METALLURGICAL REMINISCENCES

By Albert Sauveur

It was in June, 1889, that I was first admitted to the society of educated men. The admission ticket had been signed, on the recommendation of my old and beloved teacher, Bobby Richards, by General Francis A. Walker at the time President of the Massachusetts Institute of Technology, an institution familiarly known as M. I. T.

I immediately proceeded to take advantage of that privilege by departing for Steelton, Pennsylvania, where I understood I was eagerly awaited by the educated officials of the Pennsylvania Steel Company. I was somewhat disappointed at the casualness of my reception and at being tucked away in that preserve closet of steel works known as the chemical laboratory. At Steelton I met Major Bent who was president of the company. When I say "met," that is a figure of speech as my acquaintance with him was confined to my being shown the estate where he lived. I came into closer contact with F. W. Wood who was the general manager; with E. C. Felton, the general superintendent; with H. H. Campbell, the superintendent of the Open Hearth Department; with Henry Souther; with Frank D. Carney and Frank Tenney, to name only the brightest lights. These men already educated were to achieve greater distinction.

Life in a steel mill chemical laboratory lacks enchantment. I entered it every morning at seven o'clock to leave it at six o'clock. To be sure, on Saturdays we stopped our labor at 5 p.m., but as we had only fifty minutes for refreshment at noon you will see that we worked, if that is the correct way to express it, exactly sixty hours per week.

While I had been told that I would be paid $50 per month for my services, when my first pay check arrived I found to my disappointment and indignation that it was only for $40. Lest you infer that a college education was worth very little in those days, you should recall that unskilled labor was being paid $1.00 for ten hours work whereas I received $1.67, from which it follows that a college education was worth sixty-seven cents.

During those long hours of forced attendance in the laboratory my time was not fully occupied. I was soon made to realize that those who had preceded me had divided the work among themselves. It was a sort of monopoly. My breaking in was resented and the morsels reluctantly surrendered constituted such a small pittance that I was kept in constant danger of occupational starvation. In fact, I seldom succeeded in grasping work that would occupy me more than two or three hours, which left me with some eight hours daily on my hands. What was I to do with them? I could not for that length of time assume the attitude and occupation of the "Thinker" of Rodin. Smoking helped but did not go far enough while papers, novels and detective stories failed to supply a satisfactory solution.

It then occurred to me that I might as well study the metallurgy of iron and steel. To be sure, I had received instruction in those subjects at M. I. T. but as it had consisted only of fifteen lectures it was evident that they had not been mastered and that self-instruction was in order so far as it could be obtained from books. Accordingly, I installed in a cosy corner in the balance room the least dilapidated chair I could find and there I read all the metallurgical books I could get hold of, old and new, day after day, while taking copious notes. I owe a debt of gratitude to those authors who through their writings helped me at this effort at self-education. The list includes: "The Metallurgy of Iron" by H. Bauerman, "Metallurgy of Iron and Steel" by Percy, "Principles and Manufacture of Iron and Steel" by Lowthian Bell, "Elements of Metallurgy" by J. H. Phillips, and "Metallurgy" by Greenwood.

Strange as it may seem, this was about the extent of the literature of iron and steel at the time, from which modern notions of the subject could be obtained. Neither Howe's nor Campbell's books had yet been published.

Dissatisfaction, however, and unrest had inevitably to take possession of me and led me to periodical trips to the office of our general manager, F. W. Wood, urging him to give me a change of occupation and also suggesting an increase in salary. My arguments could not have been very convincing, as after one and a half years at Steelton I was still seated in my cosy corner in the balance room, although to be sure, my pay check was now for $55, and the chair a little more dilapidated.

Fortunately at this time, I began to receive letters from Goodwin Stone and Jasper Whiting, two classmates, who were with the Illinois Steel Company in South Chicago.

In their letters, the charms of their occupations and of the nearby town were depicted in such glowing colors that I decided to inform their manager, W. R. Walker, that I would not be indifferent to the receipt of an offer. The offer came and after placing it before my own employer, to give him, in a spirit of fairness and strict neutrality, a chance to outbid the other fellow, I finally responded to the call of the West.

After spending a few months in the laboratory and some three hundred nights in the Bessemer mill attempting to reduce the number and size of the butts (I wonder how many of you are acquainted with this metallurgical product) and trying, often unsuccessfully, to keep awake, I was given a room all to myself, supplied with an old-time microscope and instructed to study the structure of steel and the ailments to which his flesh is heir. I may perhaps be permitted to say, without being accused of an utter lack of modesty, that this small beginning marked the introduction of metallography in the iron and steel industry in the United States. Five happy years were spent in this way, nearly each day made brighter by what seemed to me a little advance in a research in which I was now deeply interested, which was to continue fortyfive years and which God willing may go on a few more years. This early introduction of the microscope into the steel mill laboratory we owe solely to the vision of W. R. Walker, of blessed memory, who as already mentioned was at the time general manager at the South Works of the Illinois Steel Company.

Although Dr. Sorby had written earlier papers descriptive of the structure of steel as observed under the microscope, it may be fairly stated that the birth of metallography dates from the year 1886 when he read his masterful contributions on that subject before the Iron and Steel Institute of Great Britain, because not until then was any attention paid to what he had previously done and reported. Only five years had elapsed therefore when in 1891 we took up this new method of investigation at the South Works of the Illinois Steel Company. But two others were then engaged in this new field; namely, Osmond in France, who worked for a time in collaboration with Werth, and Martens in Germany.

