This is the story of the men behind one of the greatest metallurgical innovations of the 20th Century.

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The Rockwell hardness tester has been a standard fixture in metallurgical laboratories around the world since the 1920s. Its colorful inventors and the evolution of quantitative hardness together make a remarkable story. The Rockwells made an impression, so to speak, and not just on hardness measurement. They were also pioneers in the heat treating, automotive, bicycle, aircraft, and defense industries. They even made life easier for Avon Ladies!

The French scientist R.A.F. de Réaumur (1683-1757), best known for his temperature scale, devised a scratching method for hardness comparison in 1722. Austrian mineralogist Friedrich Mohs (1773-1839) devised the ordinal Mohs scale of hardness circa 1822. A number of other scientists and inventors tinkered with hardness evaluation in the late 1800s and early 1900s. One of them was A.F. Shore, a name mostly associated with the hardness of plastics nowadays, who invented the Scleroscope impact hardness tester in 1906.

Brinell hardness

Swedish metallurgist Johann A. Brinell (1849-1925) invented the first quantitative hardness test in 1900 while chief engineer at the Fagersta Iron and Steel Works in Westmanland, Sweden. Brinell correlated the diameter of the impression in steel left by a hardened sphere to the applied force, typically a 1 to 10 mm ball under a load of 1 to 3000 kg. Brinell presented his ideas in a paper to the Swedish Society of Technologists, and his invention to the Paris Exposition. The first commercial Brinell hardness testers were made by the Alpha Company of Sweden.

The differential depth hardness measurement was conceived in Vienna in 1908 by Ludwig in his book *Die Kegelprobe* (crudely, “the cone compression test”). The differential-depth method subtracted out the errors associated with the mechanical imperfections of the system, such as backlash and surface roughness.

Rockwell brothers

Brothers Albert F. (1863-1925) and Edward D. Rockwell (1854-1925) founded the New Departure Bell Company in Bristol, Connecticut, inside a clock factory in 1888. The Rockwell family was very prominent in Connecticut industry around the turn of the century — Albert also served as president of...
the Bristol Brass Corp. and the American Silver Company. New Departure originally made technologically advanced doorbells, but added bicycle coaster brakes to its product line in 1898 (Fig. 1), and bearings in 1908. The early automobiles were sometimes known as flivvers, and the application of bearings to these low-cost vehicles was a recent innovation at the time. Albert was the president of the company.

Hugh M. Rockwell (1890-1957), son of Albert, was an aviator and automobile enthusiast who worked for his father at New Departure. Stanley Pickett Rockwell (1886-1940), was a metallurgist at New Departure, but apparently no relation to Hugh and Albert in spite of their common surname and other similarities. Stanley collaborated with Hugh to invent a machine that could quickly and easily measure the hardness of curved bearing raceways and cones. They filed a patent application on 15 July 1914. The Brinell method was relatively slow and complicated, not easily applicable to small-radius curved surfaces, unsuitable for the hardest steels, and often left too large an impression to be considered nondestructive. However, the Rockwell method and machine compensated for many of the Brinell shortcomings, and determined the hardness from the difference in penetration depth between the major and minor loads. U.S. Patent No. 1,294,171 was granted to the Rockwell hardness tester and applied for a patent in September 1921. While the Rockwell method and machine and often left too large an impression to be considered nondestructive.

However, the Rockwell method and machine compensated for many of the Brinell shortcomings, and determined the hardness from the difference in penetration depth between the major and minor loads. U.S. Patent No. 1,294,171 was granted to the two younger Rockwells on 11 February 1919. Both had left New Departure by then. Albert Rockwell was ousted as president by the board of directors of New Departure in October 1915. His brother-in-law, DeWitt Page, remained as general manager.

Marlin Firearms
Marlin Firearms was established in New Haven, Connecticut, in 1870 by gunsmith J.M. Marlin (1830-1901). Investors, including the Rockwell brothers, bought Marlin in 1915 and changed the name to Marlin-Rockwell Corp. Marlin-Rockwell manufactured machine guns for the World War I effort, including the Browning Automatic Rifle (Fig. 2). They alsoopened a bearings plant in Bristol, to compete with New Departure. In 1919, Marlin-Rockwell consolidated Rockwell-Drake and several other subsidiaries under the aegis of Standard Steel and Bearings Inc., in Plainville, where Albert patented several inventions.

Albert Rockwell sued the renamed New Departure Manufacturing Company for a then-astronomical $2 million in March 1917 to recover the rights to technology he had developed for the manufacture of bearing assembles. The case was decided in Rockwell’s favor in December 1924, and he settled for $950,000 in early 1925. His victory was short-lived, as he died of complications from an infected leg injury in February 1925. Older brother Edward died of pneumonia in December 1925.

Hugh Rockwell joined his father at Marlin-Rockwell circa 1915, specifically in the Rockwell-Drake division. Hugh began developing a lightweight, short-wingspan, two-man airplane immediately after World War I, the aerial flivver. In 1921, he resigned as the president and general manager of Standard Steel and Bearings. He immediately took his airplane plans and equipment to the Harding-Zuck-Poole Company in Lincoln, Nebraska. Hugh relocated again to Freeport, New York, in the late 1920s. He patented some 46 inventions throughout his career, mostly related to bearings, firearms, and aircraft.

