is, no one truly thinks that far ahead. We wonder where we're going on vacation next year or simply what's for dinner tonight. To start making his idea an attainable reality, Hillis formed the Long Now Foundation in 1996, so named by musician and composer Brian Eno to capture the idea of "the long now of centuries" as opposed to the "short now" of the year, the week, or our goldfish-like attention spans.

Eno is also involved in the project, along with Stewart Brand, a cultural pioneer and biologist, journalist and entrepreneur Esther Dyson, and Mitchell Kapor of Lotus 1-2-3 fame. All the parts are in place, but as important as the meeting of the minds is, only air is free. A rather large bank account is needed for such a (cough) expansive project. That's where *Amazon.com* founder Jeff Bezos, who is acting as the deep pockets for this tall project, comes in. He's not just throwing money at it. Bezos is keenly interested in what the Long Now Foundation is doing and in what Hillis aims to accomplish. He's a key team member who's truly involved in the details of the Clock. Just don't start looking for Long Now Clock bookends to show up for sale on his website this holiday season.



With the team assembled, Hillis still couldn't just start building the clock. He had to set some huge ground rules about what functions the clock will perform, and even more significantly, how it will be maintained over 10 freakin' centuries. He came up with five fundamental rules:

1. Since future conditions could not be predicted — weather, world conditions, accessibility — the clock had to run without major maintenance and it would have to run accurately for thousands of years.

2. The clock would have to be based on a simple design, assuming that the possibility existed that technology either might not advance in the future or that society and technology might regress.

3. The clock should not require complicated instructions, meaning that upon inspection, future societies could easily deduce how the clock functions.

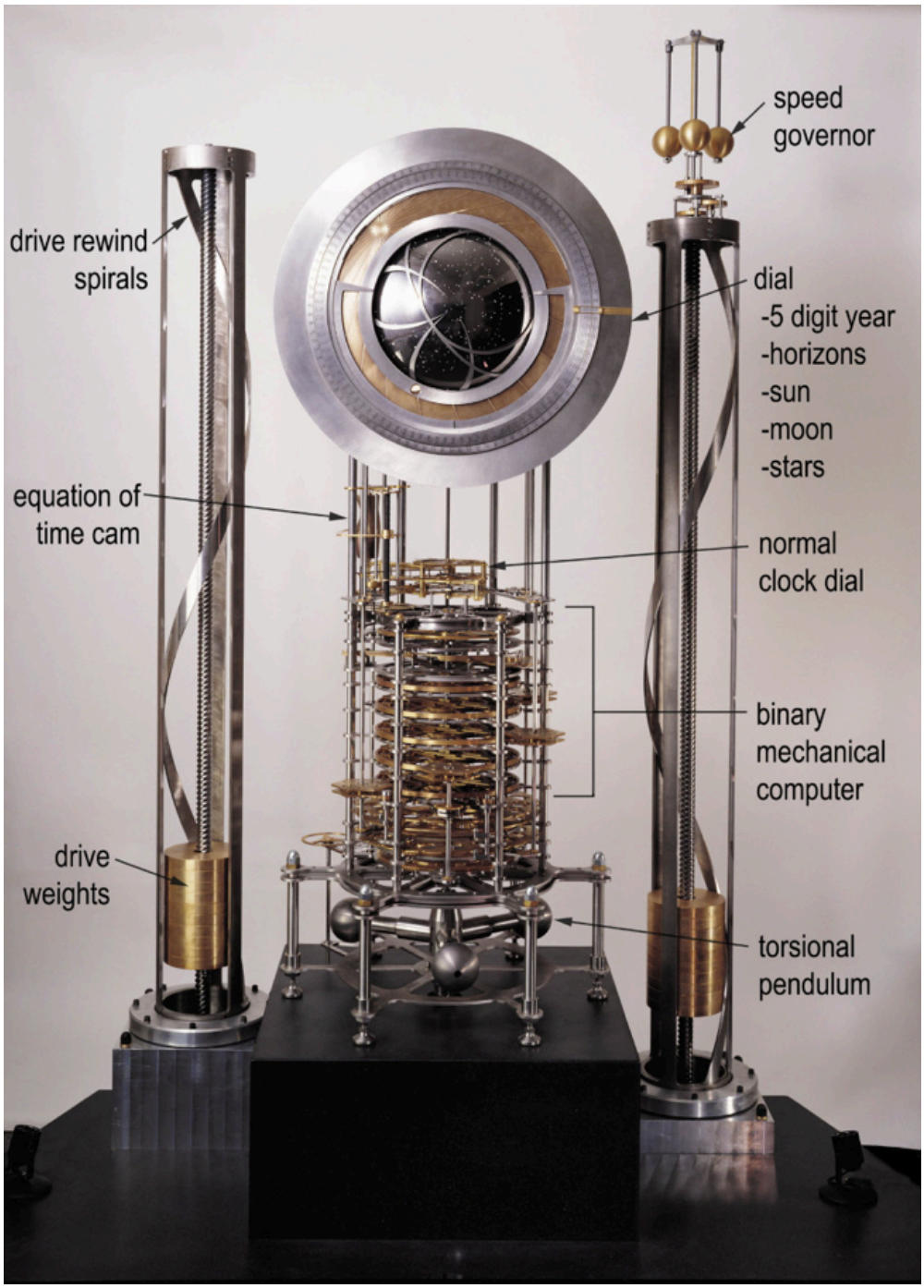
4. At any point over the next 10,000 years, the clock should be able to be improved upon by those who encounter it.