It may be of interest to quote from a letter of H. M. Howe, dated September 15, 1891, after I had asked him about the advisability of consulting Dr. Sorby before undertaking my work. It reads: "Replying to your favor of September 7, I see no possible objection to your addressing Dr. Sorby, who is a very good-natured old gentleman, so far as I have seen. It gives me great pleasure to hand to you the enclosed letter of introduction to Dr. Sorby. I cannot hold out any great hopes to you of his being able to aid you, for he has grown old and rich, and I think has passed his days of activity. He is an excellent microscopist, and when I saw him a year ago, found him full of vigor, but so far as I could make out, disinclined to push his investigations in the structure of steel any further. However, it is quite possible that a letter from you might stir him up to renewed activity. If you do not get anything out of him, there is M. F. Osmond of Paris, who is a good friend of mine and who has considerable activity in microscopic work, who represents the future, and Dr. Sorby the past. I am sure that M. Osmond would be very glad to hear from you, and to cooperate with you, especially if you make it clear to him that you are carrying on work not as a private individual, but in a certain sense as the microscopist of the Illinois Steel Company, for the French attach the greatest possible importance to official position."

I did not write to Sorby, but I started with Osmond a correspondence which was to last until his death in 1912. In him I found generous cooperation, encouraging criticism, and above all friendship.

Among the early workers who followed us may be mentioned in the order indicated J. O. Arnold in England, Henry Marion Howe in the United States, Roberts-Austen, Robert A. Hadfield, J. E. Stead, all Englishmen, and Henry Le Chatelier in France. Of these, now that Le Chatelier has passed away, but one, Sir Robert Hadfield, is living. I shall always be deeply grateful for the privilege that was mine to work in close and friendly association with such men. They were stars of the first magnitude in the metallurgical sky.

My first endeavor in settling down to work was to reproduce what Sorby had done by following faithfully the manipulations described by him and for several hours every day I was diligently rubbing back and forth small specimens of steel upon emery paper, tripoli powder, crocus, Water of Air stone and jeweler's rouge. My microscope was of necessity a simple upright instrument with fixed stage, while the oxy-hydrogen light and calcium cylinder was the best illumination obtainable.

Notwithstanding the crudeness of the instruments and the slowness of the operations, I succeeded in obtaining satisfactory photomicrographs under moderate magnification, which to the best of my knowledge were the first photomicrographs of the structure of polished samples of steel produced in the United States. It would be interesting to know how many millions have been taken since.

The South Works of the Illinois Steel Company were exclusively concerned at the time with the manufacture of Bessemer steel rails, and it was natural that I should have focused my attention as well as the lenses of my microscope on that type of steel and on the finished product. It soon became apparent to us that the properties of steel rails were largely dependent upon the dimensions of their microscopical constituents or grain sizes, and that in turn these dimensions resulted chiefly from the finishing temperatures. In this way the importance of controlling these temperatures was brought forcibly to the attention not only of rail makers, but of other manufacturers of rolled or forged products, who until then held the view that hot-worked articles should be finished at the highest possible temperature in order to reduce the power and hence the cost required to shape them. We were able to show that a certain critical temperature existed, which we called *x*, which yielded the smallest grain size after slow cooling following hot work. We now know that this temperature, *x*, corresponds to the critical temperature A_{321} or to the critical range $A_3 - A_1$.

These early results were described in a paper entitled "The Microstructure of Steel," presented to the American Institute of Mining Engineers at the Engineering Congress held in Chicago in 1893, which shows that my first two years of work had not been barren. Well do I remember my misgivings in mailing this, my first attempt at technical writing. It was, however, generously received and translated into French, German, and Russian.

At the same meeting Osmond presented a paper on "Microscopic Metallography," and Martens a paper on "The Microstructure of Ingot Iron in Cast Ingots." These three early contributions on metallography were extensively discussed under the topic of "Physics of Steel," and constitute a landmark in the progress of that Science.

My work began to attract the attention of others and frequently I had visitors trying to find out what it was all about, some of them departing favorably impressed but most of them I fear unconvinced if not actually hostile. Walker, however, for whom I had great reverence, continued to encourage me by his unabated and keen interest and too generous praise. The wide adoption by others of this new method was destined to be slow as the obstacles that had to be overcome were quite formidable. As I have stated on another occasion, these obstacles resulted from ignorance, ill-will and prejudice, while ridicule was the favorite weapon of the opponents. When some metallurgical wag discovered that by photographing a certain variety of ginger snap under the microscope a design was obtained suggesting the structure of mild steel, it was a source of much gratification in some quarters and it was predicted that a deathblow had been dealt to the microscopical examination of steel. Such innocents are to be found in all walks of life. While they do not add much to the patrimony of mankind, they enliven our existence.

In 1896 my microscopical work was temporarily interrupted because of the discovery of *x*-rays by Roentgen in the latter part of 1895. In January, 1896—that is, a very few months later—at the suggestion of W. R. Walker, experiments were undertaken to ascertain whether by the use of such rays internal defects in steel could not be detected. My outfit consisted of a "Crookes" tube, an induction coil and a storage battery. Obviously with such crude appliances, the rays we were able to generate failed to penetrate even the thinnest steel sheets. Our experiments, however, attracted enough public attention to warrant first-page reports in the newspapers of the day and for a while we enjoyed intense publicity. I believe it can be claimed that we were probably the very first to enter the field of radiography.

Failing to obtain results with steel, I turned my attention to a substance less resistant to penetration, namely the hand of my assistant, W. C. Post, and obtained a very satisfactory picture. I have a vivid recollection of the thrill I experienced when the bone structure of Post's hand flashed into view in the developing tray.

In 1896 I wrote my second paper, "The Microstructure of Steel and the Current Theories of Hardening," the following gentlemen taking part in a lengthy discussion: A. Ledebur, R. A. Hadfield, Ralph G. Scott, Henry C. Jenkins, J. O. Arnold, Roberts-Austen, Henry D. Hibbard, P. H. Dudley, E. D. Campbell, F. Osmond, and Henry M. Howe. This discussion and the author's reply occupied one hundred pages of the Transactions of the American Institute of Mining Engineers. It may be added that so far as the hardening of steel is concerned the discussion never ceased and is still going on today.