Marin-Rockwell’s arms business declined after the war and was auctioned in 1924. Its bearings business was acquired by the predecessor of TKW Inc. in 1964, and sold to Swedish bearing maker SKF in 1986. New Departure and another bearing firm, Hyatt, were acquired by United Motors, a division of General Motors Corp., under the direction of future GM chairman Alfred Sloan in 1916. The New Departure and Hyatt brand names are now the property of the General Bearing Company of West Nyack, N.Y. Delphi Automotive Systems Corp. and Kryklos Bearing International also trace their origins to New Departure.

Later Rockwells
Stanley Rockwell was born in New Britain, Conn., son of S. Willis and Annie Pickett Rockwell. He earned his degree from the Sheffield Scientific School of Yale University in 1907, and was on the rowing team his senior year. He took a job with Weeks & Hoffmann in Syracuse, N.Y, where he improved the design of the original Rockwell hardness tester and applied for a patent in September 1919.

He served as a captain during the war in the ordnance department. After the war he started a business in Hartford, where he added a dashpot to the hardness tester to regulate the rate of loading, and applied for the third patent in May 1921. While
awaiting the results of the patent examiners, he wrote and presented a landmark paper at the American Society for Steel Treating Convention in Indianapolis, in 1922. ASST became the American Society for Metals in 1933, and is now ASM International. He received two U.S. Patents consecutively on 18 November 1924, Nos. 1,516,207 and 1,516,208.

Stanley then established the New England Heat-Treating Service Company in Hartford in 1921. NE-HTSC was renamed the Stanley P. Rockwell Company two years later, and still provides heat treating services to this day. Stanley invented a dilatometer in 1928 to measure the thermal expansion of steel to optimize its heat-treatment temperature, and a quench tank agitator in 1929. In addition to heat treatment and metallurgical analysis, the Rockwell Company also sold furnaces for the American Gas Furnace Co. and General Electric, process instruments for Wilson-Maeulen, and supplies for the Rodman Chemical Co. Success and growth prompted the company to move into its current facility in 1929.


Wilson instruments

Charles H. Wilson, an instrument salesman for the Wilson-Maeulen Company in New York, saw the potential for the Rockwell hardness tester in 1920 and began a long-term collaboration with Stanley Rockwell. Wilson suggested many improvements to the tester, including standardized loads and reversal of the scale such that the highest hardness corresponded to the highest scale numbers. Wilson developed the diamond indenter for hardened steel in 1924 that is still sold under the Brinell trademark. Wilson added a hardness gauge of his own design in 1930 that made the Rockwell hardness tester as it is known today.

With the success of the hardness testers, Wilson’s company was renamed the Wilson Mechanical Instrument Co. Inc. Wilson’s company developed the superficial Rockwell hardness tester in 1932 for measuring the hardness of sheet metal, brittle materials, and other specimens not suitable for the original higher-load test. Additional improvements to the Rockwell hardness tester were made in subsequent years, including some by Wilson’s competitors. The Wilson company has been owned by Instron Corp. since 1993.

Other hardness tests

The Rockwell method of hardness determination was revolutionary, but hardly the last word in hardness testing. It had two shortcomings: the indentions were too large for very small components or for microstructural analysis; and it was not a reliable way to characterize the hardest and most brittle materials, such as dense ceramics.

To deal with very small specimens, the Vickers method was developed by Smith and Sandland at Vickers Ltd. circa 1922, to determine the hardness of individual grains and phases in a microstructure. The Vickers method had a pyramid-shaped diamond indenter, sized so that Vickers hardness numbers correspond to Brinell numbers for the same material, up to about 600 on either scale. Vickers, a London-based aerospace company, became part of British Aircraft Corp. in 1965.

The Knoop method, developed in 1939 by Knoop, Peters, and Emerson at the National Bureau of Standards in Washington, D.C., modified the Vickers indenter design. Knoop et al. changed the dimensions of the Vickers diamond pyramid indenter to reduce the depth of penetration and the degree of cracking around the indentation in brittle materials. Nanoindentation principles were conceived as early as the 1950s, and put into practice as instrumented indentation hardness circa 1992.

Neither the Vickers, Knoop, nor various other hardness techniques have replaced the Rockwell method in the last nine decades—the alternative methods merely fill the niches where Rockwell does not apply.

Albert Sauveur Award

Stanley Rockwell was awarded the fifth Albert Sauveur Achievement Award by ASM in September 1939. The Sauveur award “recognizes pioneering materials science and engineering achievements that have stimulated organized work along similar lines to such an extent that a marked basic advance has been made in the knowledge of materials science and engineering.” The award’s namesake and first awardee was himself a pioneer in metallography and heat treating as a professor at Harvard University. The list of Sauveur awardees is a veritable metallurgical hall of fame, and includes such luminaries as Jominy, Bain, Mehl, Kroll, Chalmers, Barrett, Rhines, Chang, and Dieter.

Stanley Rockwell met a tragic end on a Sunday afternoon in August 1940 when his private 50-ft yacht Chin-Chin exploded in the Connecticut River near Middletown while he was on board alone. The boat had been fumigated a day earlier, but the cause of the explosion was never officially determined. Rockwell was an experienced sailor, and with his wife spent summers on the yacht in Connecticut and winters in Florida. He was survived by his wife Ruth, son Dudley, and daughter Marianna.

Neither Stanley nor Hugh Rockwell was closely related—if related at all—to artist Norman Rockwell (1894-1978) or industrialist Willard F. Rockwell, Sr. (1888-1978). Coincidentally, Willard Rockwell, the founder of Rockwell International Corp. and the namesake of Rockwell Automation Inc. and Rockwell Collins Inc., also made his early fortune by manufacturing bearings right after World War I.

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