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THE CHEMIST IN THREE WARS[1]

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THE CIVIL WAR

AT the beginning of the Civil War chemistry was in its infancy. The chemical requirements of armies at that time were, of course, proportional to the world's contemporary scientific standards; they comprised in the main the procurement of a few basic materials such as iron, copper and saltpeter; among manufactured products, gunpowder was the most important. Small as these demands appear when compared to those of modern fighting forces, they constituted problems of magnitude for the chemists and industrialists of the time.

The agricultural South, having built its economic structure on cotton, found itself in a precarious position at the outset of the conflict. According to census figures for the year ending June 1, 1860, the United States had produced in twelve months 884,474 tons of pig iron; out of this total the South, represented only by Tennessee and Virginia, had contributed a mere 25,513 tons. The blast furnaces in the South were small and antiquated; a daily output of thirteen tons, reached by newly erected furnaces in Alabama, was considered a decided improvement over the older plants of Virginia and Tennessee. The methods used were obsolete, chemical control unknown. In many cases iron ore and fuel had to be brought from distant places by a dilapidated railroad system or by teams; nevertheless, the Confederacy is said to have produced 50,000 tons annually during the war—a remarkable achievement, especially in view of the

[1] A paper read before the American Institute of Chemists at Chicago, September 18, 1942.

fact that, as the Northern armies advanced, many furnaces had to be abandoned. To augment the supply, collection of scrap iron was instituted early in the war, much along the lines we follow to-day, with Richmond appealing to her patriotic citizens to give up their "broken or worn-out ploughs, plough-points, hoes, spades, axes, broken stoves and kitchen utensils" against adequate compensation.[2] Similarly, lead was collected successfully from various sources. 200,000 pounds were gathered from window-weights in Charleston alone, and a like amount was obtained from lead pipes in Mobile. Large amounts of lead were also systematically recovered from battlefields, and the government paid high prices for the metal so collected.

The only copper mines available for exploitation were located in Tennessee, and these passed into Union hands soon after the beginning of hostilities. Copper was sorely needed for bronze field-guns and for percussion caps. In this exigency, the South bought up turpentine and apple-brandy stills, which were made of copper and of which there was an abundant supply. By stopping the casting of bronze guns and limiting the use of copper to the manufacture of caps, a shortage of this metal was avoided.

In regard to saltpeter the South was relatively better off than her adversary. There were deposits in limestone caverns near Columbia, Charleston, Savannah, Augusta, Mobile and Selma. These were mined under supervision of a special government agency called the Nitric and Mining Bureau. Less than one half of the saltpeter needed was procured in this way; the rest came from other domestic sources and through the blockade.

The direction of all chemical activities in the South was in the hands of three men, to whose energy and ingenuity history has accorded but scant recognition. To earn the world's applause, heroes must—as we chemists know only too well—do something more spectacular than provide their country with sorely needed products, even if it is military ordnance for hard-pressed armies at the front. These three men, on whom nearly as much depended as did on Robert Lee and Joseph Johnston, were Josiah Gorgas, Gabriel J. Rains and John Wm. Mallet. General Gorgas was a Pennsylvanian by birth and had graduated from the U. S. Military Academy in 1841. As an officer in the ordnance office of the United States Army he had shown such outstanding ability that Jefferson Davis appointed him chief of ordnance of the Confederacy as early as February, 1861.[3] He was an organizer of the highest type, possessed of courage, initiative and a driving force that overcame the most discouraging obstacles. General Rains was equally dynamic, resourceful and persevering. Born in North Carolina and graduated from the U. S. Military Academy class of 1842, he was a resident of New York in 1861, but joined the Southern forces as colonel of infantry in March of that year. In September he was made brigadier general and fought with distinction at Shiloh, Perryville and Seven Pines, where he was wounded. But his ability as a chemist was soon recognized, and he was asked to turn his energy from leading troops on battlefields to the less colorful but equally essential task of creating a chemical industry.[4]

The third man of this small group was John William Mallet, an Irishman educated at Trinity College, Dublin, and at Göttingen, Germany. He had taught chemistry at Amherst and at the University of Alabama in the decade preceding the war and was made superintendent of the ordnance laboratories at Macon, Ga., in 1862. One of his principal assignments was the procurement of mercury for the Southern arms, which proved difficult without any native sources of quicksilver. Mallet remedied this shortage, at least partially, by ordering the breaking up of all thermometers and barometers throughout the South. After the war, Mallet became professor of chemistry at the University of Virginia, and in 1882 was elected president of the American Chemical Society.[5]

