My inspiration for the learning more about clocks was the exhibit "Ships, Clocks, and Stars." This exhibit was on loan to Mystic Seaport Museum from September 2015 through March 2016.

In addition to the special exhibit, I've had the opportunity to work on an E. Howard Company (EHC) tower clock that was built around 1865. The clock is located in the Greemanville Meeting House on the grounds of Mystic Seaport Museum, Mystic CT. For the remainder of this document, I will refer to the Greemanville Meeting House's EHC tower clock as EHC clock.

After learning much about Gearotics during the design of my chronometer simulation, I decided that I would use Gearotics to document the design of the EHC clock.

GEAR DOCUMENTATION & CREATION

Arbors are consecutively numbered in horological style starting from the “great wheel/ winding drum” up to the escapement. A similar arbor numbering system is used on the strike side starting at the driving arbor on the strike side (Arbor 1S).

The simulation copies gear-ratios and gear diameters of the EHC clock as closely as possible.
Each gear was documented by measuring or estimating: outside diameter or circumference, number of teeth and when possible, inter arbor spacing.

Features of Gearotics that were useful in the development of the EHC clock simulation:

- Created a custom library of gear-pairs (wheel-pinion pairs). This sped up re-building the model when the need arose. These library gears have an extension of .gtlib that are copied into the “Library” folder within the install directory of Gearotics.
- For circular gears the “calculator” button allows one to force desired gear diameters or arbor spacing given the wheel-pinion tooth counts. In my case I measured or estimated the outside diameter of a gear although to really duplicate a gear the diameter of the pitch circle would need to be known. Sometimes I would have to interactively play with the forced wheel diameter and/or shaft spacing to get the desired outside diameters of both gears in a set.
- The freeform placement of sprockets allowed me to couple together the time and strike sides of the model. This coupling is for the “looks” of the simulation. This provided a work around for the need to have the simulation look like it had multiple drivers.
- The ability to rename objects in the Project tree is a very powerful debugging feature when building a large simulation model such as the EHC clock. It enables me to quickly locate parts of the model and turn on/off visibility of items.
- The ability to build custom indicators using a CAD program such as LibreCad and to import them into a simulation via the “indicators” tool. This feature allowed me to add decorative non-gear items such as a vanes, snail, dial faces, etc. These custom indicators are of .DXF format and are copied into the “indicators” folder within the Gearotics install directory.
- Concentric shafts such as found in minute/hour hand of a clock are easy to duplicate using Gearotics commands. The 4:1 and 3:1 reduction gear-pairs in the motion works portion of the EHC clock model were estimated in size based on a photograph of actual motion works. The first set of gears (e.g. 4:1) was created using an estimated diameter of the larger gear and the “calculator” wheel size option. This established an initial shaft spacing between the gears. The second gear-pair (e.g. 3:1) was then forced to the proper shaft spacing using the “Calculator” - shaft spacing option. Move on gear option placed the concentric shafts nearly in alignment. Final adjustment of the concentric shafts used the Gearotics shaft-to-shaft option.

Simulation Approximations / Compromises

- Gearotics defines the “escapement” as the driver of a simulation which is the reverse of real clocks. This probably confuses Gearotics beginners into believing that a pendulum / escapement magically powers a clock.

The power source on a mechanical clock is either a wound up spring or weights that transmits energy to a great wheel/winding drum. A gear train carries the energy from the great wheel/winding drum to the escape wheel. The escape wheel / pallets coupled to the pendulum regulate the energy delivered from the power source. The escape wheel/pallets deliver pulses of energy to keep the pendulum swinging. The length of the pendulum determines the rate of the clock.

- The time side and strike sides of the EHC clock are powered with separate weight stacks. The time side is wound by hand and the strike side has a motor-driven auto-winder so technically speaking there are three power sources in the actual EHC clock.

  Gearotics only allows a single driving source. As mentioned earlier, the "free placement of sprockets" feature enabled the strike side to show motion for simulation "looks."

  The triggering of the strike side uses cam/levers driven off the time side of the clock. This could not be simulated in Gearotics. The EHC clock model's strike side runs continuously driven by a fake sprocket hidden in the Bevel-50T gear that is located on Arbor02.
- The bell is rung using a lever that rides on pins of a cage gear that is located on the strike side Arbor01S. This could not be simulated.
- The strike count is determined by a combination of a rack/pawl arrangement and a lever that rides along a stepped wheel (a "snail"). In the EHC clock simulation, there is no rack/pawl/lever.
- Bevel gear-pairs that lead to the clocks dials have universal joints on both the input and output sides of the bevel gear-pairs. Gearotics does not model universal joints so the simulation's bevel gear-pairs leading to the clock dials have right angle geometries from pair to pair. In the model, the shaft labeled Drive02-45degRun would have been angled upward at 45 degrees, if simulated universal joints had been available.
- The pendulum on the EHC clock is 10 feet long with a 100lb bob. The simulation uses a much shorter pendulum simply to make the simulation easier to view.

The Models

A library of gear-pairs specific to the EHC are labeled by arbor number and whether it is a wheel or pinion. For example the great wheel on Arbor01 drives a pinion on Arbor02 would have a gear-pair named 1W-2P
There are two simulation models related to the EHC clock:

- EHC-MotionWorks – Models the approximate gearing in the motion works of the EHC clock. Motion works takes input from a "minute" shaft and performs the 12:1 reduction to drive an hour hand. There are four dials in the tower, this simulation only models a single motion works with its minute and hour hand.
- EHC-TimeStrike – Approximately models both the time side of the EHC and the strike side. There are some compromises in the design of the model where portions needed to be eliminated or "faked" using custom indicators. These indicators are described in the MyCustomIndicators.pdf file.