11/29/2017

Team 18: The Centennial Calendar

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1.1 Project Scope

Project Description

A prototype of a non-electric, mechanically driven mechanism which accurately measures the date for 100 years.

Key Goals

Mechanical powered movement, minimum maintenance, accurate, aesthetically pleasing, visible.

Stakeholders

- Advanced Manufacturing Training Center at Tallahassee Community College
- Sponsors (Amy O'Donnell, Robert Parsons, David Sellers, Rick Frazier)
- Team Members (Zachary Brower, Michael Patrick, Alyna Segura-Sanchez, Jacob Williams)
- Tallahassee Community
- Horologists
- Power System Engineering Industry
- Power Industry
- Future Senior Design Teams that continue forward with this project

The main stakeholders involved in the development process of the Centennial Calendar Project are the Advanced Manufacturing Center at Tallahassee Community College, the project Sponsors which include Amy O'Donnell, Robert Parsons, David Sellers and Rick Frazier, and the design team which includes Zachary Brower, Michael Patrick, Alyna Segura-Sanchez, and Jacob Williams. Additional stakeholders without a direct involvement in the project are future senior design teams to take over this project, horologists, power system engineers, the power industry, and the Tallahassee Community College, who will view the final product for years to come.

Assumptions

Assume availability of tools including a machine shop and design software. Also assume little to no maintenance is done on the calendar mechanism. Assume the mechanism and energy source will not be tampered with while on display. Assume the entire project is reasonably sized and able to fit through a doorway. Assume future senior design teams will take prototype and continue with improvements.

Market

Team 18's primary market is the faculty of the Advanced Manufacturing Training Center since the Centennial Calendar will initially be solely utilized by them in order to keep track of the date so they will know when to open their time capsule. Team 18's secondary market pertains to clock manufacturers and clock aficionados world-wide because a self-sustaining clock that is able to accurately display time for 100 years would be new technology that would appeal to both groups.

1.2 Customer Needs

Coming Up with the Needs

Prior to meeting with the sponsor, initial design parameters were distributed online and background research was conducted by team members. The initial design parameters were vague, unclear and did not present sufficient information. Therefore, our team met with the Centennial Calendar sponsors to present a list of questions and expectations to identify and confirm specific parameters.

Documentation of Customer Needs

Customer needs are initially determined by asking the sponsors questions pertaining to design parameters, typically in a group meeting. Example questions that were asked in the first group meeting can be seen below.

- How accurate does the calendar need to be?
- What does “non-electrical” specifically mean?
- Are there any size restrictions?

Their answers are then transcribed onto paper by the members of Team 18. From there, the sponsor’s words are translated into customer need statements that allow for more direct association to the desired goal while using engineering terminology. These needs can then be used as a starting point for the design process. Finally, these translated phrases are then organized into a table. The result of this process is seen in Table 1 on the next page.

Table 1

Customer Needs Translation Table

Question/Prompt	Customer Statement	Interpreted Need
Typical Uses	I need a mechanism that works with no electrical input.	The mechanism is powered using only mechanical processes.
	I want a mechanical calendar that is accurate to one day.	The mechanism accounts for leap years and non-leap years.
	I want the mechanism to be aesthetically pleasing.	The internal workings of the mechanism are visible to the viewer.
	I do not want the mechanism to be costly.	The mechanism uses cost-effective materials without sacrificing quality.
Likes	I like the layout of the traditional calendar.	The mechanism displays a traditional American date.
	I would like the mechanism to be self-sufficient.	The mechanism is compact and is powered alternatively.

1.3 Functional Decomposition

After clarifying the customer's wants and needs, the specific requirements and specifications of the calendar must be determined. To accomplish this, the flow chart in Table 2 was created based off the interpreted customer needs from Table 1. Using the interpreted needs, the most important aspects of the mechanism were determined. For example, one of the interpreted needs mentions that the calendar must account for leap years. From this need, it is clear that the time-keeping mechanism plays an important role within the entire mechanism, so one branch was created specifically for the time-keeping mechanism. The other branches were determined in a similar fashion, except for encasement. While the customer needs do not specifically mention the mechanisms encasement, it was deemed an important aspect since the placement of the calendar had not yet been determined, and could potentially be placed indoors or outdoors.

From each of the main branches, we determined what specifics of the customer needs applied to these aspects of the mechanism and branched those off from those aspects. The needs were interpreted further in order to assign units to each sub-branch. These numbers were chosen off of average power consumption values in standard grandfather clocks. The finished design for this project will likely run on a much lower amount of power simply due to the efficiency needed to run the device for 100 years, but these numbers at least provide a rough base line. Moreover, the metric chosen for the tamper-proofing, TL-40, is a standard used in determining the resiliency of gun safes from mechanical and electrical tools. This particular rating insinuates the device can withstand 40 minutes of continuous abuse from typical handheld mechanical and electrical tools. Similarly, the metric for the weather-proofing is based off the international ingress protection scale. The IP-55 rating guarantees a minimal amount of ingress from dust particles, at least not enough to compromise the internal workings, and no ingress of water from small jets of water hitting the encasement from any side. In the end, the device will very likely be hermetically sealed this weather-proof rating should be easily surpassed.

After reviewing the customer needs, it was determined that some of the specific customer needs applied to multiple branches. In order to view the requirements for the mechanism in a more organized fashion, a table was created from the flow chart, as can be seen in Table 3. Since some sub-branches applied to multiple main branches, the main branches were placed in one column at the top of the table and the sub-branches were placed in a column on the left side of the table. The metrics assigned to the sub-branches were placed on the right side of the table. Checkmarks were placed in the boxes where the main elements of the mechanism and the specific requirements matched up in the flow chart. This reorganization allowed for a better understanding of how the mechanism should function.