5. The clock's design should be simple enough to enable the construction of a tabletop sized model.

Keeping principle #5 in mind, it's easy to understand that you can't simply start carving out the side of a mountain and cram large clock parts inside, hoping to achieve a finished product within a couple of short years. The Long Now Foundation members knew that this undertaking would span decades, not months or mere years. At this point, most of us would've probably second guessed the source of our inspiration ("Eh, I should never put ideas on paper when I'm drunk"). But again, the project is far more than a personal endeavor or a momentary epiphany that fades when the task becomes even remotely daunting. Hillis saw beyond personal dreams into a work for humanity.

The first step was to test if something like this would even work on a smaller scale — a working prototype had to be constructed first. Work on that prototype began in 1996 and was completed after three years of research and design on December 1st, 1999. The eight-foot tall mock-up stood on a table (okay, so it's a strong table) and was designed to chime twice at midnight, New Year's Day, 2000 to mark the 21st century. The impressive model was the child of project manager and designer

Alexander Rose, mechanical engineer Liz Woods, horologist David Munro, and machinists Chris Rand and Erio Brown. Most importantly, it worked — and led to the next phase of the Clock of the Long Now project, a long road indeed.



From Prototype to Monument

Building a fully mechanical 8-foot clock from scratch is one of those tasks that makes you marvel at your accomplishment, then wipe the dust from your hands and crack open a very old bottle of whisky. But if your next task is building one 25 times larger, you'd likely need a few dozen casks more of that very old spirit to dull the ulcers and pounding headaches.

Location: West Texas, underground (permanent installation); Mount Washington, Nevada (possible 2nd site)

