THE 1990 DEXTER ADDRESS

Records of Chemistry: Combustion or Conservation?

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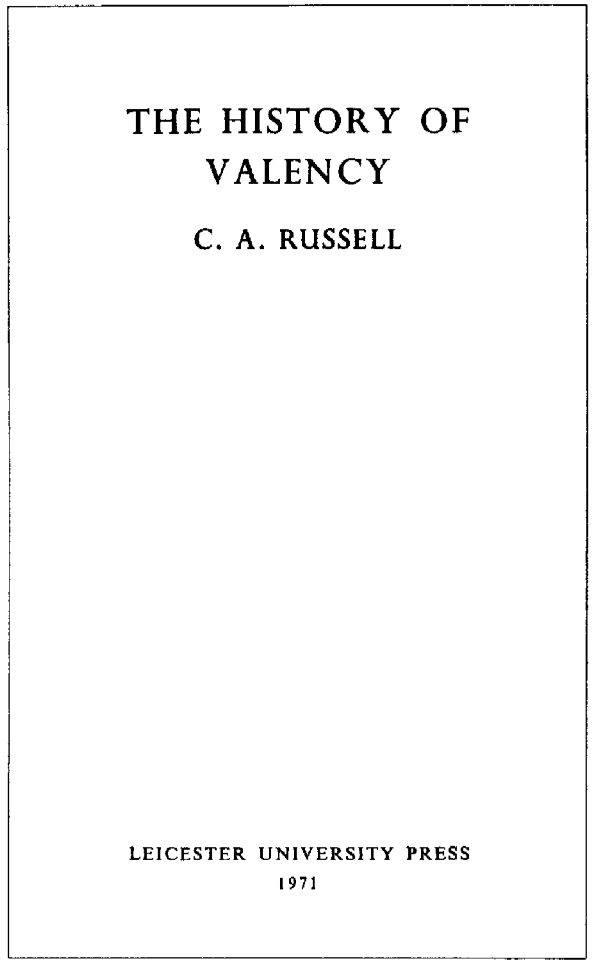
It gives me great pleasure to give this address to the ACS Division of the History of Chemistry, and to acknowledge with deep gratitude the generosity of both the ACS and the Dexter Corporation in granting me the 1990 Dexter Award.

One of my first tasks as a young chemist was to clear out an ancient storeroom. It was full of the most astonishing relics: glassware that was almost devitrified, chemicals never used in 30 years, stacks of old papers, and sodium cyanide in blocks shaped like coffin lids. All was disposed of swiftly and unceremoniously. Such ancient detritus was an offence to our sense of modernity, relics from an old technical college that were wholly unfit to grace what was to be an up-and-coming polytechnic. "Ancient and modern" might be a good title for an English hymnbook; it was utterly inappropriate as a motto for a modern chemist.

Our behaviour that day must have seemed quite typical. Chemists usually appear uninterested in objects from the past, be they literary records or old equipment. Over 150 years ago Thomas Thomson wrote disparagingly of the "rude and disgraceful beginnings" of chemical science (1). He was referring to alchemy. And today most chemists seem to share his embarrassment about their collective past and to manifest a selective amnesia.

Curiously, this ahistorical attitude is expressed at precisely the same time that, in other areas, there is a huge resurgence in historical interest. In the West there is a growing recognition of the value of history. It has been well said that a culture unaware of its history is like a man without a memory. "Forward, ever forward" may be a good watchword for lemmings; it is hardly so for civilisation, and I see no reason why it should be so for chemistry. Indeed, Thomson is a dangerous example to quote, for in fact he was concerned to promote the history of chemistry, as were many leading chemists until quite recently (2). The large scale rejection of the past amongst chemists - even a contempt for chemical history - is really a phenomenon of our own day.

But there are welcome signs of a maturing of attitudes and a return of interest in history of chemistry amongst the chemical profession. You, in the ACS, have set a shining example in having had for many years a full division devoted to history of chemistry. In Britain the RSC has a flourishing Historical Group (not yet a full Division) and many activities in which history is regularly and prominently to the fore. Now history cannot exist without records, any more than chemistry can exist without laboratories, so if history is becoming significant in chemistry, records themselves acquire a new importance. This is so for at least four specific reasons.