Table 2

Functional Decomposition Flow Chart

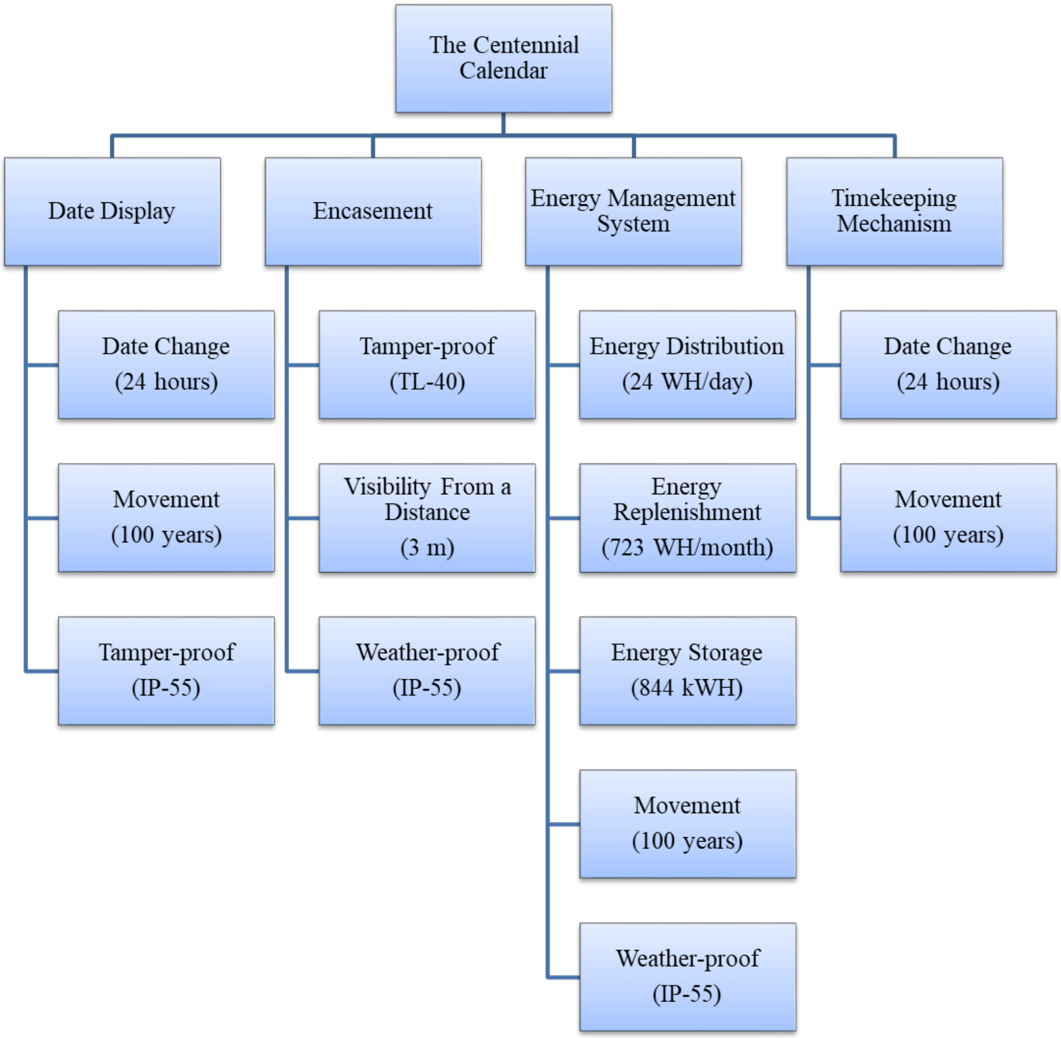

Table 3

Functional Decomposition Table

	Date Display	Encasement	Energy Management System	Timekeeping Mechanism	Metric
Date Change	✓			✓	24 hours
Energy Distribution			✓		24 WH/day
Energy Replenishment			✓		723 WH/month
Energy Storage			✓		844kWH
Movement	✓		✓	✓	100 years
Tamper-proof	✓	✓			TL-40
Visibility from a Distance		✓			3 m
Weather-proof		✓	✓		IP-55

1.4 Target Summary

Table 4

Target Summary

Metric	**Measure**	**Target**
Life span of power supply	Time	100 years
Weather-proof rating	Durability	IP-55
Maintenance interval	Reproducibility	0

1.5 Concept Generation

Concept generation, the process of accumulating the ideas in a project, is one of the most crucial steps in the engineering design process. Beginning with customer needs and targets to specify parameters of the project, a series of project ideas are collected from which a final design is decided upon. This process is important because it considers some possible solutions to a problem that can be hard to initially define.

Due to the abstract thinking required to generate concepts, much time was needed. Team 18 has spent considerable time and effort to consider questions and possibilities, examining advantages and drawbacks of each solution. This thought process created the multiple concepts below.

The Centennial Calendar consists of two main systems: the source of power generation and the clock mechanism. In an effort to promote simplicity only concepts concerning the mode of power generation are included. A total of five concepts are included. These concepts range from potentially usable designs to designs removed for their ineffectiveness. In an effort to document the decision-making process and justify the usage and advantages of good designs, the unusable designs are described.

Concept 1.

Atmos Clock

An Atmos clock is a mechanical torsion clock which requires no external power source to run. In other words, there is no need to wind the mechanism or reset a suspended weight by hand. The clock is instead powered by minute changes in atmospheric temperature. A semi-rigid pressure vessel, or capsule, containing some gas expands and contracts with changes in ambient temperature throughout the day. Modern Atmos clocks use ethylene chloride gas as the medium of expansion because it has properties of thermal expansion which allow it to expand and contract in changes of temperature as low as 1° C. This chamber of now-expanding gas is connected to a chain which winds the mainspring in the clock. The movement is similar to that of a bellows. The chamber slowly expands and contracts over the course of the day as the temperature changes. This reciprocating expansion and contraction of the capsule effectively winds the mechanism allowing it to sit unattended and unmaintained for many years at a time while still keeping an accurate time. The figure below illustrates this principle.