Height of clock: 200 feet

Primary materials: marine grade 316 stainless steel, titanium, ceramic

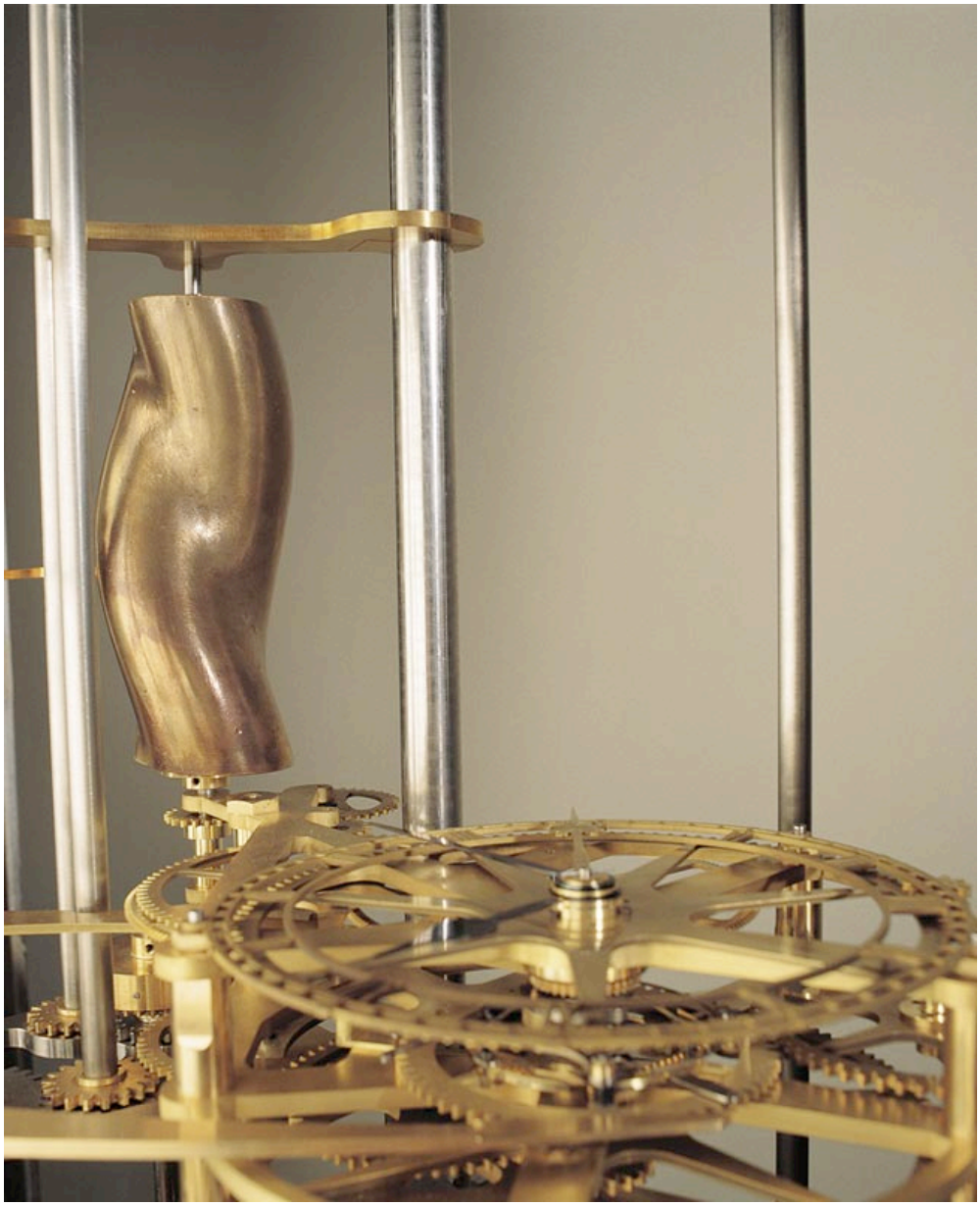
Counterweights: 10,000 lbs (each)

Gears: 1,000 lbs (each)

Number of chimes: 3,560,000 over 10,000 years

It's one thing to talk about the sheer scale of the project, but even if the clock were small enough to fit on your living room coffee table, how in the world would it last and continue to operate accurately and reliably for the next 10,000 years? The small-scale prototype only provides an indication of how the overall design will operate. Taking it to the 200-foot height of the full-sized permanent 10,000 year clock is a task not just bigger in scale but far more arduous and lengthy. Thankfully, that work has already begun. The Long Now Foundation started building the full-sized version in 2009 in a remote location in the Texas mountains near the town of Van Horn — on land owned by Jeff Bezos, himself.

The location of the permanent clock must fulfill certain critical requirements. It can't simply be an available and sufficiently sizable parcel of land that is publicly accessible. It has to be fairly free of moisture and damaging elements so the parts are minimally subjected to corrosion. It must be accessible but also remote enough to prevent anyone from intentionally vandalizing the clock. Vandals don't do day hikes. Another important aspect is that the surrounding natural life has to reflect longevity. You can't, after all, install a man-made clock in a location where natural life hasn't stood the test of time. In Texas, Creosote bushes have shown rings that test at about 11,000 years of age. The bushes reproduce around the old organism that dies, hence producing the rings. The second site in Nevada fulfills the three requirements, as well. The location is surrounded by Great Basin National Park. The park happens to house a number of dwarf Bristlecone pine trees that are purported to be 5,000 years old – lending credence that the clock could actually survive there, too. Whether or not the Nevada site is pursued for a second clock installation remains to be seen and is dependent on additional funding.