THE HISTORY OF VALENCY

C. A. RUSSELL

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1971

* *Cultural Importance of Chemistry:* As a part of science, chemistry is a major aspect of human endeavour and a partial determinant of our culture. Its history is as relevant to a rounded understanding of our culture as is that of state, church or literature. Its methodology as a science midway between physics and biology is important as a means of understanding the nature of science. So it is not too surprising that our educators, in Britain at least, are laying new emphasis on scientific discoveries, past and present. For this purpose historical raw material is needed.

* *Contemporary Importance of the Chemical Industry:* Throughout Britain and America a vast variety of records are now piling up in libraries, record offices, etc., many of these being the archives of big business. One of the largest sectors of industrial enterprise is the chemical industry, but often it is also the most neglected. In the United Kingdom this is one of the major contributors to a positive balance of international trade, having many employees and much investment. On those grounds alone its archives are specially important.

* *Historical Importance of Chemistry:* Turning from the present to the past one encounters a further remarkable fact:

while the importance of chemistry is usually ignored in the teaching of 18th and 19th century history, this is most notably so at precisely the two points where its role was most critical. It is surely incontestable that in its gift to the early textile industry of soap, chlorine, and dyes, and in its provision of acids for pickling metals, chemistry made the industrial revolution possible. And, secondly, by its provision of gas-lighting, fertilisers and food, explosives (not necessarily military), medicine and much else, chemistry profoundly altered the quality of life for ordinary people, usually for the better. If one asks how the teaching of history could be so blinkered as to exclude such items, one cannot escape one obvious explanation: the sheer unavailability of sources.

* *Popular Image of Chemistry:* Under pressure from environmental lobbies the chemical community has developed a new sensitivity to its public image. At times it has been mercilessly caricatured and caricatures need exposing. Some of these are about the past, so reliable source material is urgently needed. This is an area in which systematic research has scarcely begun. Yet already evidence has appeared that "green" concerns are not new, that captains of industry were not all uncaring, that their work force was not always exploited. In many areas the history of science has shown the great danger of extrapolating from a few famous but isolated cases to sweeping generalisations. With chemistry it is imperative to explore its records to see just how typical were, for example, the contributions to atmospheric pollution by the Muspratts on Merseyside, or the combined industries of Widnes. Preliminary work suggests we may be in for surprises.

Chemical records are of many kinds. First, and most obviously, there are what are commonly called *archives.* These include manuscript books, papers and pamphlets, advertisements, letters, notebooks, ledgers, photographs, drawings, paintings, and other documents. Then there are also *artifacts*, such as apparatus, small objects, and of course industrial plants. In the present context we exclude printed books and shall focus particularly on written documents.

All historical documents offer challenges. Those relating to chemistry pose some particularly difficult and specific problems, of which the following are the most important:

* *Incomprehensibility:* Most professional archivists are not trained in science, and few languages can be more obscure to an ordinary keeper of records than that of chemistry. The effect can be imagined of presenting a specialist in medieval social history with a diagram of a catalytic converter, a planning application for an ammonia synthesis plant, or laboratory notebooks from the local university. Partly for this reason any documents of a chemical nature in a local repository are unlikely to be catalogued under "chemistry", so they are correspondingly hard to unearth.

* *Inaccessibility:* In private hands chemical archives present the difficulties commonly faced by scholars enquiring into the possibility of access: the inconvenience of intrusions into private homes, the possible embarrassment of owners if there are likely to be any skeletons in the cupboard, and so on. However, in corporate hands these problems are compounded into a daunting series of obstacles: "classified information", political embarrassment, modern image and so on.

* *Inflammability:* When my own research laboratory went up in flames one night, my research records were preserved only because the desk drawers were made watertight and fireproof by the firemen's hoses! They were fortunate survivors. The chemical industry is prone to much higher dangers than small laboratories or than other industrial installations (such as offices). For instance, in 1854 an acetic acid plant on the river Tyne (Hew Singers) was "utterly destroyed" by fire; next door was a warehouse with 1000 tons of sulphur and saltpetre. All adjacent buildings were swept away in the resulting inferno, and the flames leapt across the Tyne and destroyed buildings on both banks of the river. No one knows how many chemical records disappeared that day. Nor was this untypical of the vulnerability of chemical plants to fire. It is remarkable how many English chemical factories were named (or renamed) the "Phoenix Works"!