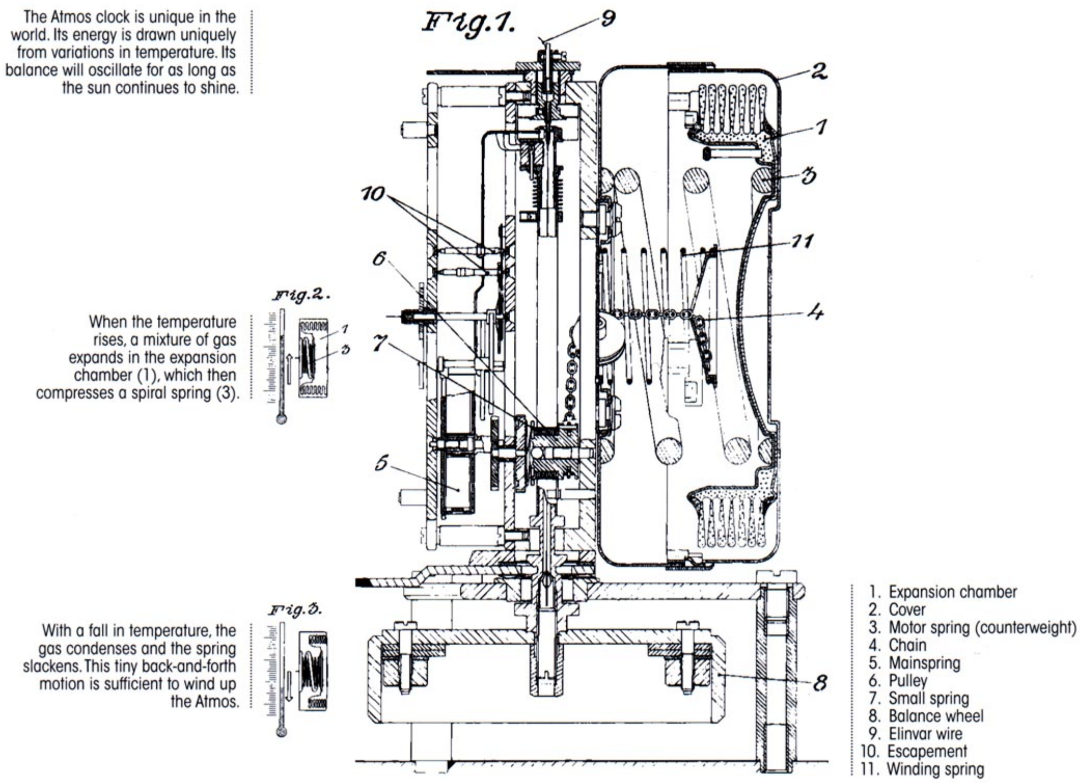

Figure 1. Diagram of an Atmos clock (note the pressure vessel with the chain attached to the torsional spring).

An early example of such a mechanism is the Beverly Clock. An early prototype of the Atmos clock, the Beverly Clock has a pressure vessel that expands and contracts with changes in ambient air temperature. This clock uses a falling weight which is periodically reset by the reciprocating motion of the pressure vessel unlike the Atmos clock which uses a torsional spring.

Concept 2.

Bimetallic Strip

A bimetallic strip converts a temperature change into a mechanical movement. Generally, the strip is made of two different metals which expand at different rates under heat. These strips, most often steel and copper, are riveted or welded together. The differing rates of expansion force the strip to bend a certain way when heated and bend the opposite way when cooled. The metal with the higher coefficient of thermal expansion is the one on the outside when heated. This phenomenon can be seen in the figure below.

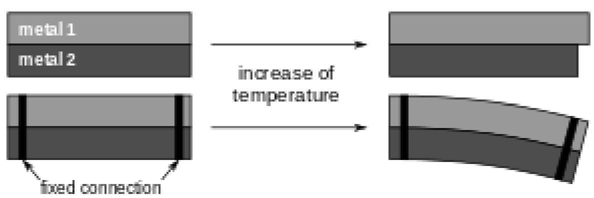

Figure 2. Bimetallic strip diagram showing the difference in thermal expansion of two different metals.

Bimetallic strips are already used in some clock mechanisms to keep the timekeeping mechanism accurate. A different usage of the strip in a clock is one similar to that of the Atmos clock. In this particular instance the strip takes the place of the semi-rigid pressure vessel. The strip, under oscillatory heating and cooling conditions throughout the day, will bend back and forth. This strip is attached to a chain which winds a torsional spring or resets a counterweight. Using changes in ambient temperature as a source of power generation is a potential solution because changes in temperature are consistent enough to cause the strip to move and the amount of energy harnessed by winding the mechanism or resetting a weight is more than enough to power the clock movement for a day.

Concept 3.

Rainwater Collection Device

One concept which is currently being considered is a rainwater collection device. Rain is a natural and consistent source of energy which already exists. Harnessing rainwater ensures that the system will have a power source for as long as it runs. Rainwater is also an ideal source of energy because it is a non-harmful substance which is easy to collect and use. This ensures that no dangerous substances will need to be discarded at any point in time.

One way we can utilize the power of rain is by creating a type of reservoir which could collect and catch the rain as it falls. This reservoir can be connected through a ratchet-like device which in turn can be attached to a main spring, which runs the mechanism. The reservoir can act like refillable weight, with the rain filling up the reservoir to create the weight. The reservoir could be on a seesaw like device which connects via an axle to the ratchet. One side of the device would be the reservoir and the other side would be a small weight or handle. This will act like a wind-up key, where the spring is wound when the water fills the reservoir enough to turn the axle connected to the spring. As the spring continues to unwind and run the entire system, the reservoir turn-key will slowly rotate back around, and the water will either fall out or evaporate. Once the turn-key device rotates back around, rain will eventually fill up the reservoir again and the process will repeat, continuously providing energy into the system over the course of its lifetime.

While using a naturally reusable power source is a potential solution, there are a few difficulties which might be encountered when implementing this concept. While rain patterns can be somewhat predicted using current technology, these predictions are not always accurate.

The main spring will have to store enough energy to run the calendar during the periods between rainfall, or there will need to be another power source for the calendar to use if there is no rainfall for a long period of time. Using water also means that part of the system will need be open to the elements. This could potentially cause rust or leaks into the rest of the system, if the system is not sealed properly. The turn-key device will also have to be strong enough to withstand storm or hurricane rain and wind since it must be exposed to the elements. These are the things we are considering before implementing this concept.

Concept 4.

Magnet Return System

Knowing that permanent magnets, such as neodymium, retain their magnetic prowess for extreme lengths of time, a system that utilizes these permanent magnets to raise the height of ferromagnetic objects seems promising. These raised ferromagnetic objects could then be dropped in order to harness their kinetic energy, and then be raised back up to their original height by the permanent magnets in order to be dropped again. This cycle could theoretically continue endlessly, allowing for a near infinite energy source, at least until the permanent magnets lost their magnetism.

Neodymium magnets in particular lose their magnetic prowess at a rate of around one percent over the course of 100 years. Therefore, they would likely be the permanent magnet utilized if a system such as the one described above were to be implemented. The ferromagnetic objects would be heavy in iron content so as to be easily influence by the magnetic fields created by the neodymium magnets, and their shape would be spherical so frictional forces of the moving object will be at a minimum. These iron balls would start at a raised height and be dropped onto a device that would store the kinetic energy, likely a seesaw type device that has a spring underneath the side of the fulcrum in which the iron balls would hit. This spring would be connected to a flywheel in order to extract and move this kinetic energy to the energy storage system of the Centennial Calendar for later use. After the balls fall and hit the seesaw, they would be funneled into a tunnel composed of neodymium. This tunnel would focus the magnetic field in the center of the tunnel and would pull the iron balls from the bottom funnel back to their starting point at the top of the device. Figure 3 roughly visualizes how this system would be laid out.