One look at the clock's design and you'd have to admit it seems at least partially inspired by the eye of Sauron. The clock's huge display, eight feet in diameter, houses six dials that represent the year, century, horizons, the position of the sun, lunar phases and the stars. The clock itself powered by two large helical weight drives, which flank the clock and rewind via spiral coils. A huge torsional pendulum at the base and a solar synchronizer, which calibrates the clock based on solar noon, provide the actual timing. They work together by operating off solar time and absolute time, using an Equation of Time Cam — which looks less like a manmade mechanism and more like something pulled from the bottom of the ocean floor, a la Neptune's Playdoh.

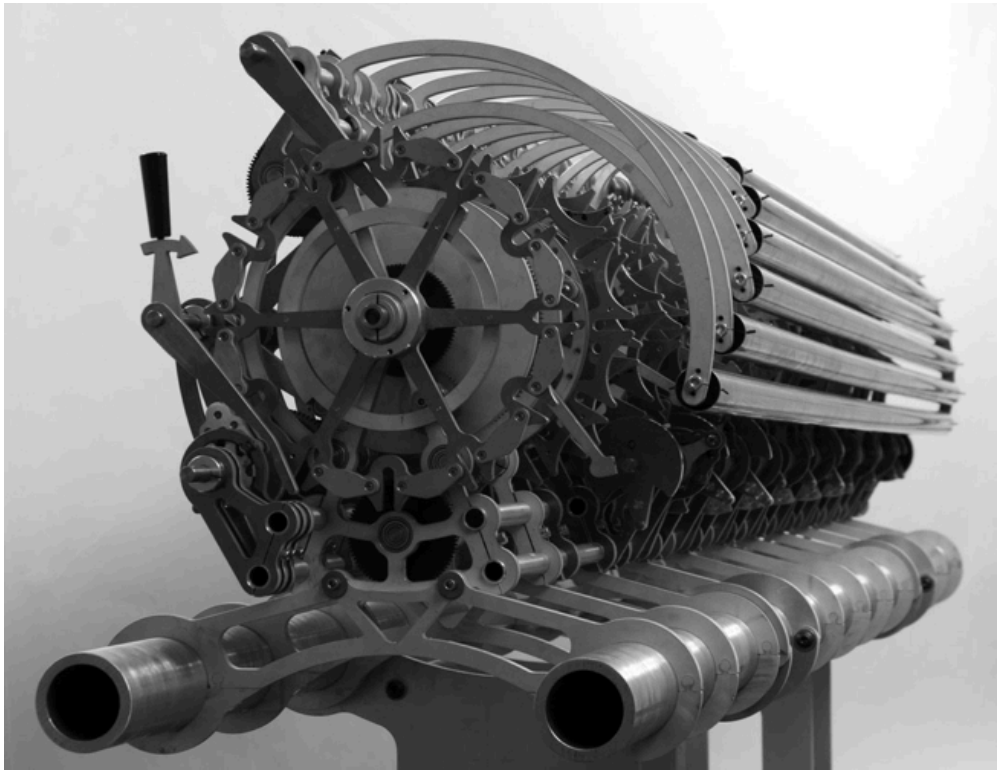
It's safe to say that your highfalutin wristwatch doesn't have one of those. Since the earth's orbit isn't perfectly round, instead moving in an elliptical fashion, variations in the absolute time kept by the pendulum and solar time is plus or minus 15 minutes per year. Over ten thousand years, that's some serious inaccuracy. The Equation of Time Cam measures the difference between solar and pendulum-kept time and re-calibrates the clock. It even incorporates the wobble of the Earth's axis, as well as the loss of its rotational speed by about 1 second per century (will anyone miss that part?). This means the clock will be accurate within one day in every 20,000 years — which amounts to nearly 400 times better accuracy than a timepiece that's off one second every 24 hours. Now that's an impressive work of timekeeping; what's more, this accuracy can be maintained without human intervention.

