PITTSBURGH, BIRTHPLACE OF A SCIENCE*

EDWARD G. WILLIAMS

WHEN the Secretary of War of the United States confers promotions of rank from Major to Lieutenant Colonel to Colonel to Brigadier General, all on the same day, for "faithful, meritorious, and most distinguished service . . . . ," real merit must be the object of the action. When the recipient of the honors is a Pittsburgher, we take note of it. At least, we can claim him as a Pittsburgher by adoption from the fact of his having accomplished the greater part of his life's work in Pittsburgh, of his having married a Pittsburgh girl, and of the birth of several of their children in Pittsburgh. Add the fact that a very small street in East Liberty was named Rodman Street in his honor.

Thomas Jackson Rodman was born in the then frontier Territory of Indiana in 1815, the year that marked the end of the War of 1812, with its Indian alarms that sent chills of apprehension through the western country clear back to Pittsburgh. His mother, Elizabeth Barton, of Virginia, was of Revolutionary stock. James Rodman, his father, came of hardy Quaker ancestry which had settled in Rhode Island just a hundred years before Lexington and Concord. The Rodman forefather was a physician who immigrated from the island of Barbados in 1675.[1]

Young Rodman received a rudimentary education under the

Mr. Williams, valued contributor to this magazine, temporarily leaving his earlier field of research here ventures into a different period of investigation and writing.—Ed.

* After this article had been written, *Ordnance* magazine published, in the July-August (1962) issue, an article entitled "Rodman's Great Guns." It is heartening that notice is at last being taken after so many years of neglect, of the accomplishments of this great pioneer of science. The permanent results of his work, however, are his outstanding contributions to the sciences of metallurgy, ballistics and pyrotechnics, rather than to his guns *per se,* as we shall see. We should like to set the record straight: his name was not Thomas Jefferson, as the *Ordnance* article states. All the West Point as well as family records show that Thomas Jackson is the correct name.

1 Josiah G. Leach, Memorials of the *Reading, Howell, Yerkes, Watts, Latham, and Elkins Families* (Philadelphia, 1898), 229, note. Dr. Thomas Rodman; Charles Henry Jones, *The Genealogy of the Rodman Family* (general information); *Dictionary of American Biography* (Charles Scribner's Sons, New York, 1935), XVI, 80. (Hereinafter noted as *DAB.*) The first two references, in the Burton Collection, Detroit Public Library, Detroit, Michigan.

primitive conditions of the frontier settlements and was able to obtain an appointment to West Point at the latest possible age for entrance. Graduating in the Class of 1841, seventh among fifty-two, Rodman entered the Ordnance Department as a second lieutenant.[2] In the roll of his class, one reads the names of such (later) notables as Major General John F. Reynolds, Major General Don Carlos Buell, and Brigadier General Nathaniel Lyon, all of Civil War fame.[3] The ranks of the Regiment of Cadets were filled, during those years, with those destined to fame in the armies of both the Confederacy and the Union. At the Academy, Rodman early evidenced an aptitude for mathematics and practical shop mechanics, carried on at the West Point Foundry across the Hudson at Cold Spring, New York.

After graduation, he plunged into ordnance work with zest and unsurpassed assiduity. He worked under the great Chief of Ordnance, Colonel George Bomford, with whose "Columbiad" cannon Rodman conducted tests and experiments.[4] He also studied the work of the French artillerist, Henri Joseph Paixhans, as did also his contemporary and counterpart in the American Navy, John A. B. Dahlgren.[5]

Rodman's first assignment, after being commissioned, was as Assistant Ordnance Officer at the Allegheny Arsenal, in Pittsburgh, where he remained from 1841 to 1848, although frequently detached elsewhere, as we shall see. It was here that he met and married, in 1843, Martha Anne Black,[6] daughter of the Reverend John Black, Scottish-born pastor of the Reformed Presbyterian Church on 7th Street, also professor of Latin, Greek and Classical Literature at the Western University of Pennsylvania, now the University of Pittsburgh.[7]

During this period, Rodman was applying himself to the problems of improvements in cannon manufacture that were to lead in making the United States preeminent in artillery and a dominant world

2 George Washington Cullum, Major General, *Biographical Register of Officers and Graduates of the United States Military Academy at West Point* (Boston and New York, 1891), II, 66. (Hereinafter noted as Cullum, *Biog. Regstr. West Point.*)

3 *Ibid.*, 29. General Lyon was killed, while heroically leading his troops at Wilson's Creek (Springfield, Mo.), August 10, 1861.

4 *DAB.*, XVI, 80.

5 *Ibid.*, 81.