In 1896, what I have elsewhere described as a hurricane in the form of a new president, John W. Gates by name, struck the South Works of the Illinois Steel Company, which in its violence carried away the metallographical laboratory and its occupants. Mr. Gates was not accustomed to deal with things microscopic, macroscopic dimensions being more to his liking. Fortunately, by that time a seed had been sown which was destined to bring forth a rich harvest.

Having attempted in vain to convince President Harper of the newly created Chicago University that the teaching of metallography should be taken up at his institution, it occurred to me that the Carnegie Steel Company should open wide its doors. Had not Mr. W. E. Corey and Mr. J. S. Unger visited my laboratory and expressed interest in my work, and were they not themselves peeping through the microscope by this time?

I was referred to Mr. Charles M. Schwab, who took the matter under consideration that he might refer it to his superiors (I never knew that Mr. Schwab ever had any superiors), and the results of these important conferences were condensed in the following short letter:

September 2, 1896

MR. ALBERT SAUVEUR,
Spencer, Mass.,
Dear Sir:

After conversation with our people in the mill I find that there is no vacancy of any description we can offer you at present.

Yours respectfully,
(Signed) C. M. SCHWAB
General Superintendent

Mr. Corey abandoned metallography to become the first President of the United States Steel Corporation, a change of occupation which I am told was accompanied by an increase in salary, while Mr. Unger's interest in metallography has always been, I believe, lukewarm. I likewise failed to induce the Watertown Arsenal to take up metallography. General D. W. Flager, at the time Chief of Ordnance, explained to me at length why such a step would be inadvisable. Quoting from his letter dated May 9, 1895, "For the present, at least, it seems to me that the investigations and tests you describe can be carried on best by the steel producer"—and later in another letter, "Our Mr. Howard is already overloaded with work, and has attained exceedingly valuable excellence in a certain line. I would hesitate to direct him to visit your laboratory and make a study of your work, because I fear he might find it so interesting as to withdraw his necessary attention from other work."

I appealed to those who had shown interest in my work and for whom I had made microscopical examinations of samples submitted by them. They included A. A. Stevenson of the Standard Steel Works who wrote that he wished his works were large enough to warrant employing me; C. D. Dudley, chemist for the Pennsylvania Railroad Company who wrote that he felt confident that it would be a very difficult thing to persuade his people to put any money into such studies as I had been pursuing and especially in view of what he understood to be the present conditions of our knowledge of the microscopic structure of iron and steel, and T. M. Drown under whom I had studied chemistry at the Massachusetts Institute of Technology and who was then President of Lehigh University, who wrote that it would be a great pleasure to him if he could assist me in obtaining a metallurgical position either in works or in a college where I could continue my investigations which had been of unusual merit; R. W. Davenport, at the time Vice President of the Bethlehem Iron Company, who wrote that their Mr. Maunsel White had recently returned from Russia but that owing to great pressure of work and several absences from town, he had not been able to talk with him in reference to the possibility of my entering the employ of the Bethlehem Iron Company.

Such were the tribulations of a young metallurgist in the gay nineties. However, ginger snap or no ginger snap, he was not to be defeated. He would become a free lance. He opened some testing laboratories in Boston and in 1898 a quarterly publication known as the *Metallographist* made its appearance, a daring undertaking, as I look at it now in my more matured age, for a young man to attempt single-handed. So many kind words have been spoken, however, about the part played by this publication in creating an interest in metallography that I am glad now that I did not have, at the time, the wisdom and prudence to keep me from an undertaking in appearance so hazardous. In deciding upon a title for this publication, I consulted Professor Howe. Should it be the Metallographer or the Metallographist? Howe wrote, "I question whether Metallographer is not a better word, with better antecedents or rather precedents than metallographist. We have geographer and cryptographer. We have, it is true, telegraphist but this, like telegram, is, I believe thought rather objectionable. However, I just throw the inquiry out for what it is worth. I think that there is a dislike to the ending "ist" as witness the violent opposition to the horrid word "Scientist," "Walkist" for "Walker." But I may be prejudiced."

It is apparent that Professor Howe failed to convince me, and the word *Metallographist* was coined. Its publication lasted seven years which considering the difficulties that had to be overcome to keep it alive is quite a satisfactory performance. The number of its subscribers never exceeded five hundred. Failing to receive any support by way of advertisement, although steel companies were urgently appealed to by Professor Howe and others, its discontinuance was inevitable and it was finally sold for a paltry sum to the *Engineering and Mining Journal* with which it was incorporated. As a bait to advertisers, it was published monthly instead of quarterly the last two years of its existence and the title changed to the *Iron and Steel Magazine*, but all in vain.

The Boston testing laboratories had a precarious existence. They were founded in the hope that they would supply the necessary funds to keep the metallographic pot boiling. However, the fuel ran low and on several occasions the pot was on the verge of freezing.

In 1903 the firm of Sauveur and Whiting was organized, but it was soon replaced by that of Sauveur and Boylston. Things now began to look up. It was then that the first edition of my book on the Metallography and Heat Treatment of Iron and Steel was published, in 1912. It was also at this time that a correspondence course in metallography was started. It was unexpectedly successful from the beginning, over 1500 students having enrolled since. I would be surprised if there were not some of them in this room.

Let me pause an instant to present to you an honor roll: To the best of my knowledge the first ten steel works to equip themselves for the microscopical examination of steel may be listed as follows: The Carnegie Steel Company in 1896, The Simonds Mfg. Co. in 1898, The Standard Steel Company in 1898, Otis Steel Company in

1898, Aetna Standard Iron and Steel Co. in 1899, The Bethlehem Steel Co. in 1899, The American Wire Co. in 1899, Sanderson Bros. Steel Co. in 1900, Benjamin Atha & Illingworth Co. in 1900, The National Tube Co. in 1900; the first testing laboratory, Henry Souther in 1899; the first manufacturer of electrical appliances, The Wagner Electric Manufacturing Co. in 1900; the first foundry, The Westinghouse Machine Co. in 1900; the first railroad company, Chicago, Milwaukee and St. Paul in 1900; the first educational institution, Harvard University in 1900; the first three nonferrous producers to equip themselves were National Enameling and Stamping Co., St. Louis, Mo.; The Coe Brass Mfg. Co., Torrington, Conn. and the Ajax Metal Company, all of them in 1901.