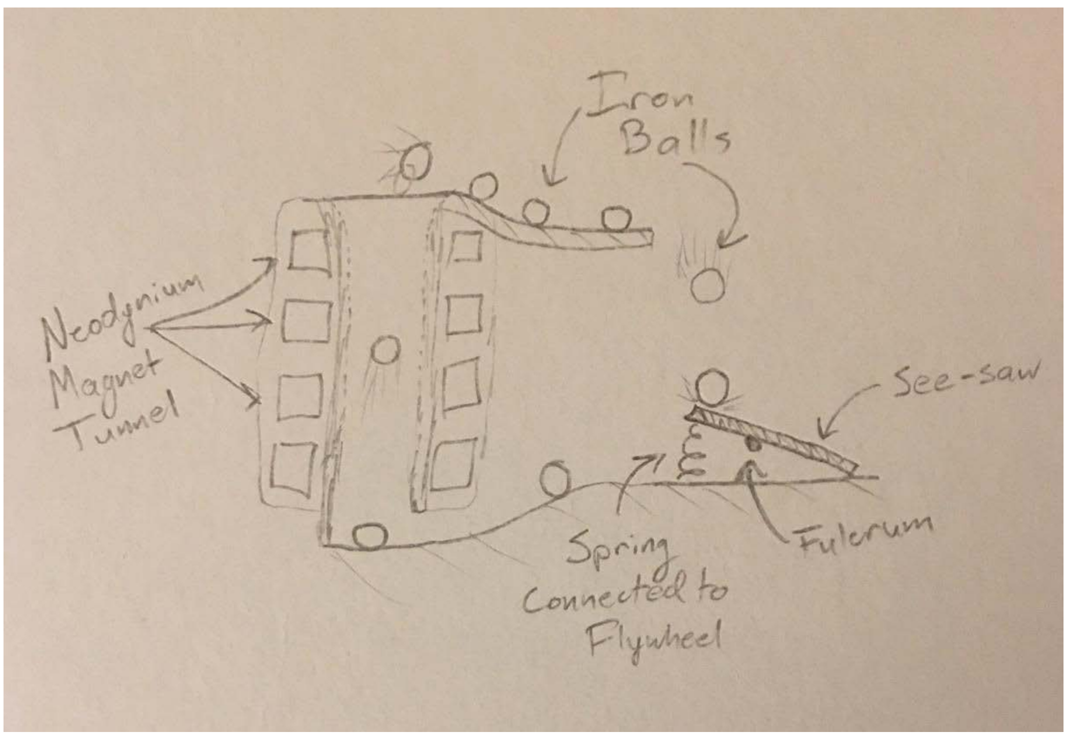

Figure 3. Rough sketch of the magnetic return system and the path the iron balls would take.

The main issue with this device which hinders it from being fully implemented, is its inconsistency with returning the iron balls to their starting location at the top of the device.

Unless the center of mass of the iron balls could be perfectly aligned with the center of the magnetic field produced by the neodymium tunnel, they will shift to one side of the tunnel and simply stick to the magnets. This will completely stop the mechanism, not allowing for any energy to be harnessed. Since this mechanism needs to run constantly for 100 years, the likelihood of the iron balls being attracted to the wall of the tunnel at some point due to an imperfect alignment is far too high to consider it as a reliable source of energy in the Centennial Calendar. Because of this, the magnetic return system will not be utilized within this project.

Concept 5.

Perpetual Motion

One of the major concepts we have considered is the use of a spinning wheel. The idea of a spinning wheel is appealing because it will allow the calendar to have continuous input, which could potentially wind a spring or turn a gear in order to keep the calendar running continuously.

The first wheel power source that we are researching is the flywheel battery. The basic concept of a flywheel battery is a cylinder which is suspended on an axle, as can be seen in Figure 4. A flywheel can be spun at high speeds in order to create or store energy. In essence, a flywheel is an electromechanical battery. Currently, flywheels spin using a motor-generator which both spins the wheel and collects the energy output. Advancements in technology have allowed the flywheel design to be more optimized through the use of vacuums and magnetic bearings. This has led to some experimental flywheels running up to two years without additional energy input.

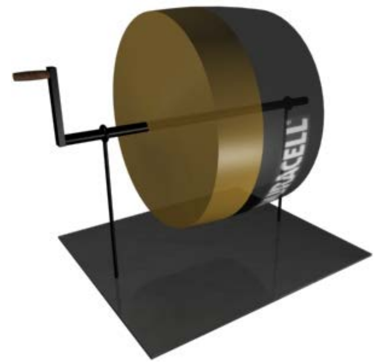

Figure 4. Basic flywheel design.

Since the flywheel battery requires a motor-generator to convert mechanical energy into electrical energy and our system cannot have any electrical components, the electromechanical version of the flywheel has been discarded as an option. The concept of the flywheel, however, has led into the next phase of research, which is perpetual motion. The idea of the perpetual motion wheel is similar to the flywheel battery in that a wheel is turned in order to create energy, but the motion of the wheel is continuously powered by its own mechanical means.

One of the early perpetual motion wheels that has been designed is the Bhaskara wheel, which can be seen in Figure 5. The Bhaskara wheel is made up of spokes attaching from the center of the wheel, with tubes filled with a dense liquid attached to each spoke. These tubes are all placed at an angle to the wheel and are only about two-thirds of the way filled with the liquid. After an initial spin to start the rotation of the wheel, the liquid falls to the bottom of the tubes on one side of the wheel as it rotates. This provides the force needed to keep the wheel spinning. As the wheel continues to spin, the liquid settles to the bottom of the tube until the tube is tipped again, after the wheel completes another revolution.

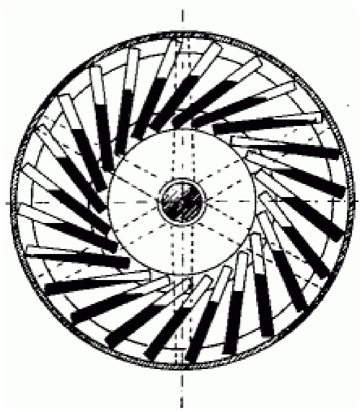

Figure 5. Bhaskara Wheel design.

This version of the perpetual motion wheel has failed, as have many of the other designs explored afterwards. One example being the Articulated Arm Wheel, as depicted in Figure 6, which uses hinged weighted arms, instead of liquid, to swing the wheel every revolution. In the end, none of these perpetual motion wheels work because the system can never output more energy than was initially input into the system, or in other words, there is no gain in the net energy. In addition, neither the shifting masses nor gravitational force do any net work on the wheel, and therefore, the wheel will eventually stop, no matter how well it's designed. It is for this reason that this design has also been discarded.