In 1861, this trio of chemical engineers faced a desperate situation. Only two of the country's powder mills were located in the South, one in South Carolina, built for the sole purpose of furnishing powder for blasting a tunnel, and one at Nashville, which was exposed to enemy attack. The South Carolina plant employed a crew of three men, the one at Nashville a crew of ten. Both together could produce scarcely enough powder for anything more than frontier skirmishes.[6]

Gorgas immediately took steps to put the manufacture of powder on a solid and broad basis. With Rains in actual charge, a large mill was started at Augusta, Georgia, in September, 1861; operations began seven months later. The Augusta plant remained the chief reliance of the Confederacy until the end of the war and furnished all the powder needed, and of the finest quality. Rains even found time to improve the chemical processes. He introduced, for example, the method of steaming the mixed

[2] Rhodes, "History of the United States," Vol. V, pp. 390–394, The Macmillan Company, N. Y., 1919. Miller, "Photographic History of the Civil War," Vol. V, p. 161, The Review of Reviews Company, N. Y., 1912.

[3] Jefferson Davis, "Rise and Fall of the Confederate Government," V. 1, p. 477.

[4] "Photographic History of the Civil War," V. 5. Jefferson Davis, "Rise and Fall," pp. 316–317 and 475.

[5] "History of the Explosives Industry in America," by VanGelder and Schlatter, New York, Columbia University Press, 1927, pp. 107–118.

[6] "Du Pont. One Hundred and Forty Years," pp. 90–99, by Wm. S. Dutton, Chas. Scribner's Sons, 1942.

ingredients for gunpowder just before incorporation in the cylinder mills, which greatly increased the output, besides bettering the quality. When peace came, the Augusta plant was considered one of the most efficient in the world.

As the war progressed, Southern soldiers walked without shoes, lived on parched corn, went in ragged uniforms; but they always had enough ammunition, thanks to the unflagging efforts of Gorgas, Rains and Mallet, who never failed them.

The North, although more highly industrialized at the beginning of the Civil War, also had difficulties in procuring certain products, particularly saltpeter, all of which had to be imported from India. The ordnance department had let its supplies run low and in the fall of 1861, even before much large-scale fighting had taken place, a serious shortage of this critical material developed. Lammot du Pont, the youngest member of the du Pont family who owned the large powder plant in Wilmington, Delaware, was the outstanding chemical genius north of the Mason and Dixon Line. Lammot, then only thirty years old, had graduated from the University of Pennsylvania as a chemist at the age of eighteen. Six foot two, lanky, big-boned and gifted with an iron determination, he soon became a leader in the powder industry. After the end of the Crimean War, he went to Europe to study the latest advances in the art. Before going on this trip, however, he had perfected and patented a process by which Peruvian sodium nitrate could be used for blasting powder in place of saltpeter. This invention, and the work leading up to it, was destined to become a matter of national importance in the not distant future.[7]

When young du Pont became aware of the acute shortage of saltpeter and speculated on its portentous consequences, he asked for and was granted a conference with the Washington authorities; immediately afterward he sailed hurriedly for England to buy large quantities of saltpeter. He arrived there in November, and in a few days had acquired some 2,000 tons. Just when the four ships on which the material was loaded were ready to sail, reports of the *Trent* affair reached London. The British mail boat *Trent* had been stopped on the open sea by a U. S. warship, and, contrary to international law, two prominent Southern passengers, John Slidell and James Mason, had been forcibly removed as prisoners of war.

The British government, greatly incensed at this high-handed—and unauthorized—procedure, lodged a violent protest in Washington, asking for surrender of the two Confederates and an apology for their seizure. To show that her government was in earnest, the Queen declared an embargo on all munitions, and du Pont's boats with their precious loads were prevented from sailing. Excitement ran high, both in Great Britain and the United States. The British ambassador, on December 23, handed President Lincoln an ultimatum, to be answered within seven days. War between the two great English-speaking nations appeared imminent.

In the meantime, Lammot du Pont had returned to America and was in Washington on December 26th. What transpired there is not a matter of record, but can easily be surmised. If the Federal government could not get saltpeter from England or her possessions, the war was at an end. Wars could not be fought without powder, and powder could not be made without saltpeter. On December 30, 1861, Lincoln ordered the unconditional release of the two Southern emissaries. It was an unpopular decision but, although the public remained ignorant of his motives, the President had hardly any choice in the matter.

