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WILDER DWIGHT BANCROFT

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Who was Wilder Dwight Bancroft? President of the American Chemical Society and the Electrochemical Society, founder of the "Journal of Physical Chemistry," author of hundreds of papers, professor at Cornell for his academic lifetime—such achievements have been reviewed elsewhere.¹ But this is not the record that his students and colleagues cherish, nor does it imply the uniqueness of the man as they knew him.

Bancroft published a great deal—because he edited (and largely financed) "J.P.C." for 36 years, and who had a better right to be safe from the blue pencil? But he did not put himself as senior author on every thesis from his students, and it meant a lot to a young man to see his name alone at the head of a paper, not pruned to the limit but with some character left in it. Bancroft's articles were long, often apparently strung together from quotations, but with these selected so that the conflict of ideas was clear and the key experiments needed became apparent. His review of a subject was an example of critical thinking, of clear recognition of how far the main stream of investigation had actually reached, and of the gaps and discrepancies that were not to be ignored. The books of his personal library bulged with markers of the points that he seized upon for correlation or extension.

He devoured all kinds of books, science, art, nature, detective stories; everything interested him, and his numerous book reviews in "J.P.C." were sought first by many readers. He admitted "insatiable curiosity" was his only guide, but his research was not as scattering as this might indicate. He was not a "strong chain of papers" man, but liked

to have various lines of work in progress: phase rule, colloids, contact catalysis, photochemistry, electrochemistry, proteins, color phenomena are each represented by a sequence of papers from his laboratory over a number of years.

As a lecturer, Bancroft had no "style," no "technique"—he thought about the subject aloud, with many of his best ideas taking form in the process. Sometimes he would have to refute himself the next period, but the stimulus of watching a first-rate mind in action was something his students could never forget. His phenomenal ability to cite references from memory was as fascinating as his ambidexterity, that once in a while led to mirror-writing, somewhat to his dismay.

In directing research, no one could have been less formal. He could not have operated under the modern program method of sponsored projects. He was with his men at every turn, and he went to their laboratories whenever he had a new idea, or thought an answer would be ready, sometimes several times a day. If a digression seemed interesting, it would probably be explored. If the whole course of the work turned out to be doubtful, no time was lost in taking a new tack.

Once Bancroft talked before a departmental seminar on "Guessers vs. Accumulators"; one or two of his colleagues thought he was poisoning young minds, but he maintained that if he had 10 ideas with even one of them good it was a lot more fun than to ride the one to its tedious limit. He didn't preach the virtue of "training to think" by this method, but his students loved the quiet excitement that came from contributing their ideas along with his to the pool.

Bancroft was an arguer; he would take either

(1) Findlay, *J. Chem. Soc.*, 2506 (1953); H. W. Gillett, *Ind. Eng. Chem.*, **24**, 1200 (1932).

side of a question, just to clarify his ideas. If a research student could talk him out of a proposed experiment he was happy—"Look at all the work we've saved." A frequent discussor at meetings, he sometimes irritated people by comments that seemed impatient and blunt. But scientific argument was impersonal to him; the polite compliments as a preamble to the stroke of the knife were not his way.

It seemed at times as if Bancroft had little use for the mathematical approach to physical chemistry; he believed strongly in qualitative experimentation to answer clearly formulated questions, with quantitative work as confirmation of the theory thus propounded. Never did he let his men get lost in numbers without a definite idea of where the data were leading them. If an experiment didn't sustain his theory, he was the first to recognize that it was misleading or inapplicable, and to suggest another one that should settle the question.

Bancroft was serenely independent of campus politics; for many years he turned back his salary to buy equipment. He was never ruffled, harbored no grudges, and kept his social and professional lives

separate. He played football at Harvard, followed sports ardently, and golfed and skated long after most people would have abandoned such exercise. He was greatly concerned, after an accident that gave him a serious concussion, lest his brain had been damaged, because his bridge game was for a time not up to its usual high quality.