What days we did live during the last decade of the last century and the first decade of the present! What harvest was being gathered! Le Chatelier perfecting his thermo-electric pyrometer; Osmond pouncing upon it and discovering by its means the upper critical points of iron, denoting them by the symbols A_2 and A_3 and announcing the existence of iron under the three allotropic forms, alpha, beta and gamma; Stead describing the behavior of phosphorus in cast iron and your humble speaker the recrystallization of ferrite after plastic deformation; discussing the phenomenon of the hardening of steel which at times bordered on riots and divided metallurgists into two hostile camps, the allotropists and the carbonists; Tschernoff contributing his masterly description of the occurrence of dendrites in steel and later Belaiew giving a more exact picture of the mechanism of their formation, as well as of the Widmanstätten type of structure; Ewing and Rosenhain demonstrating the nature of the plastic deformation of metals; Roberts-Austen suggesting the use of neutral bodies in the determination of the critical points of iron-carbon alloys; Beilby and his amorphous phase in metals; Arnold suggesting the existence of the carbide $Fe_{24}C$ and attributing to it the hardening of steel; Charpy introducing the three-dimensional diagram to represent the constitution of ternary alloys at various temperatures and explaining the directional properties resulting from hot working; Le Chatelier devising the inverted type of metallurgical microscopes now so universally used and suggesting levigated alumina as a polishing powder; the naming of the constituents of steel—ferrite, pearlite, and cementite by Howe; austenite, martensite, troostite and sorbite by Osmond; Roberts-Austen and others explaining the significance of eutectic alloys; the development of the iron-carbon equilibrium diagrams by Roozeboom, Roberts-Austen, Carpenter and Keelings, Benedicks and Rosenhain; Howe in a letter to the editor of the *Metallographist* dated June 4, 1903, discussing the relative merits of "eutectic" and "aeolic" to designate steel made up completely of pearlite after slow cooling, and in a postscript to that letter dated June 9, suggesting the word eutectoid in the following terms:

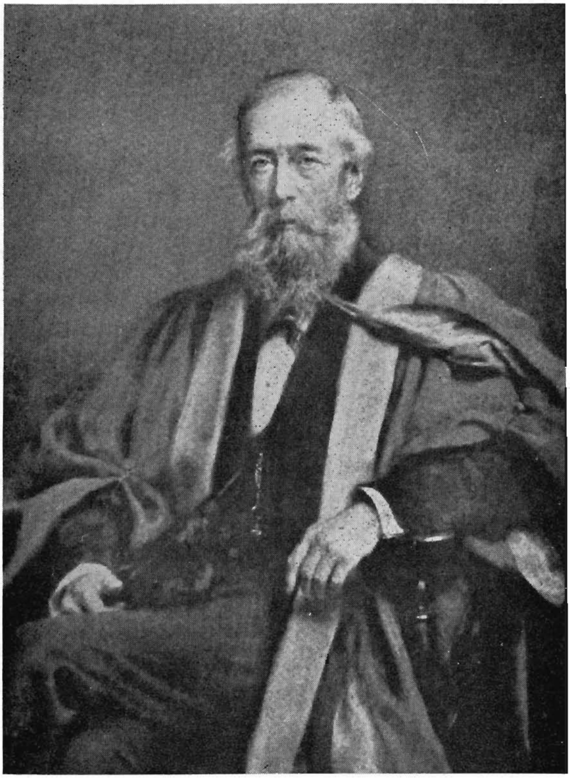
P.S.—By *esprit d'escalier* I have contrived, too late to serve me where I sorely needed it, a word which seems to meet the certainly strong objections restricting the "eutectic" to the alloys of lowest freezing-point, while giving me all that I contend for, viz., that the basis of the definition of "eutectic" shall not be completely changed and that we shall be able to distinguish the alloy of lowest transformation-point clearly and easily from that of lowest melting-point. Let us use the word "eutectoid" to denote alloys of lowest transformation-point. The suffix "oid" clearly indicates that the eutectoid has the form or other important properties of the eutectic; it keeps the resemblance of the eutectoid to a eutectic before the mind, while it allows us to preserve the initial meaning for eutectic, and to distinguish between these two really distinct though related entities.

This was probably the first time that the word "eutectoid" was written.

This period witnessed also the concerted attacks on beta iron which although repeatedly buried had a disconcerting habit of coming back to life. Permit me to quote from some of my previous remarks on that subject: "The most imposing of the funeral services was held at a meeting of the Iron and Steel Institute in 1913. This led me to ask for a post-mortem inquiry on the suspicion that the patient had been buried alive. Professor Arnold on that occasion referred to the burial in his usual amusing vein. He said that the whirligig of time brought around some truly curious revenges. They were actually assembled that day to bury that poor, battered, threadbare old myth hard beta iron, and by some irony of fate the grave diggers were Dr. Rosenhain and Mr. Humphrey, while the officiating clergyman was Dr. Carpenter. Professor Arnold did not realize then that his own creation, the carbide $Fe_{24}C$, would be buried to much greater depths. It is now as dead as a dodo, whereas beta iron still shows signs of life because of that troublesome A_2 point which no one has yet been able to rule out of existence, not even Dr. Yensen; and now are we not told that a tetragonal space lattice occurs in martensite corresponding to a transition step in the transformation of face-centered gamma iron into body-centered alpha iron? And why is not this beta iron?"