Not only documents but whole factories are irretrievably lost to posterity. Records of few other enterprises can be so vulnerable to fire. And it must be said that not all combustions have been accidental. In 1983 the Tharsis Chemical Company destroyed five tons of archives simply to make more space. And sometimes combustion is not the only means of destruction. The archives of the Fuller's Earth Union (c. 1890-1975) were damaged but not destroyed by a fire in the wooden shed in which they were housed, then dumped in a skip where they suffered several months of English weather. Now fragile beyond belief, and crumbling at almost a touch, they were microfilmed at the Surrey Record Office and their contents thus preserved.

It remains for me to mention briefly three projects concerned with chemical records undertaken recently by my own research group.

* *The Archives of Sir Edward Frankland:* In 1962 Pearce Williams wrote of "a trunk in an attic containing unpublished letters from Darwin, Huxley, Kolbe, Pasteur and a host of others ..." unfortunately not available to the scholar (3). I believe he may have been referring to the letters of the English chemist Sir Edward Frankland. The family who owns them have shown an understandable reluctance to accept intrusion by unknown scholars, but eventually were prepared to allow them to be microfilmed in their own home. Detailed examination revealed hundreds more letters than had previously been suspected, and subsequently three other collections were discovered, all in private hands. Nearly 4,000 documents have come to light. To identify, catalogue and (eventually) microfilm them became a major objective of the research group at the Open University (4).

Frankland was one of the leading chemists of the United

Kingdom in the 19th century, yet he is largely unknown today. The archives reveal the reason: a dark secret of illegitimacy precluded him from giving personal interviews and he remained an excessively shy, very private person. To this day no biography has appeared, and only now is the material for such a work available to scholars. Yet Frankland knew most leading scientists of his day, and was a member of the ACS and many other chemical bodies. Surviving correspondence includes 29 letters from Darwin.

Frankland was renowned for his work on water analysis, and his chemical analyses of drinking water fill many volumes of notebooks and occupy many letters. His work as an educator is represented by several sets of lecture notes, while correspondence with Kolbe and others throws much new light on his changing views on valence, structure and theoretical organic chemistry. Quite apart from technical material, the letters reveal his role in scientific politics and open up new ways of understanding the fine structure of Victorian science.

* *Archives of the British Chemical Industry:* In 1981 the Annual Conference of the British Records Association was concerned with scientific records. It became apparent that no systematic survey had ever been undertaken of those relating to the British chemical industry. The next year a Research Fellowship was set up by the Open University to deal with this problem and in due course Dr. Peter Morris was appointed. Suitable publicity in the press was followed by a protracted campaign of letter-writing to all known chemical firms and to all likely holders of archives (5). The years from 1983 to 1986 were devoted to fieldwork. In the following two years company histories were compiled and checked. In 1987 Dr. Morris rejoined us (as Royal Society/British Academy Research Fellow) and publication soon followed (6).

The responses from industry were diverse, though they were usually improved when our intention was understood of limiting our search to the years before 1914. In a few rare cases we were welcomed with open arms, usually by the few very large firms that already had their own archives in good order. More commonly we were given a cautious welcome, being given to understand that this was a special privilege not accorded to the general public. In some cases denial of access was absolute, and we could expect no exceptional treatment. And there were some companies who cheerfully denied having any archives, and (in a few cases) of ever having had any!

The results were as delightfully diverse as the responses had been. In all about 120 institutions were identified as archives holders (Record Offices, libraries, firms, etc.). Nearly 1000 constituent companies made some appearance in the 180 company entries that eventually constituted the bulk of our report. All manner of documents emerged, including laboratory books and inventories. Amongst the latter was a sales catalogue for an immense calico-printing works at Catterall in Lancashire, almost the only technical evidence of its scale; at the other extreme was the firm of H. Ogden (Sunderland),

Sir Edward Frankland

which had "a copperas bed, metal stills, coolers, acetic acid stills and condenser, a three-chaldron boat and one useful carthorse!"