This little-known backstage setting to one of the Civil War's most stirring episodes had far-reaching consequences. Lammot du Pont was determined not to let the country be caught again in a similar critical situation. From Indian saltpeter he turned to the sodium nitrate deposits of South America, and succeeded even during the war in broadening the scope of his patented process so as to make it applicable also to the manufacture of gunpowder. The Indian monopoly was broken. From then on the United States ceased to depend for its supply of saltpeter on a European nation or her colonies.[8]

Thus the Civil War laid the foundation for the industrial development of the South and, still more important, for the military self-sufficiency of the United States., If wise leadership were to follow, the lessons of the fratricidal slaughter, learned at such bitter cost to both sides, would not be forgotten. The recent past was even then foreshadowing the events of the future. A big war, it was clearly shown, was no longer a mere clash of armed forces; it was a struggle between peoples and entire economic systems, essentially not much different from the competitive struggle between two large business enterprises. The South had starved in the midst of plenty because of its broken-down transportation and finances; the North had almost lost through poor management of its supply department. There was ground for hope that the re-United States would not allow a repetition of similar blunders, and that no attack would ever again find the war department without a thoroughly prepared, all-embracing business organization and an abundance of the most vital sinews of war.

[7] "E. I. du Pont de Nemours, A History," Houghton Mifflin Company, 1920, pp. 82–99.

[8] "Du Pont, One Hundred and Forty Years." "E. I. du Pont de Nemours, A History."

The First World War

The first World War was characterized by one chemical achievement of such overwhelming interest that it outweighed all others. I am speaking of gas warfare. Aside from its novelty in modern combat, the introduction of this weapon carried with it the germ of a thought which, if it had been properly understood and interpreted, might have changed our entire conception of and preparation for warfare in general. Unfortunately for us, the Germans did develop the thought, and thereby gained an incalculable advantage over her opponents in the present world conflict.

I am not going to discuss at length the pros and cons of whatever moral issues may be involved in the use of poison gases. My personal opinion that gas warfare is no more evil than any other kind of human slaughter is, I believe, shared by most chemists. Attempts to outlaw it are bound to end in failure. Technical progress, whether for good or evil, can not be undone. Even if outlawed, the fear that the enemy will do the unlawful, would force us to keep all our knowledge and preparations up to date. The world has looked in turn upon arrows, Greek fire and gunpowder as illegitimate methods of combat and has tried to suppress them. Only twenty-five years ago, many voices were clamoring for the abolishment of submarines. No one advocates their abolishment to-day. Nations in mortal danger have always ignored peacetime treaties, for war itself is a denial of all laws and agreements. *Silent leges inter arma,* as the Romans put it, "when the arms speak, the law becomes silent." Two men on a rock-bound island fighting for the last crumb of bread or drop of water do not follow Marquis of Queensberry rules. But this is beside the point. The thought I have in mind tends in a different direction.

When the idea of a gas attack, on which German laboratories had worked for some time past, was first submitted to the German High Command, it was received with disdain. The graduates of Potsdam thought they knew all about warfare and wanted no advice from outsiders. It is said that only personal intervention by the Kaiser brought about a change of heart among the commanding generals. Nevertheless, they immediately set out to sabotage the plan, whether through lack of capability or malice is immaterial. The proper procedure would have been to call a conference of their leading chemists, inventors, military officers and business executives—the best brains of the country—to discuss the possibilities of this gas plan and perfect it before putting it to use. The businessmen, if men of vision, would no doubt have voted against its immediate adoption. Let there first be found a gas that was less visible, less odorous and not as easily identified as chlorine. Even a poker player would have advised against tipping a hand that held great possibilities, but still had to be played.

Months would have passed. Then the chemists would have submitted their improved product, phosgene. Invisible, insidious, highly poisonous, it would have broken the Allied front; for no soldiers can stand up against a weapon they can not see and against which there is no defense. Of course, the attack would have to be carried out on a long front, one hundred, two hundred miles at least, and be sustained by a full onslaught against the incapacitated or demoralized opponents. What if victory were achieved by means called unfair or even illegitimate? The world had a way of bowing to the victor, regardless of the means he had employed. One had only to read history for confirmation of this fact.

But the decision was not put into the hands of a board with vision; instead, it was left in the hands of men who had only the narrow view-point of the German military caste. Like the hungry man to whom a good fairy granted one wish and who asked for a meal when he could have asked for a King's ransom, the Germans made their gas attack on a three-mile front; they killed 5,000 Frenchmen and French colonials, injured 10,000 and captured 6,000 more. That was all. There were not even enough German troops in reserve to march through the breach to the English Channel, which they could have done.