So, how does the large display actually function? The timekeeping display is composed of Serial Bit

Adders (which reduce friction and are more accurate than standard gears) and the dial itself. The pendulum at the base of the clock provides timing that's converted by the adders using binary mechanical system, which causes changes in the dial. The dial was designed to be readable by just about anyone who comes across it — so languages and Roman numerals are absent. It has been kept visually simple just for that purpose, but an actual manual is included (don't lose this one), just in case.

ONE LOOK AT THE CLOCK'S DESIGN AND YOU'D HAVE TO ADMIT IT SEEMS AT LEAST PARTIALLY INSPIRED BY THE EYE OF SAURON.

The binary-mechanical gearing for the huge clock involves 20 horizontally stacked gears, each one weighing 1,000 pounds. Technically known as Geneva wheels or Geneva drives, the gears modulate time calculation and display as well as initiating the chiming of the clock. They essentially comprise a high-tech and simultaneously rudimentary computer — this in that it possesses 32 bits of accuracy while only being powered by the sun and human power. That human power is required to helm a winding wheel. Those humans who happen upon the clock and surmise to wind it will execute this exercise in a virtually silent environment (unless they bring their iPhone 5005s), accompanied only by the ticking of the clock's huge 300-pound titanium pendulum. So large is the pendulum that it takes ten seconds for it to make a full swing.



The silence will only be broken by human speech and by one of the note combinations in the clock's chimes. The chimes were designed to be wholly unique each time they are played and; no melody will repeat within the 10,000 years, or at least that's the intent. In actuality, the chimes will run a bit short on tunes, given that there will be about 3,560,000 different chime combinations available on the clock — about 90K short of the required unique chime for each day of the 10,000 years. But who's counting?

WELL, THE CLOCK HAS BEEN DESIGNED TO BE ACCURATE WITHIN ONE DAY IN EVERY 20,000 YEARS — WHICH AMOUNTS TO NEARLY 400 TIMES BETTER ACCURACY THAN A TIMEPIECE THAT'S OFF ONE SECOND EVERY 24 HOURS.

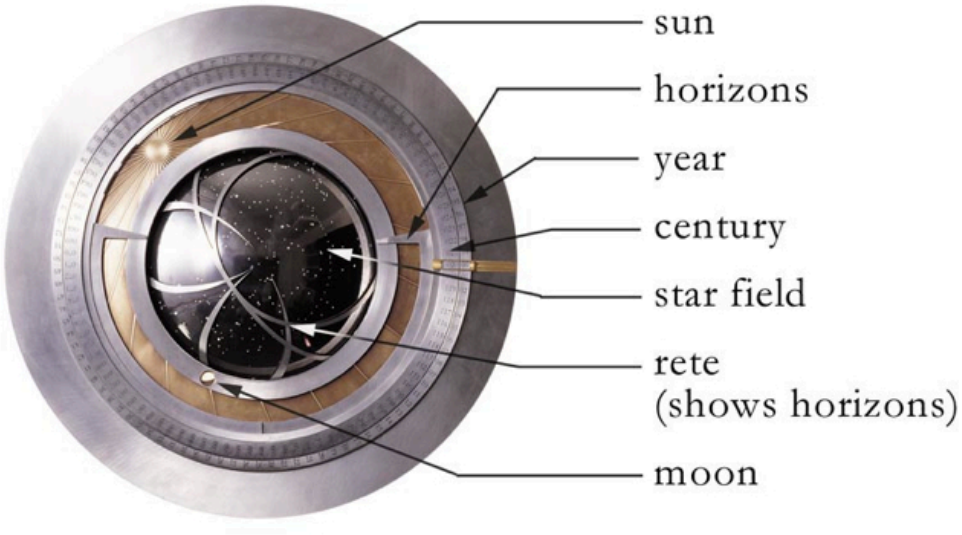
Humanity's Timepiece

A huge factor in the design of the clock is perhaps its most basic. What power source would the clock require? Myriad options presented themselves to the team: wind/water, geothermal energy, radioactive decay, or perhaps the easiest, electronics. But none of those options appealed to Hillis, since his original thought behind the clock involved human participation and influence, thereby provoking long-term thinking and a mankind-driven legacy. In light of that premise, if the clock relied on an 'automatic' power source, what degree of involvement would humans actually have in its perpetuation?