6 *Ibid.*, 81; Elizabeth Moorhead Vermorcken, *Whirling Spindle* (Pittsburgh, 1942), 63.

7 Agnes L. Starrett, *Through One Hundred and Fifty Years* (Pittsburgh, 1937), 72, 76, Sarah H. Killikelly, *History of Pittsburgh, Its Rise and Progress* (Pittsburgh, 1906), 294.

power in one of the most crucial periods of her history. However, it is in the field of metallurgy that Rodman made his greatest contribution to modern science, although he is best remembered for his big guns. The great English scientist, and American expatriate, Sir Benjamin Thompson (Count Rumford), had opened the way to new conceptions of artillery manufacture at the end of the eighteenth century by his investigations in thermodynamics;[8] and Paixhans in France, as already noted, was producing new ideas about "bomb cannon" in Rodman's century.[9] In America, a group of young officers under Colonel Bomford had made a conspicuous beginning in the construction of testing machinery and chemical analysis. These experiments, carried on from 1844 to 1852, were contained in a report signed by various officers in 1856.[10] Rodman had borne a part in the construction of the testing machines, having been sent on detached duty to Richmond, Virginia, for that purpose, early in 1845, and again during the latter part of the same year to superintend cannon casting.[11]

It was while engaged in this work at Richmond that Rodman first took note of the porosity of samples taken from castings near the bore and of the relatively low density of the metal near the exterior surface of the gun barrels. He reasoned that as the barrels had always been cast solid and cooled from the outside, a reversal of the process would result in a denser metal near the bore, where greater stresses occurred. Rodman proposed to cast the gun barrels hollow and to cool them from the inside, a revolutionary process.[12] This he accomplished by circulating a stream of cold water through the core in the center of the casting.[13] Many were the trials and

8 *Dictionary of National Biography* (London, 1909), Sir Benjamin Thompson, Count Rumford, XIX, 687.

9 Henri Joseph Paixhans, *Bibliographie Universelle* (Par une Societe de Gens de Lettres et de Savants) (Paris), XXXI, 634. H. J. Paixhans, Lieutenant Colonel of Artillery, *An Account of Experiments Made in the French Navy for Trial of Bomb Cannon, etc.*, Translated by J. A. Dahlgren, Lieutenant, U. S. Navy (Philadelphia, 1838), the whole work.

10 U. S. Ordnance Office, *Reports of Experiments on the Strength and Other Properties of Metals for Cannon, With a Description of Machines for Testing Metals of the Classification of Cannon in Service, 1856.* Reports signed by a group of officers.

11 Cullum, *Biog. Regstr. West Point*, II, 68.

12 *Ibid.*, 68.

13 Captain T. J. Rodman, of the Ordnance Department of the U. S. Army, *Reports of Experiments on the Properties of Metals for Cannon and the Qualities of Cannon Powder, with an Account of the Fabrication and Trial of a 15-Inch Gun, by Authority of the Secretary of War* (Boston, Mass., 1861), 101 ff. (see Report XII). (Hereinafter noted as Rodman, *Reports.*)

failures and many hundreds were the tabulations of the temperatures of the water at introduction and on leaving the moulds. Many are the plotted cooling curves supplementing his exhaustive reports.[14] Thousands of test firings were necessary to prove the hollow cast barrels superior in every way to a like number cast solid using conventional cooling methods, both using identical ores or mixtures of ores, in moulds from identical patterns, in the same furnaces, and all identical conditions so far as it was humanly possible to effect it.[15] Tests, by firing, proved that Rodman's methods resulted in greatly increased endurance (gun life), lessened wear in the bore from friction, minimized enlargement of vents, and greatly reduced effects of gas erosion.[16] One table showing the endurance of all pairs of hollow and solid cast guns showed that one of Rodman's hollow cast guns withstood 1500 firings, while its mate, cast solid under otherwise identical conditions, was destroyed upon firing the 299th round.[17]

Rodman's experiments at first had been conducted with casting and testing Bomford's "Columbiads," but his thinking now turned to the problem of redesigning the guns so as to dispose the metal along lines of uniform pressure within the gun when fired; in other words, to place the most metal where the pressure was greatest.[18] To study pressures, he developed a pressure piston that was inserted in holes drilled along the entire length of the bore. It was so arranged

14 *Ibid.*, following page 262, are 8 pages of graphs representing (by plotted curves) Extensibility and Compressibility.