This happened on the 22nd day of April, 1915. On the 23rd, 100,000 gas masks, hurriedly made from cotton pads saturated with reducing agents and chlorine-reacting compounds, were on the Allied front. The great peril was past. Germany's chemists had presented their country with a great opportunity to win the war with one stroke, and the general staff had exchanged the gift for a mess of pottage.

From a far-off perspective, this first modern gas attack deserves a much closer study than it seems to have received. Reduced to its simplest terms, this had been the problem. A big business concern, called Germany, had been offered a new invention that would speed up its output, in this case the killing or disabling of enemy troops. As in the case of any other invention, she asked her specialists to pass on its technical merits. The chemists approved. There was a gas called chlorine that could be taken to the front and used to kill people. The supply or manufacturing department affirmed its ability to produce chlorine cheaply and in large quantities. The invention was now submitted to those who had to use it, the plant managers and engineers, or in war, the general staff and the front line officers. They agreed, reluctantly and with understandable professional pride—or perhaps jealousy—that the proposed new method was feasible; their main objection probably was that existing methods were satisfactory, and that the situation was well in hand. Now the invention should have been passed back to the board of directors, the big keen brains of the enterprise. Here was an invention that could not be patented nor kept secret for any length of time. What was the best policy to profit by it? Disregarding the character of the novelty, the directors would ask several pertinent questions. Could the invention be easily imitated? It could. Why not wait then until it was made more complex before putting it on the market? And when it was time to sell the article, let it be turned out in such big quantities, that competitors would be swept off their feet, and be out of the running before they could catch their breath. But the business firm called Germany had no board of directors; and having no board of directors, she missed her one golden opportunity to win the war.

In principle, there was no great difference between a novelty to be sold to the public and a new weapon called poison gas. Germany lost the first World War because she did not recognize that war had become Big Business; hence she had no board of directors to conduct the war in a business-like fashion. An invention which would have swung the balance was there, but its use was left to the discretion of one single department which muffed it. It was as if a big steel company would leave a question of fundamental policy in the hands of its distributing agents. They would be consulted, of course, but they would not be asked to carry the responsibility; for the introduction of new processes involves more than mere technical sales ability; it involves questions of finance, tariffs, patent laws and others that can only be weighed efficiently by shrewd and experienced groups of masterminds, not by specialists in any one line, no matter how brilliant. The proper utilization of poison gas was neither a purely chemical nor a purely military problem. In its larger sense it was a business problem, and its solution should have been left to the shrewdest business minds of the nation.

In its primitive stages war was a clash of brute force against brute force. By and by weapons were devised and improved, and those with novel arms were the most successful. The waxed bow of the Northern tribes, the short sword of the Romans, showed that technical ingenuity had its rewards even in the early stages of warfare. The men of the Macedonian phalanx were forerunners of our shock troops, the elephants forerunners of steel tanks yet to be invented. At the same time, strategy began taking the place of mere brawn. In spite of these developments, however, war was still largely a matter of soldiering. Just as the owner of a primitive iron furnace was his own chemist, engineer, salesman and credit department, so the primitive general embodied in his own person all the knowledge and ability necessary to organize, arm and lead his troops.

The graduates of Potsdam were finely educated soldiers, but they still thought of war in terms of rifles, siege guns, local strategy. They failed to recognize that modern wars had grown beyond the art of soldiering and had become an enormous business enterprise which they were not trained to conduct.

The German High Command did not properly evaluate what chemists could do, because they lacked the vision and experience of keen and successful businessmen. It was not they who failed; the system failed which they served. One simple businessman, unable to tell a machine gun from a revolver, but shrewd in the ways of the competitive world, sitting in conference with the military officers, might have kept them from the elementary error they were about to commit. His advice could have changed the course of history. But to have such an outsider take part in military discussions is something the German High Command would have considered ridiculous.

The first World War demonstrated that chemical ideas, properly utilized, can win wars. This does not mean, of course, that chemists alone can win them without cooperation from others. In order to win a war by means of a startling invention, or at least help win it, a coordination of four different types of mentality is needed, and they must work in harmony, like a well-organized athletic team or the integrated parts of an aggressive business enterprise.

First, we must have the imaginative type which envisions things that have never happened before; not visionaries who dream of perpetual motion, but minds that can visualize a gas adapted to warfare and base their dreams on sound chemical and physical principles.