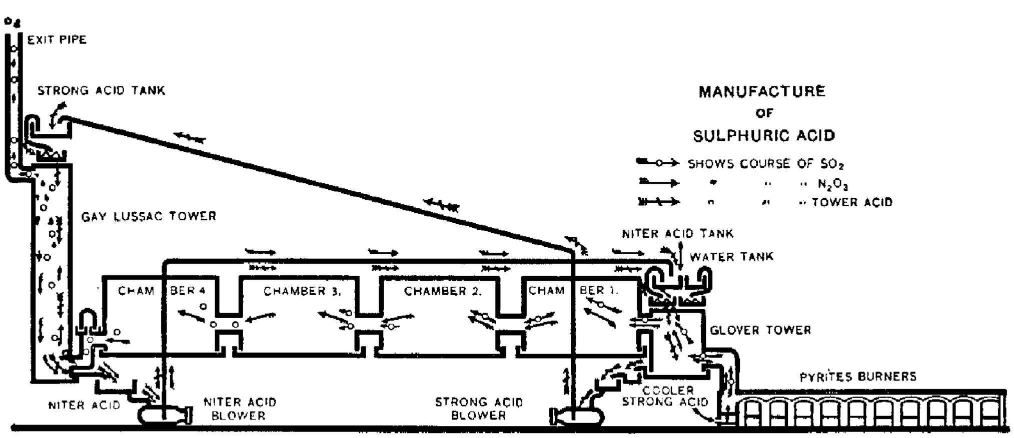
Then there were all kinds of plans and maps, legal documents (not merely about injunctions against pollution), advertisements, pamphlets, broadsheets, diaries and, of course, innumerable letters. We were particularly glad to discover a set of student lecture notes, taken by Peter Spence in 1854, from a course delivered by Edward Frankland at Owens College, Manchester.

* *Industrial Archaeology of the Chemical Industry:* At a time when industrial archaeology is attracting increasing attention, it may seem surprising that little has been done on the chemical industry. Our archives research revealed a number of surviving buildings in the United Kingdom, some still with their original function, but most now put to other uses. In some cases restoration is an urgent necessity. Although we have identified about 20 sites in Britain, much more must remain to be discovered and there is a pressing need for systematic cataloguing. If the research is broadened to include university and private laboratories, it would be the first comprehensive attempt to identify surviving "temples of chemistry", and even then in one country only. This is clearly a task for the future, perhaps through a new research fellowship.

We have, however, made some progress in locating old chemical plants. In connection with an undergraduate course (*Science and the Rise of Technology from 1800*) it was resolved to assemble existing archive film of chemical processes that were once of great importance. We had some success, for example, a revolving furnace from the Leblanc process and early shots of potash plants on Merseyside. But there was nothing like enough material for our purposes. So, in some desperation, we enquired whether any such processes had themselves survived into the 1970s. To our surprise, the result was positive. Since no one else had ever filmed most of them we decided to do the job ourselves (through the BBC) (7).

So there is now on record the last example of the puddling process for wrought iron (at Bolton). On the subject of explosives manufacture students were able to "visit" Waltham Abbey and the plant where gunpowder had been made for centuries, Nobel's original Scottish site at Ardeer, an early nitration plant for TNT, etc. in Galloway, and to witness an actual laboratory nitration of glycerol.

We were better pleased to find important relics of the coal-tar chemicals industry: some coke ovens from the early 19th century survive at Gateshead, as do a few men who once operated them; at Falkirk are some of the first tar-stills, and in Derbyshire an early nitration plant. And in a remote part of southwest Scotland was a coal carbonisation process still in use with horizontal hand-fired retorts of the 1840s design. To watch that process is still one of the most evocative ways I know of recapturing the essence of early 19th century chemical industry.



The lead chamber process for sulfuric acid as diagrammed in the 1909 edition of Thorp's *Outlines of Industrial Chemistry*.

But perhaps our greatest pleasure came from discovering and filming the world's last example of a process that was the foundation of Victorian Britain's economic prosperity: the lead chamber process for sulphuric acid. We discovered this survivor at Seaton Carew, on a windswept coast in northeast England. Never filmed before, the process yielded its secrets as the camera crew swarmed all over the plant: furnaces, Gay Lussac and Glover towers, the vast leaden chambers (including interior shots of one under repair); distant views conveyed something of its immense scale, as well as of the desolate landscape around; spoil heaps enabled us to trace changes in raw material and waste products; interviews with past and present staff gave the personal dimension; and in a ruined cottage were discovered invaluable plans of the whole site (8).

Within a few months of our filming, the Seaton Carew plant was closed down. The same fate befell the old coal carbonisation plant in a year or two. In each case we were just in time. How much more we might have accomplished had we started five years earlier will never be known. In whatever success we may have had, and still more in our failure, is a sombre illustration of both the richness of our chemical heritage and of the urgency with which problems of conservation and recording must be addressed.