15 Rodman's *Reports* (1861), Report X, 57-58; Experiments Made for the Purpose of Determining the Relative Endurance of Guns Made from the Same Iron, But Melted in Furnaces of Different Construction; Also, That of Those Made from the Same Iron, Melted in the Same Furnaces, But Differently Cooled, One Gun Being Cast Solid, and Cooled From the Exterior, and the Other Cast Hollow and Cooled from the Interior.

16 *Ibid.*, Report XII, 101: Report of the Fabrication and Proof, Up to 2450 Service Charges Each, of Two 10-inch Trial Guns; One Cast Solid and Cooled from the Exterior, and the Other Cast Hollow, and Cooled from the Interior; *Ibid.*, 108, Difference in Velocity of Shot, Due to Difference in Enlargement of These Guns; *Ibid.*, 111, Mechanical Tests of Metal in These Guns; *Ibid.*, 112-120, Enlargement of Bores by Firing; *Ibid.*, 121, Tables of Enlargements of Vents.

17 *Ibid.*, Report XII, 133-134, Table Comparing the Endurance of All the Pairs of Solid and Hollow Cast Guns Made Up to Date of This Report.

18 After exhaustive experiments, of which results were carefully tabulated, Rodman was able to draw a design of an efficient gun. See *Reports* (1861), 223, for the design itself. Dahlgren, of the Navy, claimed that the design approximated his own *externally cooled* gun and wrote letters to the U. S. Ordnance Department deprecating the idea of internal cooling. See Mrs. Madeleine V. Dahlgren, *Memoirs of John A. Dahlgren* (Boston, 1882), 265-269. It is apparent, however, even from Dahlgren's own testimony, that Rodman arrived at his design independently; and his demonstrated results controverted every argument contrary to his methods.

that, when the gun was fired, the point of the piston arm penetrated into a block of annealed copper (the penetrometer that bore his name). By measuring the depth of this penetration with a special micrometer, the relative pressure at that point could be established, and the pressure pattern along the whole length of the bore determined by taking successive readings.[19] In this way Rodman proved the hypothesis that "The strain from a central force diminishes as the square of the distance from the axis increases." [20]

In order to effect uniform pressures, it was necessary to investigate powders, which had been improved very little since the days of the Revolution. The evolution of gas from burning powder in a confined space became the object of Rodman's research, and his work started at Allegheny Arsenal with many of the reports written from there.[21] Controlled combustion was essential, and Rodman produced that effect by reducing the surface of powder grains exposed to initial combustion. He compressed the powder into "perforated cakes," so that the holes in the cake burned larger as combustion advanced. This gave a progressive push to the projectile and produced greater muzzle velocities than ever before attained, without subjecting the gun to undue strains.[22] In order to verify this, he adapted and devised his own improvements to the Navez electro-ballistic pendulum.[23] A little later, Rodman had powder pressed into the form

19 Cullum, *Biographical Register, West Point,* II, 68; Rodman, *Reports,* Report V, 37-38; *Ibid.,* Report LI, 300. Bomford had drilled barrels; Rodman improved his methods and invented the penetrometer.

20 *Ibid.,* Report XXXII, 191-193.

21 With the exception of some of the earlier experiments at West Point and the series of experiments, in the last half of 1859, at Watertown, Mass., nearly all of the casting and tests were performed at the Allegheny Arsenal and Fort Pitt Foundry in Pittsburgh. See especially Rodman, *Reports,* Report XII, 129-135; XIII, 139-140; XXXI, 191. Fort Pitt Foundry cast 15% of all the ordnance purchased by the Federal Government during the Civil War and all but 8 of the 73 Rodman 15-inch guns, as well as the great 20-inch Rodman gun (cast Feb. 11, 1864; 20 feet in length, 56 tons finished, 80 tons of molten metal poured). Louis Vaira, "Some Aspects of Pittsburgh's Contributions to the Civil War," WESTERN PENNSYLVANIA HISTORICAL MAGAZINE, VI, 14-15. Fort Pitt Foundry, formerly operated by Knapp, Wade & Co., but Knapp, Rudd & Co. in 1864. *Pittsburgh Directory, 1863-64;* WESTERN PENNSYLVANIA HISTORICAL MAGAZINE, III, 90. It was located between 12th and 13th Streets on the Allegheny River, *Ibid.,* IX, 92-93.

22 Rodman, *Reports* (1861), Report XXI, 176, Preliminary Trials With Accelerating Cartridges; *Ibid.,* 176, Preliminary Trials With Grained Powder; *Ibid.,* XXVII, 181, Greater Uniformity of Pressure from Accelerating Charges; *Ibid.,* XLVI, 272-274, Experiments With Powder of Variable Grain; *Ibid.,* XLIX, 291-294, Of Perforated Cake Cartridge.