In 1899 I was invited to join the teaching staff of Harvard University and I have remained in that Institution until my retirement a year ago, i.e., for a period of thirty-six years—but that is modern history and it is not, I am sure, your desire that I should discuss it. In concluding I would like to award honorary degrees to the builders of the Science of Metallography accompanied by the usual citations. They will be presented in the following pages in chronological order according to the dates of their births.

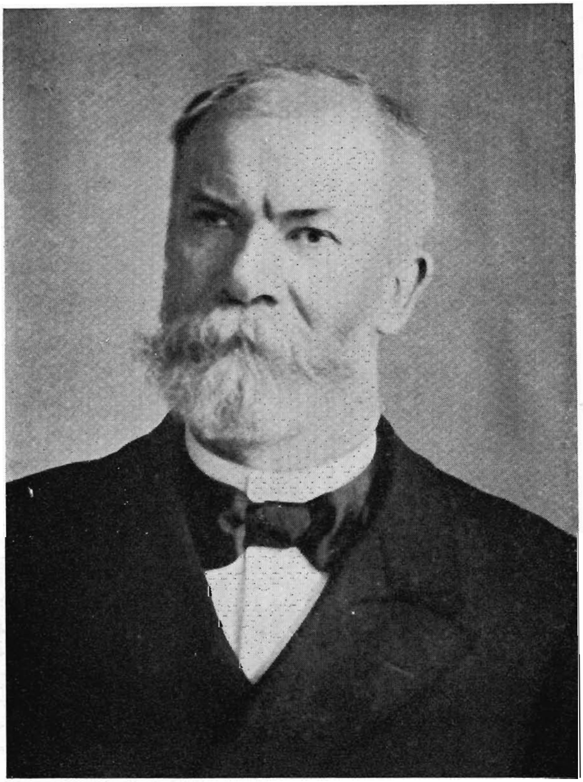
It is gratifying to note that fourteen of these twenty-two pioneers were awarded the Bessemer Gold Medal by the British Iron and Steel Institute, that nearly all the Englishmen were members of the Royal Society and that three of the four Frenchmen were members of the French Academy of Sciences.



HENRY CLIFTON SORBY

1826–1908

A great microscopist, mineralogist and petrographer, who through his happy thought of examining meteorites under the microscope as he had examined minerals and rocks, and in extending that examination to alloys of iron and carbon, and through his masterful interpretation of what he saw, created the science of metallography.



DIMITRI TSCHERNOFF

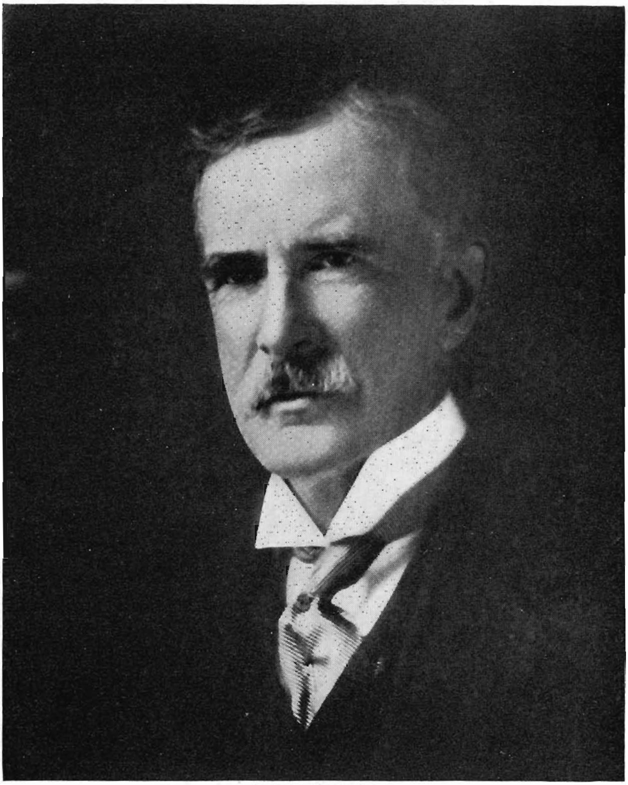
1839–1921

Famous Russian metallurgist, who with crude appliances and at a time when metallurgy was emerging from the dark ages, but with a clear vision, studied the dendritic structure of castings and the rationale of the hardening of steel by rapid cooling.

SIR WILLIAM ROBERTS–AUSTEN

1843–1902

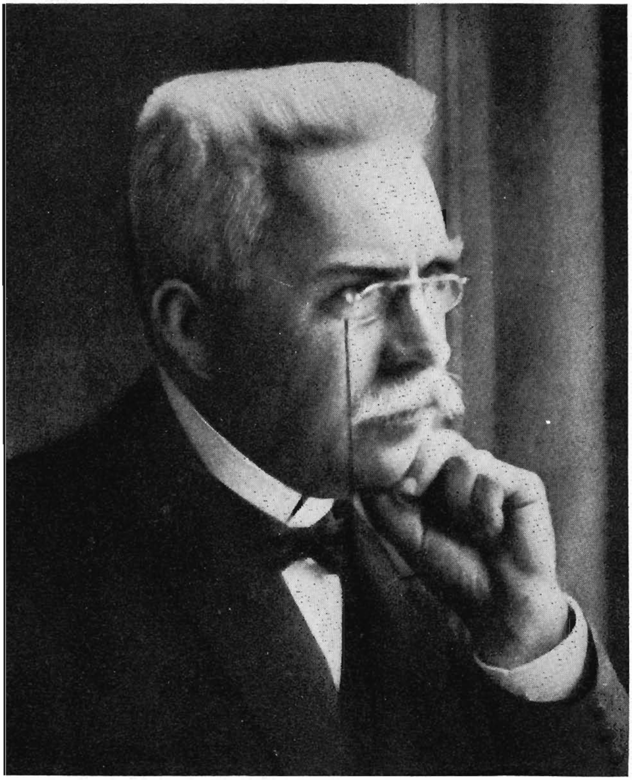
English teacher, chemist and metallurgist. A pioneer in the study of the constitution of metallic alloys. He took an active part in the development of the iron-carbon equilibrium diagram and suggested the use of neutral bodies in the determination of the thermal critical points.