Second, we need the specialist, the expert in the field to which the proposed invention belongs and who is competent to judge which dreams may be reasonably expected to come true. He need not be imaginative, but neither must he be hidebound, for it is up to him to translate a vision into an actuality, or else decide definitely that to do so is impracticable. This expert must have a large staff of chemists, physicists, engineers, physicians, mechanics and others at his beck and call, so as to carry new ideas to their completion.

The next man to take over is the man in whose hands the invention is to be placed. In commercial life we call him the distributor; in war he is the military officer at headquarters. It is he who must determine how the invention fits into his task at the front and work out the details of its proper application.

Had a gas best be ejected from projectors brought close to the enemy's lines, or should it be put into shells? Is it advisable to disguise the odor of a gas by the admixtures of other gases? These are questions on which his decision should be final. This officer must be a man of intelligence, for it is up to him to either carry out new ideas or else pass them back to the laboratory to strengthen them for actual combat use, but his authority should not be allowed to extend beyond these specialized tasks.

The fourth type of mind is that of the general director who has before him an over-all picture of the entire war and whose word alone can release the invention. His judgment, not that of the military staffs or any other groups, should decide if, when and how a new weapon is to be put to practical use. If he fails, the invention fails, no matter how meritorious it may be *per se*. The German generals should not have shouldered a responsibility that properly belonged to a type of mind they did not possess.

The great achievement of chemistry in the first World War was the lesson we learned—or should have learned—how to utilize new chemical ideas correctly. Gases may or may not play a prominent part in our present conflict, but other chemical inventions may take their place, carrying with them that element of surprise which is so essential to military success. If such an invention should be brought forth, it will undoubtedly be developed and used with full consideration of the lesson the Germans taught us unwittingly by their abortive gas attack at Ypres almost thirty years ago.

Above all, of course, the first World War confirmed what the Civil War had indicated—that war has become an enormous business and that its direction should no longer rest exclusively on the military branch of the government; strategy, arms and manpower have ceased to be the only means by which war is waged. Each nation needs in addition much other new equipment, such as a research department—scientists. But equally important is a board of directors to coordinate all branches and infuse into the whole structure the shrewdness, experience and all-around brain-power without which no Big Business can be successfully conducted.

(To be concluded)

SCIENTIFIC EVENTS

DEATHS AND MEMORIALS

DR. EDMUND S. CONKLIN, formerly head of the department of psychology of Indiana University, died on October 6 at the age of fifty-eight years. Before going to Indiana University, Dr. Conklin was head of the department of psychology at the University of Oregon.

DR. WINFIELD SCOTT HALL, since 1919 emeritus professor of physiology of Northwestern University, died on October 2 at the age of eighty-one years.

DR. FRANK WILLIAM MARLOW, professor emeritus of ophthalmology of the College of Medicine of Syracuse University, died on October 4. He was eighty-four years old.

DR. HERBERT POTTS, professor emeritus of oral surgery of the Dental and Medical School of Northwestern University, died on October 7 at the age of sixty-nine years.

THE death is announced, while a prisoner of Japan, of Dr. Robert Cecil Robertson, professor of bacteriology at the University of Hongkong and a member of the League of Nations Medical Mission. He was fifty-three years old.

Nature announces the death of Dr. L. Aschoff, professor of pathological anatomy at the University of Freiburg in Breisgau, aged seventy-five years, and of Dr. H. C. Lawrence, formerly of the Imperial Forestry Service, Burma, on August 25, at the age of sixty-seven years.

THE Soviet Academy of Sciences has set up a special committee, under the chairmanship of M. Krylov, the mathematician, who translated Sir Isaac Newton's works into Russian, to celebrate the tercentenary of Newton in December.

MICROFILM RECORDS OF THE LINNEAN SOCIETY OF LONDON

SOME time ago a grant was made by the Carnegie Corporation to the Linnean Society for the purpose of making a complete photographic record of all Linnean manuscripts and specimens. Although these documents were in storage outside London the task of photographing the material has now been completed. At the time the grant was made the officials of the Linnean Society offered to deposit a complete microfilm record in some American institution, and later the council of the society selected Harvard University as the place of deposit. The extensive series of microfilms, transmitted from London through British government channels, is now at the Arnold Arboretum. As soon as the necessary descriptive data are received these will be deposited at the Gray Herbarium, Harvard University. Once the material is organized arrangements will be made to supply