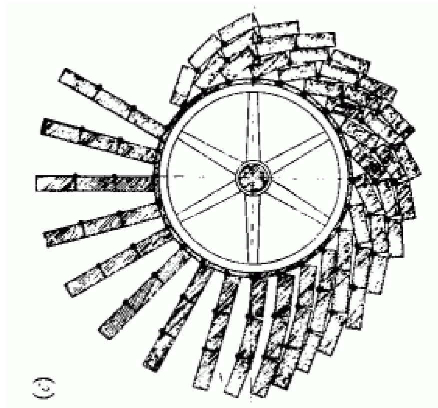

Figure 6. Articulated Arm Wheel design.

The last perpetual motion device that has been researched is the Free Energy Magnet Motor. This idea is, again, similar to the flywheel, in that it can be used to produce electrical energy, but like the Bhaskara Wheel, it can theoretically run forever. The Free Energy Magnet Motor can be created by attaching small magnets, with one or alternating poles facing outward, to a fan or a wheel with spokes. An example of how these motors are often portrayed online can be seen in Figure 7. When a larger, standalone magnet of the opposite pole is brought close to the fan, the small magnets are repelled by the larger magnet and cause the fan to spin. This has turned out to be mostly an online hoax, as the small magnets, no matter how strong or how precisely they are positioned, will always be attracting the larger magnet at some point in the revolution, which quickly brings the fan to a stop. It has been discovered that no instance of perpetual motion has ever been successfully implemented, so the entire concept of perpetual motion has been completely disregarded.

Figure 7. Free Energy Magnet Motor design example.

1.6 Concept Selection

House of Quality

In order to determine which of the subsystems listed in the functional decomposition and their respective characteristics were the most important to the success of the project, Team 18 created a house of quality, which can be seen in Table 5.

From this house of quality, it was determined that a strong emphasis needs to be put into picking the correct materials for both the timekeeping mechanism and the various components of the energy system as a whole. This makes sense that material selection is such a crucial portion in the success of the project, as the device must run for 100 years without degradation of the components in order to ensure the device can last such a length of time. Likewise, a strong emphasis needs to be put into perfecting the accuracy of the date display, as a calendar that cannot provide the correct date is a useless calendar.

Table 5
House of Quality

Legend

Symbol	Meaning
++	Very Strong Relationship
+	Strong Relationship
-	Weak Relationship
--	Very Weak Relationship
▲	Increasing is Better
▼	Decreasing is Better
Darker	Higher Importance
Lighter	Lower Importance

	1	2	3	4	5	6	7	8
1		++			+			
2				++	-	++	+	
3				++	++			
4								
5							++	+
6							++	
7								+
8								

Row Number	Relative Weight	Weight / Importance	Customer Requirements \ Engineering Characteristics	1 Timekeeping Mechanism Material(s)	2 Timekeeping Mechanism Accuracy	3 Energy System Material(s)	4 Energy Dispersion Rate	5 Energy Replenishment Rate	6 Date Display Transition Accuracy	7 Encasement Protection Rating	8 System Size
				▲	▲	▲	▼	▲	▲	▲	▼
1	16.1	5.0	All mechanical workings	9	9	9	9	9	9		
2	16.1	5.0	Keeps accurate account of the date		9				9		
3	16.1	5.0	Runs for 100 years	9		9		9		9	
4	12.9	4.0	Requires no maintenance	9	3	9	9	1	3	9	
5	12.9	4.0	Date displayed is visible from 3m						9		
6	9.7	3.0	Aesthetically pleasing	3		3			3	3	3
7	6.5	2.0	Device fits through 203cm x 107cm doorway								9
8	6.5	2.0	Visible Workings	1		1			1		3
9	3.2	1.0	Signal to notify 100 years have passed		1				1		
			Technical Importance: Absolute	442	332	442	261	303	484	290	106
			Technical Importance: Relative	16.6	12.5	16.6	9.8	11.4	18.2	10.9	4.0

Following these three crucial aspects of the device, the house of quality also tells us that we need to focus on the perfecting accuracy of the timekeeping mechanism accuracy and energy replenishment rate next. The accuracy of the timekeeping mechanism goes hand-in-hand with the accuracy of the date display, the most crucial aspect of the entire device, since the date will change based on information transferred from the timekeeping mechanism of the device. It is then crucial to ensure enough energy is replenished as time goes on else the device can run out of energy and stop working. Energy replenishment rate coincides directly with the energy dispersion rate, the next most important criteria to focus on. If the device uses up energy quicker than the energy can be replenished, failure of the device will be inevitable.

According to the house of quality, two of the least important factors to focus on are the encasement protection rating and the actual size of the system itself. This makes sense, as if we have a perfectly weather-proof encasement that can withstand the Florida elements for 100 years, but no working calendar to put inside of it we will have nothing more than a glorified box. Likewise, the size of this box is unimportant to the overall success of the project. It will be more important for Team 18 to focus on creating a working, self-sustaining timepiece than to ensure the encasement for the workings is reasonably sized and able to last outside in the Florida elements for 100 years.

Decision Matrices

In order to properly determine which of our energy conversion concepts are optimum we first had to determine the criteria in order to rate each system. In order to determine this, we used a decision matrix, as can be seen in Table 6. These criteria were determined from the functional decomposition. Each system must have energy distribution, replenish that energy, store it, and be weather-proof in order to allow the system to operate under normal conditions.

A baseline had to be determined as well in order to rate each system off of. Considering the absence of an existing concept to improve on, a generic hand wound energy system was used as the baseline. This baseline was given a rating of 0 in each category to show that each subsequent energy conversion concept is an improvement to the existing hand winding method. Each criteria is then given a weight, the highest weight being the energy storage because storing the energy produced is paramount, and the lowest weight being the weather proofing because the production and sustainability of energy is more important. The concepts are then rated for each criteria from 0 to 4. That number is multiplied by the weight of the criteria to come up with a final value. These values are added up for each concept to determine the totals. Based on the given weights of each criteria and the how well each energy system fulfills those criteria from 0 to 4, 4 being the highest weight, a higher total value means the system fulfills the criteria more effectively. From the decision matrix in Table 6, it can be determined that the Atmos clock is the most effective model as an energy conversion system.

The criteria specified above are consistent with the HOQ. The most important criteria concern the energy distribution, replenishment, and storage and the HOQ reveals that some of the most important criteria are the energy replenishment and energy dispersion. The least important criteria according to the HOQ is the encasement. This is also consistent with the decision matrix because weather proofing is listed as the least important criteria.