Henry Marion Howe

1848–1922

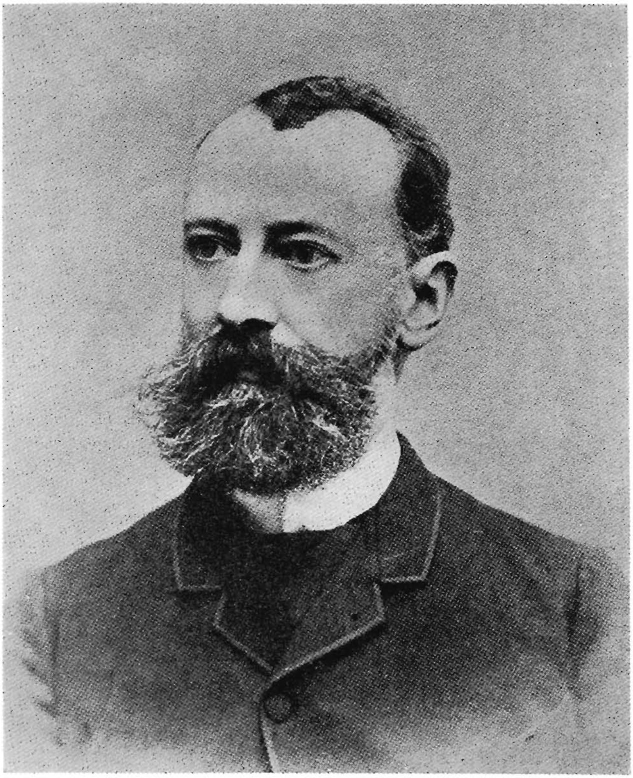
A great American teacher and metallurgist of illustrious parentage; a masterful coordinator endowed with the gift of bringing order out of chaos and light out of darkness.



HENRY LE CHATELIER

1848–1936

A great teacher, chemist and metallurgist, representative of the French savant at his noblest; enunciator of some laws of chemical mechanics which threw much light where obscurity prevailed; designer of a pyrometer which revolutionized the art of heat treatment and made possible the discovery of the upper critical points in iron and steel. He also gave us the modern metallurgical microscope.



FLORIS OSMOND

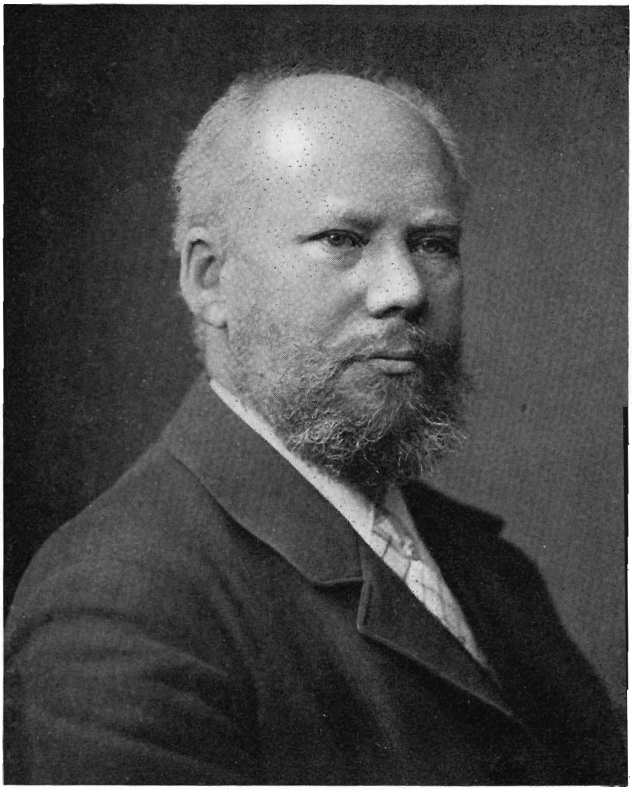
1849–1912

French engineer and metallurgist, torchbearer of the Science of Metallography; a prince in the field in which he labored. Through his discovery of the upper thermal critical points of iron-carbon alloys, he established the allotropy of the element iron. His early description of the microscopical constituents of steel has remained classical.

John August Brinell

1849–1925

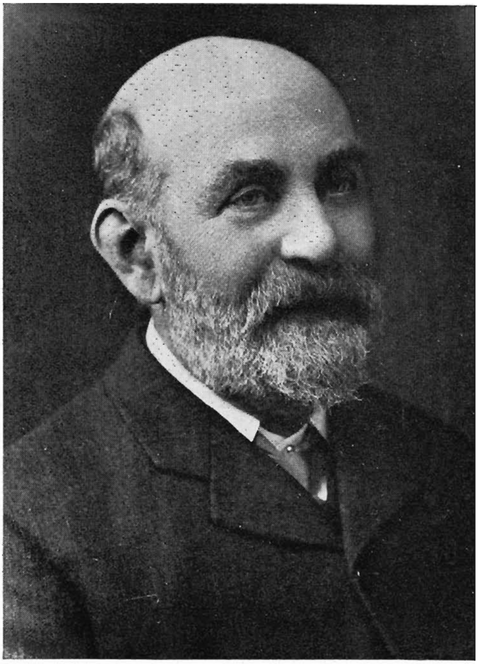
A Swedish engineer and metallurgist, who made us conscious of the importance of measuring the hardness of steel and who gave us the method that bears his name. He also advanced our knowledge of the occurrence of blowholes in steel and of the influence of manganese and of silicon in preventing it.