23 *Ibid.,* Report III, 31, The Velocimeter.

of little fluted prisms, with seven holes in each, to effect the low explosive feature of the propelling charge.[24]

Some idea of the thoroughness of Rodman's investigations can be seen from the heading of Report XIII of his full reports to the War Department: "Report of Experiments Made at Allegheny Arsenal, by Capt. T. J. Rodman, U. S. Ordnance Department, in the Years 1857 and 1858, for Determining the Properties of Gun Metal, the Resistance Which Guns Can Offer to a Bursting Force, the Actual Pressure per Square Inch Due to Different Weights of Powder and Shot, . . . " etc., etc.[25]

It is worthy of note that the United States Government did not then approve or accept Rodman's methods, improvements, or inventions. Prussia and Great Britain, however, avidly seized upon the new powder for their own military uses, without any acknowledgment. Russia also appropriated the prismatic powder and, not being able to obtain any of his guns, managed to smuggle two of Dahlgren's naval guns, of similar design, aboard ship.[26] Russia, even then, was deep in intrigue and espionage to obtain military secrets or inventions by any means whatsoever.

Finally, in 1859, fourteen years after the start of his laborious investigations, Rodman's methods received the stamp of approval by the War Department.[27] In the spring of 1861, the report of experiments was published "by authority of the Secretary of War." [28]

A moment's perusal of Rodman's reports will convince the observer that he was a thorough scientist, far ahead of his times in any department of scientific investigation, and especially in the field of metallurgy. Leaders in that science assure us that methods such as here exhibited were not used prior to his time and were not generally used among metallurgists until well after the turn of the twentieth century. This was certainly one of the very first (if not the first) practical applications of calculus, both differential and integral, to industrial problems. He has deduced formulae expressed in higher mathematical terms of integral calculus and presented many logarithmic computations accompanied by many pages of plotted curves to sup-

24 *Ibid.*, Report XLIX, 291-294; Albert Manucy, *Artillery Through the Ages* (Washington, 1949), 28.
25 Rodman, *Reports*, Report XIII, 139.
26 *DAB*, XVI, 81; G. W. Cullum, *Biog. Regstr. West Point*, II, 68-69; Mrs. Madeleine V. Dahlgren, *Memoirs of John A. Dahlgren*, 220 ff.
27 *DAB*, XVI, 81.
28 Rodman, *Reports (1861)*, Title Page.

port his findings.[29] The Ordnance report that preceded this one, submitted by several officers in 1856, on metal for cannon, had none of the above described features, except tabulations of test firings. The work of Paixhans had none of it, while that of Dahlgren had but little of it.[30]

These experiments had been carried on under circumstances often most discouraging. When Rodman, next, attacked the problem of balancing his gun on its trunnions and using the recoil to bring the gun back "from battery" after firing, even his superiors scoffed that "the idea of a balanced gun was the product of an unbalanced mind." But again the "brass" was proved resoundingly wrong, since accuracy, range, and recoil were all augmented by the innovation.[31] Rodman was considered a laboratory soldier in an age of dashing young officers who rode dangerously over the Plains and dazzled a scintillating society in Washington with flashes of gold braid and glittering sabres. But young Rodman was too occupied with important business that concerned the future welfare of his country to take any notice of it. His service record reads like the itinerary of an ubiquitous present-day defense officer. Certain it is that today he would have traveled by air and with top priority. He was in Pittsburgh, then in Richmond, back to Pittsburgh, to West Point, to South Boston, to Iron Mountain and Pilot Knob, Missouri, back to Pittsburgh, then to Baton Rouge, Louisiana, and so it went.

During the Mexican War Rodman was Ordnance Officer at Camargo and Point Isabel depots on the Mexican border. For most of the time from 1848 to 1854, he was back in Pittsburgh as Assistant Ordnance Officer at the Allegheny Arsenal; but his reports of experiments show how often he was detached to West Point, or South

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29 These observations were confirmed in an interview with Doctor Blaine B. Wescott, formerly Executive Vice-President of the Gulf Research and Development Center, one of the nation's leading research institutions. A metallurgist of national note, recipient of the American Society for Metals' Distinguished Service Award, Doctor Wescott's wide knowledge of the literature of the science of metallurgy and his helpfulness are here acknowledged.
Rodman's calculations and mathematical proofs of his hypotheses, quotations of physical laws, and graphical plottings give the impression of a detailed present-day engineering study. Of many of the pages of tabulations, one series covers 38 pages (quarto).

30 A perusal of the works of Paixhans and Dahlgren shows that they are all of the nature of philosophical treatises, expounding their respective theories, rather than reports on practical proofs of those theories, reports of tests, etc.