This selection is also consistent with our predictions. The Atmos clock rates far above the other concepts due to its ability to store and distribute energy well and consistently replenish it over the course of a day. The magnet return system is the lowest scoring system due to its inconsistency in its magnet return.

Table 6

Energy Conversion System Decision Matrix

Energy Conversion System						
Criteria	**Baseline (Hand Wound)**	**Weight**	**Atmos Clock**	**Bimetallic Strip**	**Rainwater Collection**	**Magnet Return**
Energy Distribution	0	3	3	3	3	3
Energy Replenishment	0	2	4	4	1	0
Energy Storage	0	4	2	1	3	1
Weather proof	0	1	4	0	0	4
		Total	**29**	**21**	**23**	**17**

The timekeeping mechanisms were rated in a similar fashion, as can be seen in Table 7. A standard clock is used as the baseline and the movement is given the highest weight because the mechanism must move in order to operate. The concepts rated are the horizontal floating gears and the hourglass. Both concepts were given the same rating. However, we determined that the most important concept and the one that we will likely pursue is that of the horizontal floating gears. This is due to the consistency inherent in solid gears and potential inaccuracy associated with a fluid keeping time in the hourglass.

The most important criteria gleaned from the HOQ is the accuracy of the timekeeping mechanism. This is reflected in the decision matrix in the movement and date change criteria. Keeping the mechanism accurate is crucial due to its inherent relation to the date display which is important in order to conform to our needs.

Table 7

Timekeeping Mechanism Decision Matrix

Timekeeping Mechanism				
Criteria	**Baseline (standard clock)**	**Weight**	**Horizontal Floating Gears**	**Hourglass**
Date Change	0	1	2	2
Movement	0	2	2	2
		Total	**6**	**6**

1.7 Spring Project Plan

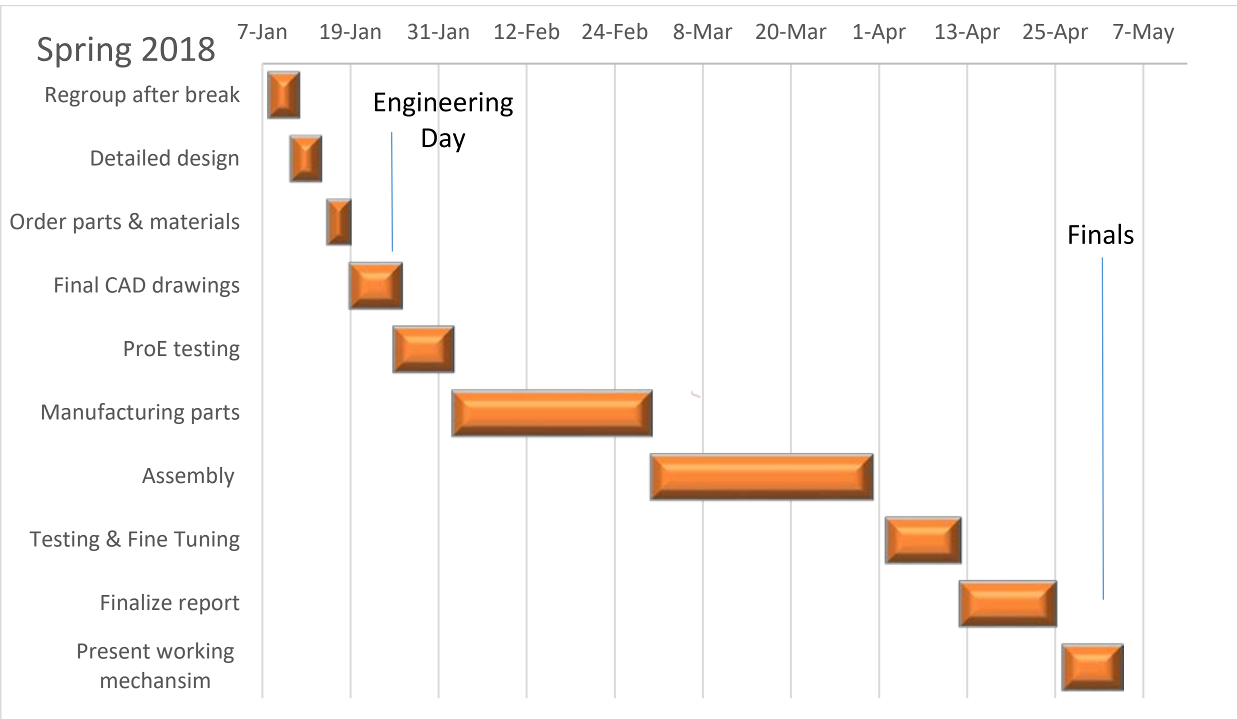

Figure 8. Gantt Chart Spring 2018

In the Gantt chart, which can be seen in Figure 8, milestones and deliverables are arranged into a time line as a visual aid to help determine our plan for next semester. These parameters have been specifically chosen and dated to appropriately space out the time from the start of the Spring semester through Graduation in May. During this time period, many steps are required to ensure a working, finished prototype. As the visual aid shows, the middle of the semester is flooded with two major tasks: manufacturing parts and assembly. This is due to the fact that finding free time to work in the shop with every other group's project will limit our availability of time and resources. Team 18 has pre-planned for this limitation and will be sharing workshop time at Tallahassee Community Colleges Advanced Manufacturing Training Facility, where our sponsor is employed as a master machinist instructor. This partnership is very beneficial to us because the shop at AMTC is far more outfitted and updated than the FAMU-FSU College of Engineering machine shop. Assembly is also a mass time expenditure and is very important to the calendar performing accurately. No matter how precise the manufacturing process is or how durable the material is, if the assembly is not done carefully with attention to detail, the device will not perform with precision or accuracy.

Following winter break, Team 18 met to discuss current mechanism designs in order to move forward. We have determined it would be more timely to order a clock to keep track of time and to purchase plans of a display instead of designing these items ourselves. The clock will come preassembled and the display will be manufactured via laser cutting and 3D printing from dxf drawings. A simple material analysis may be sufficient enough as far as the design is concerned. Although, we intend to run the prototype at an accelerated rate. We are doing so to allow for future enhancements to be made by future design teams where they are necessary. It is important to have a mechanism that works as intended and have discussion on materials for future work. The design needs to be complete and correct. Any error in manufacturing could be detrimental to the project by reducing the amount of time we have to assemble and test. The testing is extremely important because it will include a predictive analysis of how long our given mechanism will last under certain conditions. This will also serve as a useful tool to verify the mechanism's operation and power consumption. The finalized prototype will be shown at the last design review to illustrate its operation and serve as a presentation tool. After which, the accelerated testing of the prototype will begin.