So, Hillis decided that his creation should be kept in operation by a reliable source, but still wound by human hands to ensure responsibility for its operation. The temperature difference between daylight and night translates to thermal energy that's transmitted to the clock via metal rods and can keep the clock ticking even if no one visits for long periods of time. Even without human involvement, the clock will continue to keep time using thermal energy from the temperature changes and stored energy from sunlight, as well as using the sun's position for calibration.

In that case, what will people accomplish when they wind the horological behemoth? Well, humans participation allows our future children, children's children, and so on and so forth, to actually view the time on the clock's dial, as well as keep the chimes ringing. But the "handwinding" takes a certain amount of work, which is all part of Hillis's intent. It will take at least two people (or someone the size of Andre the Giant) to wind the clock, thereby lifting the 10,000 pound, VW Beetle-sized counterweights.

If any of us is around when the Texas timepiece is completed and ready for visitors, what might we expect to experience on our quest to the clock? After an arduous day's hike to a location 1,500 feet up from the Texas desert floor, we'll find a discrete entrance with a slightly inset jade door. It opens to a second door, made of steel, both of which are meant to keep out the elements and the critters. The nearly lightless 500 foot vertical tunnel is only partially lit by daylight at its very top. We ascend the stone spiral staircase that has been specially designed and cut into the rock around the timepiece. The first evidence of the clock we'll find is its huge counterweights. Then we'll encounter the winding station, essentially a big turnstile that (remember now) takes at least two people to wind. Once the turnstile stops, the gears that drive the chimes are wound and ready to resound in the chamber for our ears only. Those before us have heard these tones, and those coming after for thousands and thousands of years will, too.



Our hamstrings will endure further punishment as we scale more stairs to pass the gears of the clock, which calculate the chimes and permute in a combination for only us. As we approach the top of the tunnel, we near the end of our journey. We finally find the beautiful face, which displays not just the time, but also the cycles of astronomical time, the pace of the planets and stars and, finally, the procession of the Earth in "galactic time". But to update the actual displays on the large 8-foot dial, we'll need to do a bit more winding, this time on a smaller scale and with less effort than our earlier workout. This being done, the current date and time will magically appear on the dial. We've done our part.

It will be impossible to mistake the clock for a simple gimmick or passing fancy; it's not some amusement park or a booth at a local carnival. The Clock of the Long Now is a bold statement by and for the human race, and our participation is both key in its operation and but an inconsequential blip in time. Hopefully, we will have marveled at the clock's ingenuity, participated in its perpetuation and deliberated over the significance of the legacy we will leave in the broad scheme that is all time.

So, what's the expected completion for the build in Texas? Nothing's been set and any commitment to a timeframe would be tantamount to insanity, given the scale and complexity of the project. The work isn't letting up, and even though the design of the clock is completed, the legwork is still in the fledgling stages. Clock components are in the build process, the 500 foot deep shaft has been cut and a custom-designed stone stair-cutting robot works to build the intricate and long descending spiral staircase. As the clock parts make their way to be permanently housed in the Texas site, it will be the next phase of what could be the most amazing man-made wonders of our time.

In the current and somewhat alarming culture of fast food, smart phones and immediate gratification, it is quietly comforting to see a group of minds and hands come together to bridge past, present and future time in a project that will emblazon an horological icon in the annals of history. It is our own fascination with timekeeping, as well as the artistry and brilliance of man, that fuels our passion for this remarkable endeavor. We hope to see more progress in the Long Now Clock in the coming years and hopefully in our lifetime; and one day that we, or our children, will make the trek to this monumental achievement to humanity.

Learn More: Here

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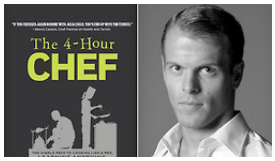

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