ADOLPH MARTENS

1850–1914

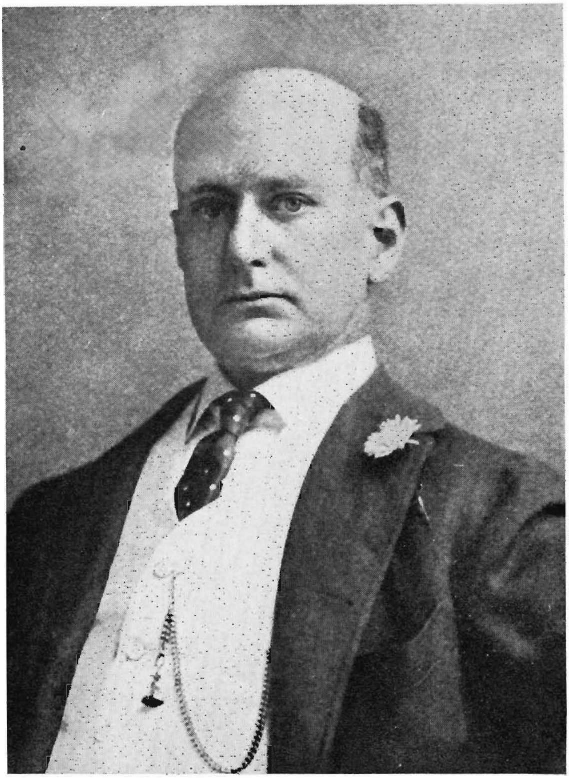
A German testing engineer; a pioneer in the application of the microscope to the study of steel.



JOHN E. STEAD

1851–1923

English chemist and metallurgist, who explained to us the occurrence of phosphorus in steel and in cast iron and also a certain brittleness in mild steel known as Stead's Brittleness. He eased the work of metallographists by the design of useful appliances and the description of simple manipulations.



MAUNSEL WHITE

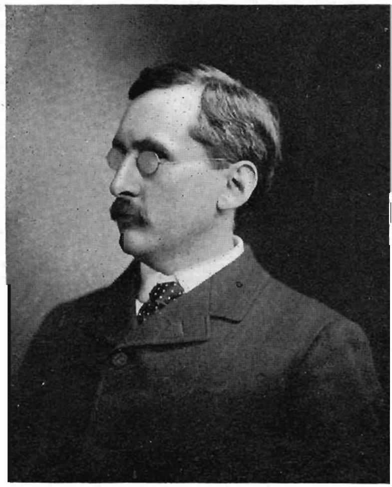
1856–1912

An American metallurgist, who with T. W. Taylor discovered high-speed steel, or if you prefer, the heat treatment conferring high-speed characteristics to steel of suitable composition—enough of an accomplishment for any man.

John O. Arnold

1858–1930

An Irish professor and metallurgist, with an Irish temper, who conceived the existence of the carbide of iron $Fe_{24}C$, a pioneer in the use of vanadium in steel and an implacable enemy of beta iron.



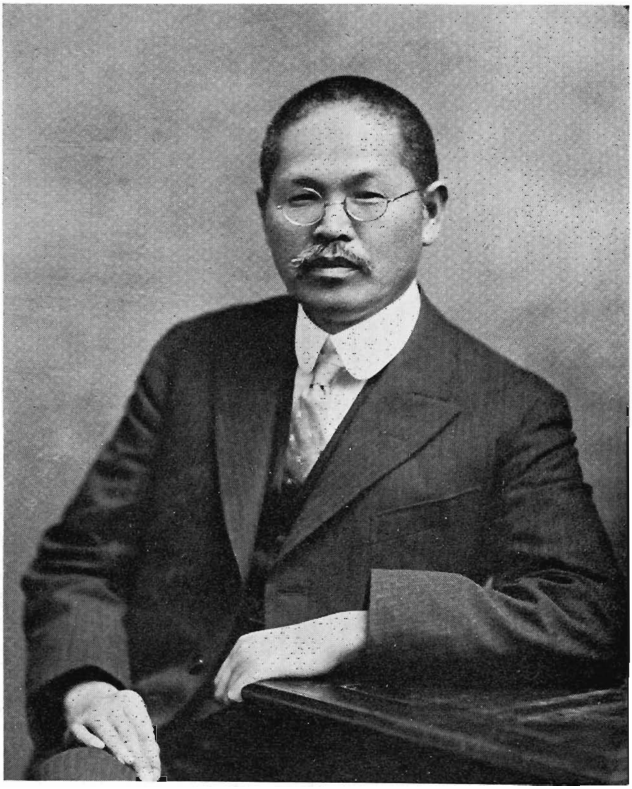
Edward De Mille Campbell

1863–1925

An American professor of chemistry, who became interested in the microstructure of steel and studied the occurrence of carbon in steel; accidentally becoming completely blind while still in his prime, he heroically carried on.

Sir Robert Hadfield

Famed English industrialist and metallurgist. Discoverer of austenitic manganese steel and of silicon steel. A prolific writer on metallurgical subjects and a generous patron of metallurgical research.



KOTARO HONDA

President of a Japanese University, which through the maintenance of a world-famous Research Institute, manned by a large number of competent workers, has contributed much to the advance of metallography. His studies of molecular magnetism are outstanding, and he discovered one of the best alloys for permanent magnets.

Léon Guillet

French metallurgist of great renown, director of a famous Engineering School, a prolific and vigorous writer, who has added much to our knowledge of alloy steels and of the heat treatment of steel.