As of now, only $50 of the $2000 budget has been spent. This money has gone to purchasing dxf drawings of a date display mechanism. In the coming days, a mechanical clock will be purchased. In addition, some materials will need to be purchased for laser cutting mechanism parts. Fortunately, 3D printing is free of charge at the Dirac Science Library located on Florida State University's main campus. Team 18 does not intend on spending the totality of the budget allotted by the AMTC. It is imperative we are strict on budget so this project has funding for future design teams.

Appendices

Appendix A: Code of Conduct

Mission Statement

Team 18 is dedicated to promoting a healthy work environment that invokes a sense of trust, respect, and professionalism. All team members will assist to establish and preserve such an environment, as this is paramount in the overall success of this project.

Roles

Each team member is delegated a specific role based on their experience and skill sets and is responsible for all here-within:

Team Leader: Zach Brower

The team leader enables the group to work effectively and efficiently through medium of communication, delegation and organization. The team leader is known as the manager that oversees the project from start to finish and creates realistic deadlines and goals to reach in order to remain on track and in the right direction. The most important job the leader has is communication, for no communication leads to errors and missed deadlines. Communication will be very transparent as the leader will carbon copy “cc” all emails from the sponsor, team members, and faculty members to assure all parties are connected. In communication, the leader takes all parties into consideration before making a finalized decision for the betterment of the project.

Additionally, the team leader is responsible for setting meeting times with the sponsor, faculty, and or group members-- keeping all parties accountable and considered. A composition notebook of all meeting details will be included and signed by the team leader after every meeting. Lastly, the team leader is responsible for team energy, team progress, and project completion.

Lead Mechanical Engineer (ME): Alyna Segura-Sanchez

Oversees the mechanical design processes throughout the project. Lead ME is responsible for keeping track of the design details and adjustments. Takes charge of modeling process, keeps documentation of all design changes and is responsible for gathering together team report

Lead Energy Systems Engineer (ESE): Jacob Williams

Lead ESE is responsible for the design and efficiency analysis of the energy system that will be used in the project. Will ensure lead ME is aware of any alterations made to the design of the energy system. Keeps all documentation pertaining to the energy system.

Financial Advisor: Michael Patrick

The financial advisor is responsible for collecting a record of which all of the money handled for the project is placed. Any money requests must be made to the project advisor. Included with the money requests must be the reason for the expenditure and an account of the cost analysis done on the particular request. This is important in order to review potential cheaper alternatives and save valuable money. This information must be relayed to the team, all of whom must agree on the selection, and then, if the request is fulfilled, order the part. It is imperative that a record be kept of all cost analysis in order to adjust the budget as needed.

All Team Members:

- Will be a devoted team player

- Perform assigned duties

- Advocate for project and team success

- Effectively communicate

- Be willing to consider others ideas

- Respect other team members

- Build off other's critiques

- Act professional

- Relay our work to the public

Communication

Communication between teammates will primarily be done through a group text and at group meetings. The team will also remain in contact through email when electronic documents need to be shared. Any final drafts of electronic documents shared this way must also be uploaded to a Google Drive. This Google Drive will serve as a means for all team related information to be stored. Because the file sharing is being done through Google Drive, all team members are required to have a Gmail account so they may access and alter these files.

To communicate with the sponsors, university emails will be used. The team leader will be responsible for maintaining the primary line of contact between the group and the sponsors, but each member of the team will be carbon-copied onto these emails so as to be fully aware of any conversations. Team members are required to check their emails once a day.

Team meetings may only be missed if members give a 24 hour notice. Missing meetings because of emergencies will be excused. Sponsor meetings are not allowed to be missed by any member who agrees to the meeting time.

Team Dynamics

The students will work together on all tasks and discuss the delegation of said tasks. The students will work on these tasks without fear of negatively voiced criticism. Any criticism should be constructive and any issues a member has with another member will be brought up in a civil manner and discussed. This will prevent “tilt” and allow a separation of emotions from the work being done. The team members will work together in the most effective ways possible in order to stay on task and meet project requirements and deadlines.

Ethics

As an engineer, one is ethically bound to promote safe, fair practice of the specific field the engineer has studied. This ethical obligation keeps the team members working on projects within expertise. For years, this has been the status quo and has been organized into code known as the NSPE Engineering Code of ethics. Team 18 will follow the specific guidelines per NSPE Engineering Code of Ethics.

Dress Code

Team meetings held at the college of engineering have no specific dress code. Sponsor meetings, staff meetings, and group presentations will vary to accommodate each specific circumstance. The dress within these categories range from casual, business casual, and formal at the team's discretion.

Weekly and Biweekly Tasks

Team members will meet at least twice a week to discuss work that needs to be done. These meetings do not include meeting with the sponsor, advisor, and/or instructor. Items discussed during said meetings will include constructive ideas, the budget, and due dates and any subsequent time conflicts. There will also be project updates at each meeting in order for the members to stay accountable and keep track of progress. Minutes will also be taken at each of these meetings which all members will sign in order to log what was discussed and prevent any future disagreements.

Decision Making

A decision is carried out after a majority of the team comes to an agreement. The entire team should participate in making all decisions, unless conflicts emerge. If conflicts arise from a moral/ethical basis, then the morals/ethics will be discussed and a majority vote will decide the resolution. If a conflict of interest arises with a team member, the conflict of interest can remain undisclosed, but the member may not participate in making decisions relating to the conflict. Each team member is expected to act ethically and place the interest of the team before personal preference. Below are the steps to be followed for each decision-making process:

- Problem Definition – Define the problem and understand it. Discuss among the group.
- Potential Solutions – Team brainstorms possible solutions. The solutions are narrowed down to the most reasonable and realistic choices
- Research – Do appropriate research and gather any necessary data needed in order to refine solutions.
- Refine Solutions – Using findings from the Research phase, refine solutions. Discuss within group to again narrow down the refined solutions.
- Design – Design the Refined Solution product and construct it. Re-evaluate for plausibility and effectiveness.
- Test and Simulation/Observation – Test design for Refined Solution and gather data. Re-evaluate for plausibility and effectiveness.
- Final Decision – Review the data gathered from the Testing phase and determine if the solution is appropriate or could be improved. If final solution is unrealistic, or unusable return to the Research or Refine Solution Phase.

