Nils Gustaf Dalén (1869-1937): Inventor, Experimenter, Engineer, and Nobel Laureate

By Robert N. Clark

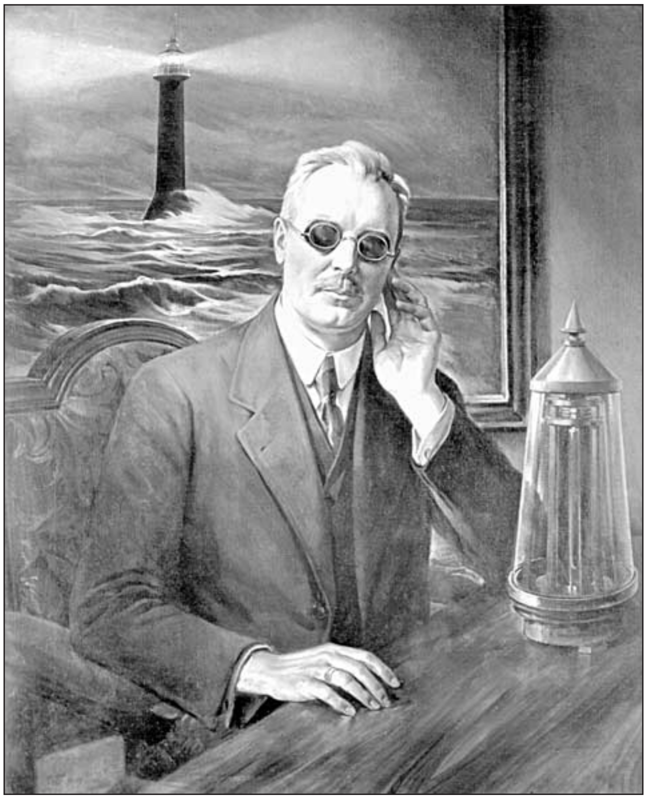
The Nobel Foundation was established by the will of Alfred B. Nobel, engineer and chemist, who died in 1895. The will funded annual prizes to "those who shall have conferred the greatest benefit on mankind." The prize in physics was to go to "the person who shall have made the most important discovery or invention." In 1912 the Nobel Prize in Physics was awarded to Nils Gustaf Dalén, an engineer, for the invention of an automatic regulating system of valves designed to be used with gas accumulators in lighthouses, lightships, and light buoys. It was the second time the physics prize had been awarded for an invention; the first was to Guglielmo Marconi in 1909 for inventing the wireless telegraph.

For many nations, especially Sweden with its long coastline and many islands, the problem of a reliable coastal lighting system had been a pressing one. By 1912 several such nations had installed Dalén systems and had realized both a remarkable improvement in the safety of maritime navigation and an enormous economy in the operation and maintenance of these navigation aids.

Nils Gustaf Dalén was born in 1869 at Stenstorp, Sweden, where his family operated a farm. His early education in an agricultural school prepared him to succeed his father as a farmer. His inventive talents became apparent in his work around the farm; in 1892 he invented a device for checking the fat content in milk, and he showed it to Gustaf de Laval, a prominent inventor and industrialist. De Laval's firm manufactured a new type of reduction gear for high-speed steam turbines that were coming into use in marine applications. (During his lifetime de Laval received more than 90 patents and founded 37 companies.) De Laval recognized Dalén's abilities and suggested he study engineering at the Chalmers Institute of Technology in Gothenburg. Dalén took this advice and enrolled at Chalmers. In 1896 Dalén graduated as a mechanical engineer with hopes of joining de Laval's steam turbine company, but de Laval suggested that he continue his studies at the renowned Polytechnische Hochschule in Zurich, Switzerland. Dalén, acting on de Laval's advice, spent more than a year in Zurich, where he studied under the direction of Prof. Aurel Boleslaw Stodola, who was deeply involved in research on high-pressure water turbines, particularly in the dynamics of their speed regulation devices. It is probable that de Laval, who had studied in Germany, knew Prof. Stodola through their common interest in high-pressure turbines.