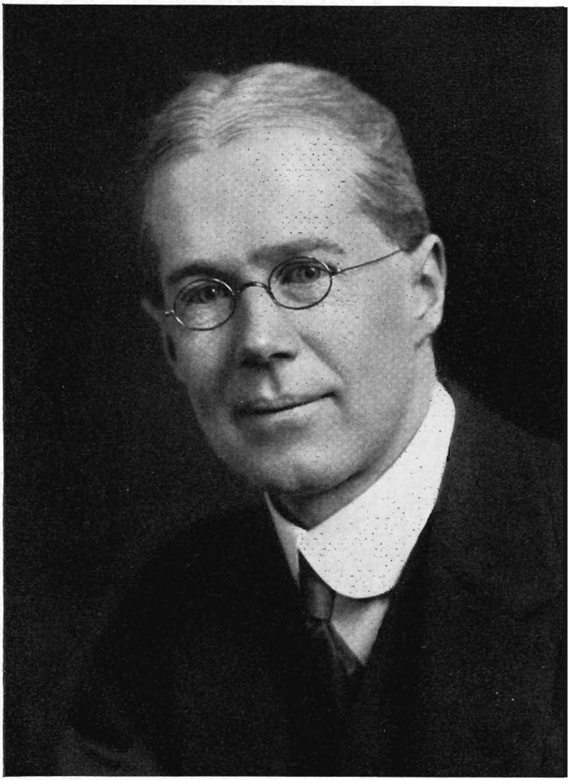
George Charpy

A French metallurgist, who when operating important steel works discovered and explained the cause of the directional properties of steel following hot work. A pioneer in the impact testing of metals and in the application of the three-dimensional diagram to ternary alloys. His study of bearing metals opened the way to fruitful research in that field.

WALTER ROSENHAIN

1875–1924

A brilliant metallurgist and physicist, Australian by birth. An independent thinker, bold in his attacks on the theories he considered ill founded. He disclosed to us the mechanism of the plastic deformation of metals and took an important part in the development of the iron-carbon equilibrium diagram.



Sir Harold Carpenter

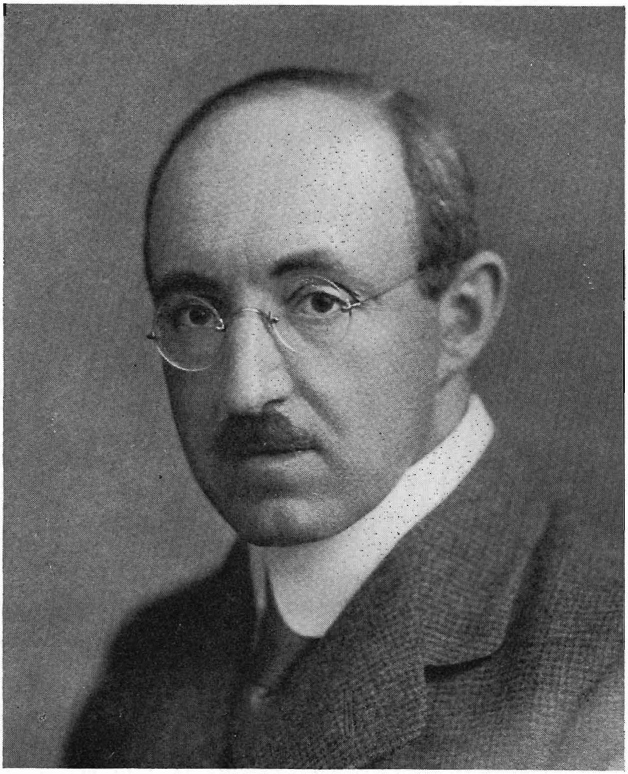
An English metallurgist, descendant of the illustrious Henry Cort. Distinguished alike by clarity of thought, skill in experimentation and soundness in argumentation. To him we owe much of our knowledge of the formation and properties of single metallic crystals.

Colonel N. Belaiew

A Russian disciple of Tschernoff, who has brilliantly carried forward the work of his master and who treats metallography as a fine art. His description of the crystallization of steel will long remain a classic.

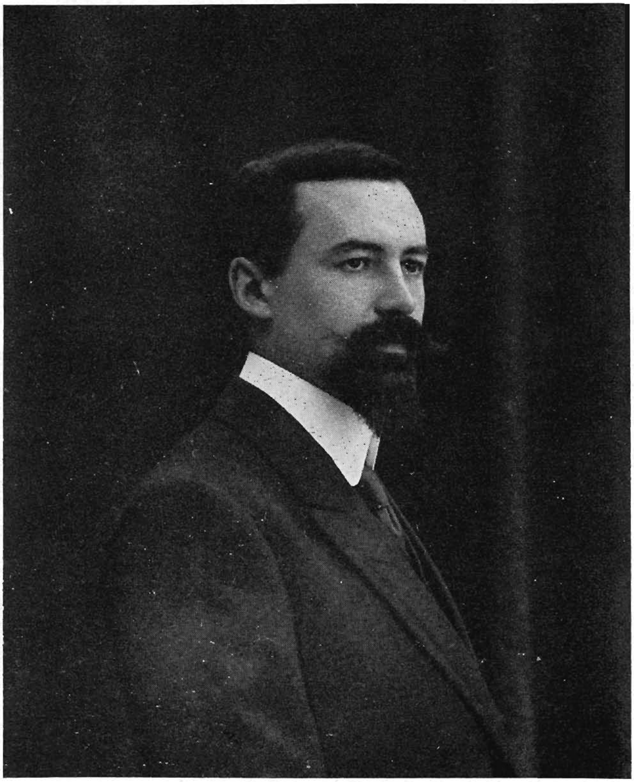
Harry Brearley

An English metallurgist, universally beloved because of his great contribution to the world in presenting it with stainless steel and because of his modesty. An exponent of simplicity and clarity in thought and expression.



Carl Benedicks

Distinguished Swedish metallurgist, to whom we are indebted for many important contributions on various aspects of metallography and for the part he took in the development of the iron-carbon equilibrium diagram.



ALBERT PORTEVIN

French metallurgist capable of exquisite thinking on metallurgical subjects. His artistry has penetrated into many dark corners, where it has shed a pleasant light and his activity has left few corners unexplored.