References and Notes

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1. T. Thomson, *The History of Chemistry*, London, 1830, p. 2.

2. C.A. Russell, "'Rude and Disgraceful Beginnings': A View of the History of Chemistry from the Nineteenth Century", *Brit. J. Hist. Sci.*, **1988**, *21*, 273-294 (Presidential Address to the British Society for the History of Science).

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4. C. A. Russell and S. P. Russell, "The Archives of Sir Edward Frankland: Resources, Problems and Methods", *Brit. J. Hist. Sci.*, **1990**, *23*, 175-185.

5. C. A. Russell, "Archives of the British Chemical Industry", *Indust. Chem. Bull.*, **1982**, *1*, 90.

6. P. J. Morris and C. A. Russell, *Archives of the British Chemical Industry: A Handlist*, British Society for the History of Science, 1988.

7. The TV films referred to below are as follows: From the course AST 281, *Science and the Rise of Technology from 1800*: No. 2: "Coal and the Nineteenth Century"; No. 3: "Sulphuric Acid and the Lead Chamber Process"; No. 7: "The Alkali Industry"; No.

8: "The Explosives Industry"; No. 9: "The Use of Ferrous Materials in Construction". From the course A281, *Technology and Change, 1750-1914:* No. 4: "The Alkali Industry"; No. 6: "Making Steel: An Industry Transformed". (This course also offers updated versions of Nos. 2, 3 and 9 from AST 281)

8. These plans are now in the Science Museum, London.

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THE RISE AND DECLINE OF THE BRITISH DYESTUFFS INDUSTRY:

An Object Lesson for American Industry

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The aphorism that those who do not remember the past are condemned to live it again is an often quoted warning from the writings of George Santayana. This paper will attempt to illustrate this adage with two examples, one having historical and the other having contemporary significance. We will examine the rise and very rapid decline of the British synthetic dyestuffs industry as the historical example and the current dilemma of the American semiconductor industry as the contemporary example. Both industries were pioneers in the application of chemistry (organic in the former and solid state in the latter) to the development of entirely new technologies. Although our analogy may not be perfect, it is hoped that our study will elicit an awareness by the reader of the fact that history may indeed repeat itself.

The birth of the synthetic dye industry represents a classic example of serendipity in chemistry. During the 1856 Easter holidays William Henry Perkin (1838-1907), a student at the Royal College of Chemistry in London, working with its director August Wilhelm Hofmann (1818-1892), produced the first synthetic dyestuff - mauve or mauveine (19). Attempting to produce the drug quinine in his home laboratory by the oxidation of allyl toluidine with potassium dichromate, Perkin obtained a dirty reddish brown precipitate instead of the desired product. Persisting in his belief that quinine could be synthesized from aromatic amines, Perkin next oxidized commercial aniline, which was a mixture of aniline and toluidine. This resulted in a purple solution. It is a testimony to the keenness of Perkin's mind that he was able see the potential of this reaction mixture as a dyestuff - a potential which was

William Henry Perkin at age 28

confirmed when he sent some samples of silk that he had dyed with the mixture to Pullar & Sons, of Perth, Scotland, a silk and calico dyer. Thus, quite by chance, the synthetic dyestuffs industry was born and along with it the aromatic chemical industry.

In retrospect the dye industry is the first example of a science-based industry. As Raphael Meldola stated in 1886 (1):

> The successive steps in this development ... [furnish] ... us with one of the most striking illustrations of the utilization of scientific discovery for industrial purposes, and the reaction of industry upon pure science.

What were some of the factors that were operative in Victorian Britain that led to the development of the dyestuffs industry? This era in British history was one of technological breakthroughs in many industries, such as machinery for the production of textiles and for mining. The acquisition of wealth by investing in the exploitation of natural resources was a route that was taken by many entrepreneurs of the day. The dyestuffs industry exploited a product known as coal tar which was produced in great abundance by the gas industry but which had little if any value. A large textile industry based upon imported cotton and wool was already in place which could readily absorb the products produced by the synthetic dye industry. Prior to Perkin's discovery, this industry used dyes which were almost exclusively obtained from natural materials, most of which had to be imported at great expense. In 1856 the figure of two million pounds sterling in real value has been given for these imports. Finally, educational institutions at this