31 Cullum, *op. cit.*, 70.

Boston, or Richmond, or Watertown to supervise casting or to run tests and proofs.[32]

Obscurity and self-effacement are usually the lot of the pure scientist. Rodman was no exception, and this connatural circumstance seems to have carried over into his private life. The historian of his wife's family makes it plain that family tradition had been broken when he entered the family circle. All of the sons of Doctor Black had graduated from the Western University of Pennsylvania, and two had followed in their father's footsteps into the ministry of the Reformed Presbyterian Church. A daughter had married twice, both times to a prominent clergyman of that denomination. Another son became a physician; and another, Samuel Brown Wylie Black, entered the legal profession and died a hero's death at the head of his regiment while fighting at Malvern Hill. "But," condescended the family historian, ... "one of the latter [daughters], Martha, departed from the family pattern by marrying Lieutenant Thomas Jackson Rodman, a graduate of West Point Ordnance Department, in 1843." [33]

His wife's family may not have approved, or they may have been ignorant of the fact of Rodman's true accomplishment during the Civil War. Of course the newspapers publicized the information on his big guns, as they were finished; but it belonged in the sphere of retrospection to see the real effect produced by those guns. General G. W. Cullum, the historian and biographer of the West Point Military Academy, has given testimony that they were the greatest single deterrent to Great Britain's entrance into the war on the side of the Confederacy. He said further: "Rodman's 15 and 18-inch guns placed us far ahead of all foreign powers." [34]

From 1861 to 1865, Captain Rodman was in command of the Watertown, Massachusetts, Arsenal. There he supervised the casting of the first 15-inch "Columbiad" and 12-inch rifled guns by his hollow casting, internal cooling system. Here, too, he cast hollow-core projectiles. During those long years of stress under the strain of war, Captain Rodman never took a day for relaxation, never a single week-end, always striving to accomplish more. General Cullum has written, "His capacity for work was prodigious, his energy most enduring, his perseverance never flagging till the goal of his ambition

32 *Ibid.*, 66-67, Rodman's Service Record.
33 Vermorcken, *op. cit.*, 63.
34 Cullum, *op. cit.*, 71.

was attained." In 1864 he suffered a severe breakdown, and it was thought that he never would recover. After a few months of convalescence, however, he was back on active duty.[35]

With his classmates marching to glory on fields of action and winning promotion after promotion as their fame increased, Rodman could advance in rank only as regular promotion came due. He had been eight years a captain, so that, on June 1, 1863, he became a major. He still labored indefatigably with dedication and self-sacrificing devotion to duty and the cause of producing the most effective arms for the service of his country. The importance of Rodman's work finally came to the attention of the Secretary of War, Edwin M. Stanton, with the result that, as before mentioned, on March 13, 1865, he received promotions, by brevet, from Major to Lieutenant Colonel, from Lieutenant Colonel to Colonel, from Colonel to Brigadier General. The citations each read: "For faithful, Meritorious, and Distinguished services in the Ordnance Department." In 1867, he received promotion to Lieutenant Colonel in the Army of the United States, so that, though ranking as a Brigadier General, he still received the pay of a Lieutenant Colonel.

After the close of the war, General Rodman was assigned to the command of the Rock Island, Illinois, Arsenal. There had been located the largest Federal prisoner-of-war camp of Confederate prisoners. Exciting new plans were afoot for building a complete new arsenal and armory that was to be the most modern in design, and in shop and foundry facilities, of all the Federal installations; and Rodman was to superintend the design and construction. He accepted this new challenge with all his usual energy and devotion to duty. His health again broke under the severe strain, and he died June 7, 1871.[36]

Within ten years, Rodman's big guns were outmoded, outranged, and superseded; and they became ornaments in the memorial parks of the reconstructed nation. New and more powerful explosives, as nitroglycerin, made their appearance even while the war was in progress. New and smaller steel rifles replaced the unwieldy big guns. Let us, therefore, place Rodman's accomplishments in their proper historical perspective: The mammoth castings, in themselves are interesting, but Rodman's real and lasting significance in history lies in

35 *Ibid.*, 70.
36 *Ibid.*, 69, 71.

his having taken metalcraft out of the realm of a trade and in his having created the systematized science of metallurgy. The completeness and perfection of his investigations have led to practices in use in the field today. In his appreciation of all of the essential factors of the problems to be investigated, he towered far above all of his contemporaries, as a man far ahead of his times. We are proud that Pittsburgh furnished the field of his activities, and the world owes a debt of gratitude to this man's boundless energy and devotion to duty.