This month we begin a new series on autopilots. An autopilot relies upon the integration of many different technologies that have been developed and refined over the years. Among these are the gyroscope, feedback loop, servo amplifier/motor and programmed controller.

The man credited with first integrating these differing technologies is Elmer A. Sperry, who was born in Cortland, New York in 1860. After visiting the Philadelphia Exposition in 1876 and viewing the technology exhibition, he chose the course of his career. He studied Engineering at Cornell University for one year and then embarked upon a lifetime of invention and discovery. The evolution of the autopilot is chronicled through his research and discoveries that are summarized here.

Sperry’s first advance was in the field of electrical generating equipment. He designed an improved electrical dynamo that could produce more current that those of the time. Interested industrialists in Syracuse, New York hired him to build a large generating station to operate the city’s downtown arc lighting system. His most significant contribution was the development of the automatic, electromagnetic regulator based on closed loop feedback control. This control protected the arc lamps from damage when being extinguished. Sperry was 22 years old at the time. In 1883 Sperry moved into the lighting industry, constructing among other things, a 40,000 candlepower beacon atop a tower. As time went on, however, he could not compete with the larger companies, especially with alternating current becoming the power of choice. In 1889, he entered the coal mining industry and developed electrically powered undercutting and punching machinery for coal, an electric powered mine car and patented a method of distributing electricity in a mine. He sold the company to Thomson-Houston Electric and worked for them as a consultant, then began work in Cleveland on an experimental electric streetcar. Thomson-Houston merged with Edison Electric (forming General Electric or GE) and soon thereafter Sperry lost interest in the streetcar and turned his attention to the newly established automobile industry. It is important to note, however, that the patents purchased from him reflected upon Sperry's life long interest in automatic control systems – crucial to the development of the autopilot.

By the late 1890s, Sperry had turned his attention to automobiles, storage batteries and related electrochemistry. From 1901 to 1907, he and a colleague, Clinton Townsend, worked on the development of an electrolytic cell. For a short time after that, Sperry worked on a detinning process. At this point we have an individual who had an incredible knowledge of the electrical industry, numerous patents and projects under his belt. He was also emerging from a nasty series of patent infringement suits and once again was without a company. He changed course and sought another endeavor- the development of the gyroscope. Sperry studied all available literature on this device, from patents at that time back to its invention by Leon Foucoul, in 1854. By combining the newly acquired knowledge of the inherent stability of a gyroscope with his experience in closed loop dynamics from previous work, he had found the solution to the control of machinery in four dimensional space and time.

Sperry quickly took advantage of this marriage of technologies and in 1910 founded the Sperry Gyroscope Company. One year later, he had designed, built and installed the first gyrocompass in the battleship Delaware. By 1915, the gyrocompass was standard equipment on all Navy warships. In 1913, Sperry designed the first gyrostabilized ship, the USS Worden. Also in 1915, Sperry’s son, Lawrence, founded his own company and helped design the first aircraft autopilot. During World War I, Elmer Sperry consulted with the Navy and had close ties with the military in general. Due to this relationship the company emphasized development of military applications of gyroscopic technology. Its focus was on fire control systems, stable gun platforms, and guidance control systems for the aerial torpedo.

The two Sperrys continued to create new products and market their products abroad. Elmer Sperry, due to his respect for the Japanese, set up a distribution operation in Japan that ultimately caused the U.S. problems in World War II. After Lawrence's death in an airplane accident in 1923, Elmer continued with his work until his death in 1930.

Meanwhile, in 1927, the Minneapolis Heat Regulator Company and Honeywell Heating Specialty Company merged to form the Minneapolis-Honeywell Regulator Company, adding the production of high quality clocks to its existing electric motors, heating and furnace product lines. The company made several acquisitions in the controls area, one of which was the Brown Instrument Co., a worldwide leader in the field of industrial controls and indicators. During World War II, the company combined all of its expertise in the development of the C-1 autopilot, used on the B-17. The Norden bombsight was only as accurate as the aircraft could be flown and the C-1 proved to be of inestimable value. After the War, companies had to turn to civilian markets to sell their products. The autopilot technologies first went to commercial aircraft, then business and finally to personal aircraft.

If you study these companies carefully, you begin to understand that they all had extensive experience in feedback loops and precision instrumentation. Figure 1 below shows the operation of a temperature controlled furnace.

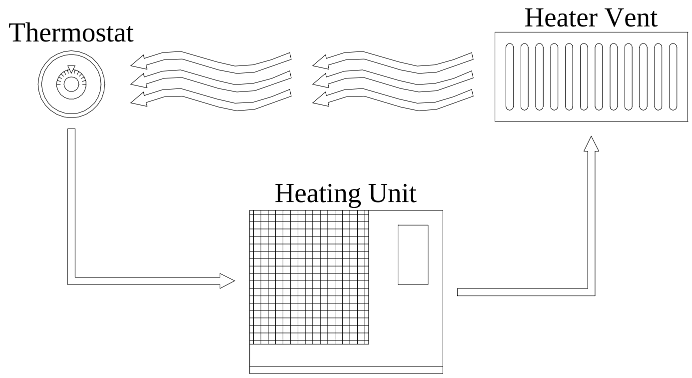

Figure 1 Furnace shown as example of feedback loop.

The furnace produces heat, which flows to the thermostat, which either closes or opens contacts that regulate the furnace output. In autopilot systems, we will study in detail this type of feedback loop. Figure 2 diagrams a simple gyroscope. This device can sense motion in two axis (the third axis is the spin axis). For more information on its operation, you may review the November 2000 edition of Tech Time.

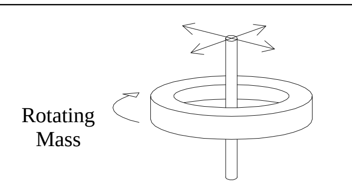

Figure 2 Gryoscope.

In an aircraft, the gyroscope provides a known position in space or attitude. The pilot selects a mode of operation on the programmed controller that outputs a signal to the servo amplifier/motor that is proportional to the displacement of a parameter from ideal. The servo amplifier/motor moves a control surface (aileron, rudder, elevator or elevator stabilizer) that causes the aircraft to move from its original position. The change in position produces a change in the gyroscope's output that travels back to the programmed controller and this continues until the conditions selected by the pilot have been satisfied. This simplified scenario becomes more complicated in actual applications, however. One more concept to be introduced is that of *rate*. In closed feedback systems, how quickly and how much the system responds to an error is of paramount importance. This was crucial to Sperry's and Minneapolis-Honeywell Regulator Company's early mastering of autopilot design.

Next Month: More Autopilots