The relationship between Stodola and his colleague Prof. Adolf Hurwitz in the early 1890s is well known to students of automatic control. It was similar to the relationship between James C. Maxwell and Edward J. Routh in Cambridge some 20 years previously. Maxwell, through his dynamic analysis of the speed governor on a precision electrical measurement device, posed the mathematical problem of determining the conditions on the coefficients of a polynomial that must hold such that the real parts of the roots of the polynomial be negative. Routh determined those conditions and expressed them in an 1876 essay: "A Treatise on the Stability of a Given State of Motion." In 1893 Stodola, through his work on turbine speed regulators, raised the same question as Maxwell had concerning the relationship between the coefficients of a polynomial and its roots. Unaware of Routh's solution to that problem, Stodola presented the question to his colleague Hurwitz, and Hurwitz had his solution within a year. It was published in mid-1895. Dalén arrived in Zurich a year after the publication of the Hurwitz paper, and it is likely that as Stodola's student he became acquainted with the technology of mechanical automatic control devices.

After he returned to Sweden in 1897, Dalén continued development work on steam turbines, financed in part by de Laval's steam turbine company, where their experiments



Nils Gustaf Dalén (used with permission from the AGA Historical Archive).

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were conducted. Following this experience with turbines, Dalén and engineering colleague Henrik von Celsing formed a firm to develop inventions into useful products. The most significant of their ventures was in the field of acetylene combustion as applied to lighting fixtures and heating devices. Acetylene burns with a much brighter flame than does petroleum gas, and this form of lighting became popular for street lighting before electricity became available. Dalén also introduced the use of acetylene for welding in Sweden in 1902, although it did not come into general use until much later.

For lighting or heating in remote locations or for mobile installations in railways and motor vehicles, acetylene offered significant advantages over petroleum gas. But the explosive nature of acetylene, especially where it had to be transported in pressurized vessels, inhibited its adoption in such applications.

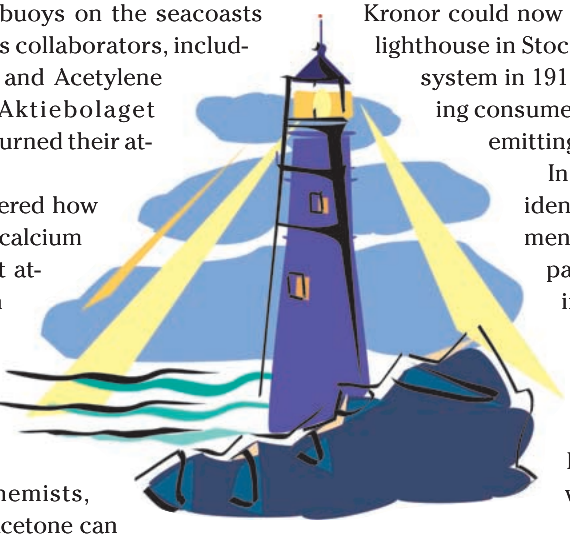
A particularly attractive application for acetylene lighting was for lighthouses and light buoys on the seacoasts along shipping routes. Dalén and his collaborators, including those at the Swedish Carbide and Acetylene Company (renamed Svenska Aktiebolaget Gasaccumulator, or AGA, in 1904), turned their attention to this problem.

Around 1895 it had been discovered how acetylene could be prepared from calcium carbide on a commercial scale. But attempts to store calcium carbide in light buoys and have the acetylene escape under the action of water supplied automatically had proven to be inconvenient, unreliable, and unworkable in cold weather. In 1896 two French chemists, Claude and Hess, discovered that acetone can dissolve acetylene in large quantities, and the solution is not explosive. Further, if the solution is compressed in a porous mass inside pressurized shipping containers, it can be transported safely, provided the mass is sufficiently elastic. Dalén discovered such a mass, which he named "aga," the initials of the firm with which he was associated.

Dalén then developed an involved process to put the aga material into steel shipping tanks, introduce the dissolved acetylene, and compress it to a pressure at which the tank contains 100 times its volume of acetylene and could be transported safely.

When used in maritime lighting, petroleum gas had to be burned in flashes lasting about six seconds, and with the valving system then in use, one liter of gas provided 50 flashes. Dalén developed a reliable system whereby one liter of acetylene provided several thousand short but brilliant flashes. The shorter flashes permitted a larger coding alphabet for the navigation signals. He further designed a special valve, known as a solar valve, or Solventil, that turned the signaling apparatus off at sunrise and back on when sunlight disappeared. This valve was actuated by a system of four metal rods, three of which were highly polished and surrounded the fourth, which was black, all four enclosed in a glass tube. The differential expansion between the dark and polished rods as the sunlight changed opened and closed the gas valve (see http://www.aga.com/history).