His students fondly spoke of him as "Banty," yet he never called them by their first names, or palled around with them on parties. He dispensed no guidance, although somehow he managed to find fellowship support for a good man who was having hard sledding. Without making any conscious gesture, he inspired affection as well as admiration, and maintained scientific democracy because he never held his personal ideas as inherently superior or infallible. In contrast to self-seeking "promoters" of Research, jealous of priority, eager for subsidy irrespective of appropriate competence, he was a "gentleman-scholar" in the old-fashioned individual and collective meaning of these terms.

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Kinetics and Mechanisms of the Two Opposing Reactions of the Equilibrium $\text{CO} + \text{H}_2\text{O} = \text{CO}_2 + \text{H}_2$ ¹

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A kinetic study has been made of the two opposing reactions which comprise the "water-gas equilibrium," equation 1. Experimental measurements were made using a quartz vessel at 900° and a flow rate which allowed a reaction time of approximately 0.5 second.

The results may be summarized in the rate expressions

$$\frac{d[\text{H}_2\text{O}]}{dt} = \frac{9.5 \times 10^{10} \exp(-57000/RT)[\text{H}_2]^{1/2}[\text{CO}_2]}{1 + 3.6 \times 10^8[\text{CO}]}$$

$$\frac{d[\text{CO}_2]}{dt} = \frac{5.0 \times 10^{12} \exp(-67300/RT)[\text{CO}]^{1/2}[\text{H}_2\text{O}]}{(1 + 1.2 \times 10^4[\text{H}_2])^{1/2}}$$

which apply to the carbon dioxide-hydrogen and carbon monoxide-steam reactions, respectively.

Homogeneous chain mechanisms, involving the chain propagating steps $\text{OH} + \text{CO} \rightleftharpoons \text{H} + \text{CO}_2$ and $\text{H} + \text{H}_2\text{O} \rightleftharpoons \text{OH} + \text{H}_2$, initiation by dissociation of hydrogen (or steam) and termination by atom (or atom-radical) recombinations have been shown to be in substantial, although not complete, agreement with the data.

Introduction

An examination of literature concerning the kinetics of the reactions which comprise the "water-gas equilibrium" shows disagreement among the various investigators with regard to the occurrence of a homogeneous reaction in silica vessels within the temperature range of 600 to 900°. ^{2a-5}

However, the considerable data from combustion and explosion experiments show that at somewhat higher temperatures reactions in the gas phase proceed with sufficiently high velocities that the "wa-

ter-gas equilibrium" is established within extremely short time intervals. ⁶⁻¹⁰

There is nowhere available sufficient evidence upon which to postulate reaction mechanisms, although the need for this information has long existed.

The objectives of the present work may be enumerated as follows: (1) to ascertain whether or not reaction between carbon monoxide and steam (as well as carbon dioxide and hydrogen) takes place to an appreciable extent in quartz vessels within the temperature range of 800 to 1100°; (2) to determine whether or not such reaction as may occur is predominantly of a homogeneous character; (3) to obtain sufficient kinetic data to evaluate a spe-

(1) This research was supported in whole or in part by the United States Air Force under Contract No. AF33(038)-23976 monitored by the Office of Scientific Research.

(2) (a) G. Hadman, C. Hinshelwood and H. Thompson, *Proc. Roy. Soc. (London)*, **A137**, 87 (1932); (b) O. Ingles, *Trans. Faraday Soc.*, **48**, 708 (1952).

(3) E. Doehlmann, *Z. Elektrochem.*, **44**, 178 (1938).

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(7) F. Haber and F. Richardt, *Z. anorg. Chem.*, **38**, 5 (1904).

(8) M. Vanpee and J. Samain, *Ann. Mines Belg.*, **5**, 630 (1952).

(9) W. Bone, D. Newitt and D. Townend, "Gaseous Combustion at High Pressures," Longmans, Green and Co., London, 1929, pp. 279-297.

(10) H. Dixon, *Phil. Trans. Roy. Soc.*, **175**, 617 (1884).