Conflict Resolution

In the event of discord amongst team members the following steps shall be respectfully employed:

- Allow concern from both parties to be communicated to the team or those it concerns. Communication includes verbal or visual explanation of points, as well as active listening from all concerned parties, to allow full comprehension of the matter.
- If entire team is present, administer a vote amongst all team members, where majority rules.
- Team Leader intervenes.
- Instructor will facilitate the resolution of conflicts.

Appendix B: Functional Decomposition

After clarifying the customer's wants and needs, the specific requirements and specifications of the calendar must be determined. To accomplish this, the flow chart in Table 2 was created based off the interpreted customer needs from Table 1. Using the interpreted needs, the most important aspects of the mechanism were determined. For example, one of the interpreted needs mentions that the calendar must account for leap years. From this need, it is clear that the time-keeping mechanism plays an important role within the entire mechanism, so one branch was created specifically for the time-keeping mechanism. The other branches were determined in a similar fashion, except for encasement. While the customer needs do not specifically mention the mechanisms encasement, it was deemed an important aspect since the placement of the calendar had not yet been determined, and could potentially be placed indoors or outdoors.

From each of the main branches, we determined what specifics of the customer needs applied to these aspects of the mechanism and branched those off from those aspects. The needs were interpreted further in order to assign units to each sub-branch. After reviewing the customer needs, it was determined that some of the specific customer needs applied to multiple branches. In order to view the requirements for the mechanism in a more organized fashion, a table was created from the flow chart, as can be seen in Table 3. Since some sub-branches applied to multiple main branches, the main branches were placed in one column at the top of the table and the sub-branches were placed in a column on the left side of the table. The metrics assigned to the sub-branches were placed on the right side of the table. Checkmarks were placed in the boxes where the main elements of the mechanism and the specific requirements matched up in the flow chart. This reorganization allowed for a better understanding of how the mechanism should function.

Table 2

Functional Decomposition Flow Chart

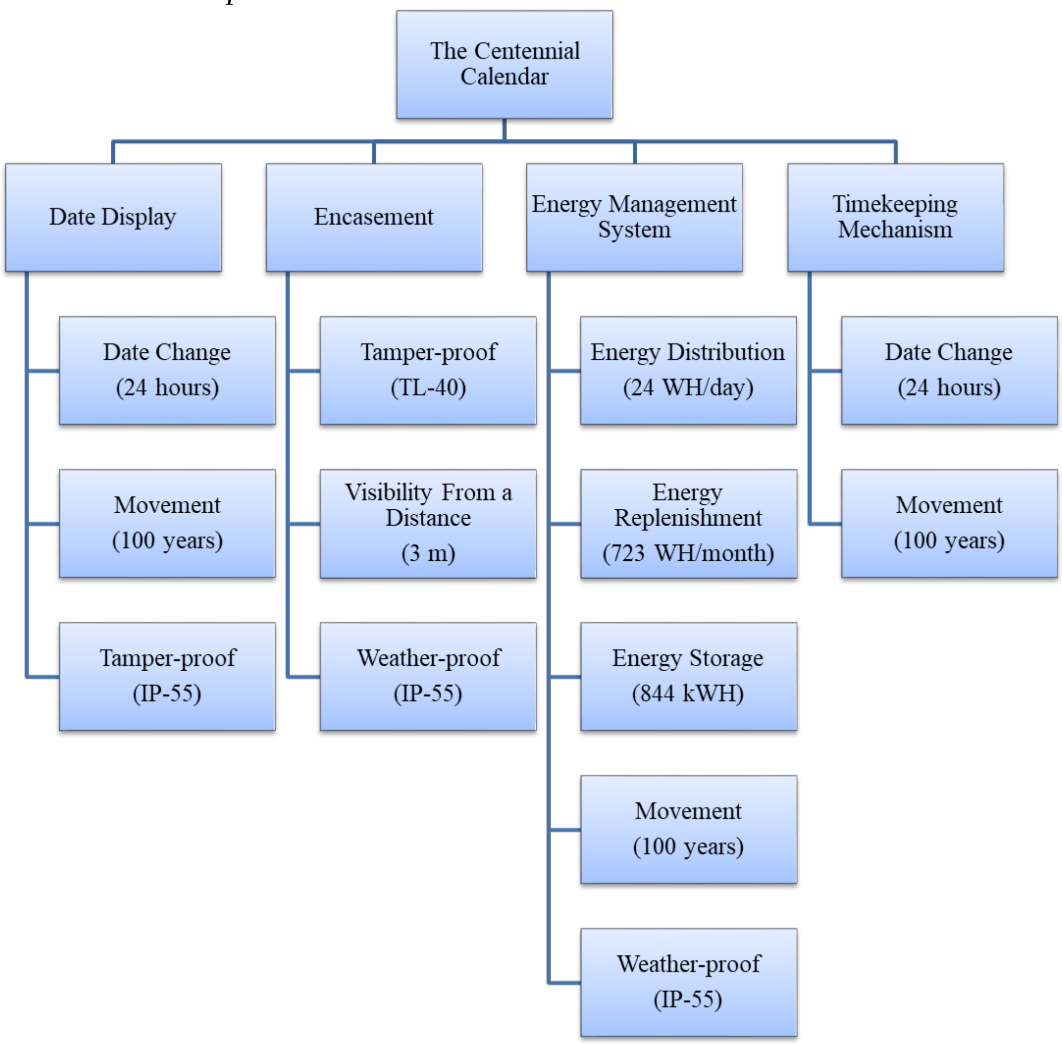

Table 3

Functional Decomposition Table

	Date Display	Encasement	Energy Management System	Timekeeping Mechanism	Metric
Date Change	✓			✓	24 hours
Energy Distribution			✓		24 WH/day
Energy Replenishment			✓		723 WH/month
Energy Storage			✓		844kWH
Movement	✓		✓	✓	100 years
Tamper-proof	✓	✓			TL-40
Visibility from a Distance		✓			3 m
Weather-proof		✓	✓		IP-55

Appendix C: Target Catalog

Table 8

Target Catalog

Metric	Measure	Target
Max allowable error in duration of use	Time	1 day
Life span of power supply	Time	100 years
Weather-proof rating	Durability	IP-55
Maintenance interval	Reproducibility	0
Max mechanism size	Dimensions	Door way
Furthest distance the date is legible	Visibility	3 meters
Organized design	Aesthetics	N/A
Amount of movements per day	Quantity	1
Tamper-proof rating	Durability	TL-40

References

Figure 1

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Figure 2

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Figure 3

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Figure 4

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Figure 5

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Figure 6

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