In 1911 the AGA Company was chosen to provide a lighthouse system for the Panama Canal, and by 1912 an increasing number of coastal installations in Sweden, and in several other parts of the world, had installed the Dalén system of lighting. Dalén's system made it possible for lights to operate automatically and without need of inspection for a year or more. Before Dalén's system, a lightship in Sweden cost 200,000 Kronor and had an annual maintenance cost of 25,000 Kronor. An automatically operated signal buoy costing 9,000 Kronor with an annual maintenance of only 60 Kronor could now replace this. The Blockhusudden lighthouse in Stockholm installed the Dalén lighting system in 1912, and it operated until 1980, having consumed 1.8 million liters of acetylene by emitting 400 million flashes in 68 years.



In September 1912 Dalén, then president of AGA, continued his experiments on handling acetylene. In one particularly dangerous test involving heating a gas accumulator, the device exploded. Dalén was seriously injured and permanently blinded by this accident. Two months after this accident, the Nobel Prize in Physics for 1912 was announced.

There were 17 nominees for the 1912 physics prize. Of these, two had previously been awarded the prize: Hendrik Antoon Lorentz in 1902 and Joseph John Thomson in 1906, and four were future winners: Heike Kamerlingh Onnes in 1913, Max Planck in 1918, Charles Edouard Guillaume in 1920, and Albert Einstein in 1921. Erik Johan Ljungberg, a prominent industrialist and member of the Royal Swedish Academy of Sciences, nominated Dalén for the 1912 prize. The Academy accepted this nomination and awarded Dalén the 1912 Nobel Prize in Physics.

Dalén eventually recovered from his injuries and even with the handicap of blindness remained active in developing new products for the AGA Company. He received many more honors and became a member of the Academy of Engineering Sciences and a member of the Royal Academy of Sciences. He was active in local politics, serving for many years on the City Council of Lidingö and also on national boards and commissions. He remained an active leader as president of AGA until he died at Lidingö in December 1937.

Photographs of Dalén, his inventions, and a charming story of his early years on the farm may be found at http://www.aga.com/web/web2000/com/WPPcom.nsf/pages/History_GustafDalen.

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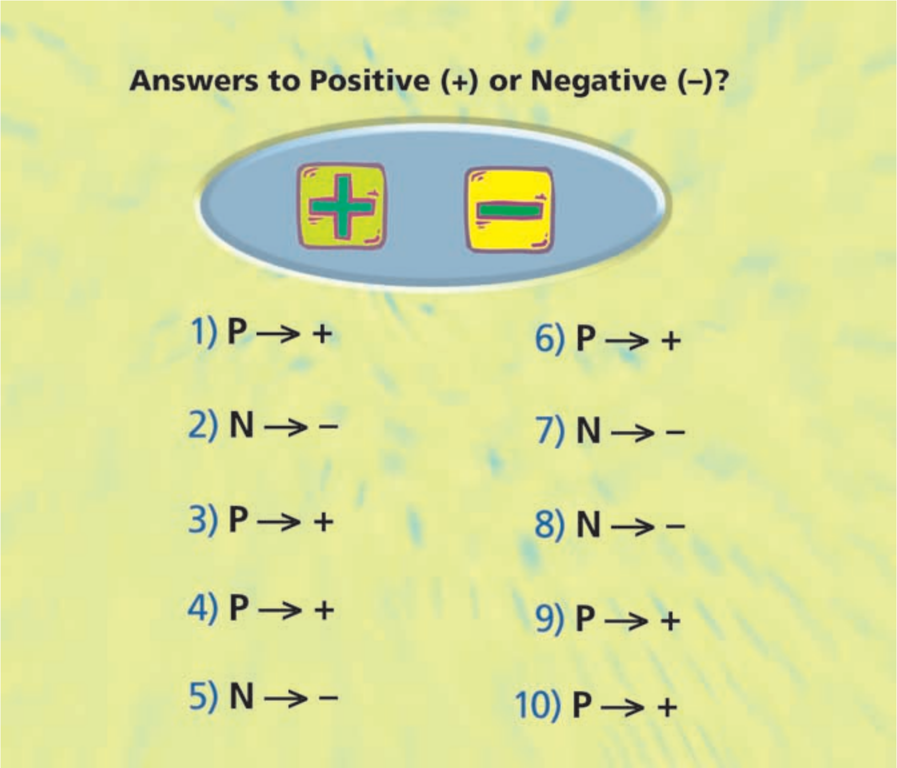
Answers to "On the Lighter Side" (p. 104)



Answers to Positive (+) or Negative (–)?

+ –

1) P –> +

2) N –> –

3) P –> +

4) P –> +

5) N –> –

6) P –> +

7) N –> –

8) N –> –

9) P –> +

10) P –> +