and the direct gravimetric analyses of oxides. The limited number of known hydrides, on the other hand, prevented such a direct comparison for the H standard and the use of oxides with this standard required an indirect calculation, whose accuracy was, in turn, limited by the accuracy of the known H:O value derived from the analysis of water (17). And so the crith and microcrith faded from memory and the situation stabilized until the discovery of isotopes, the development of accurate mass spectrometers and the coming of the ^{12}C scale and the unified atomic mass unit.

References and Notes

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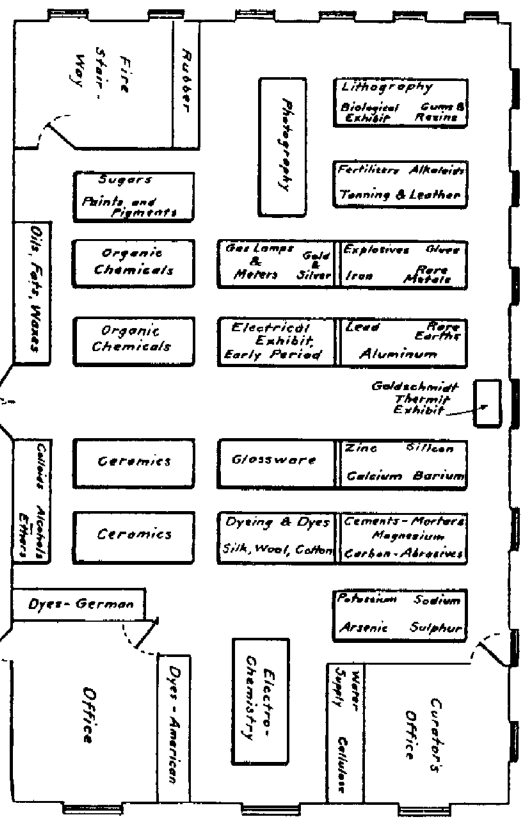
CHEMICAL ARTIFACTS

The Chandler Chemical Museum

Leonard Fine, Columbia University

The Chandler Chemical Museum is a unique record of many aspects of the history of American chemistry. As the last and largest of the great 18th and 19th century "philosophical cabinets," it is a collection of unparalleled significance for understanding changing patterns of chemical pedagogy. As a diverse selection of chemical artifacts, it is a rich resource for students of the history of chemical technology. And as a legacy of Charles Frederick Chandler's multifaceted contributions to chemistry and commerce, dating from the founding of the Columbia School of Mines in 1866, it is an important element of the history of Columbia University, of the City of New York, and of the Chemist's Club and the

Charles Frederick Chandler



The floor plan to the Chandler Chemical Museum as it appeared in 1934 (1).

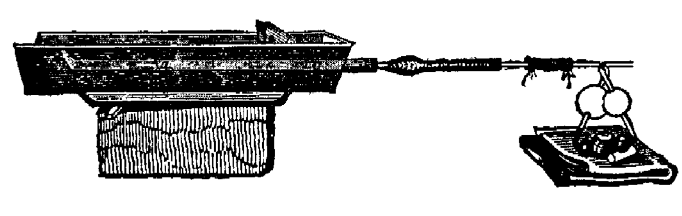
American Chemical Society. Just fifty years ago, Samuel Tucker, the then curator of the Chandler Chemical Museum, described it to Columbia President Nicholas Murray Butler as "the most unique chemical collection that can be found." On the eve of the completion of the third home for the museum, within the new Center for Chemical Research at Columbia University, Tucker's observation is truer than ever.

Charles Frederick Chandler (1836-1925) is the patron saint of chemistry at Columbia and was one of the founding fathers of the American Chemical Society. A student of Horsford at Harvard, of Wöhler at Göttingen, and of Rose at Berlin, Chandler began his teaching career at Union College in 1856. In 1864 he left Union for New York City in order to help found the Columbia School of Mines, where he remained until his retirement in 1911. The Chandler Chemical Museum was started in order, as he liked to say, "to show his boys" the things he talked about in his lectures. Beginning with the first ledger entry of the museum (dated February, 1864), this remarkable collection consists of some 12,000 specimens uniquely illustrating the rise and development of industrial chemistry in the 19th and early 20th century. It stands today as one of Chandler's most memorable achievements.

As Chandler was concerned primarily with the training of industrial-analytical chemists - he was a consulting chemist himself and placed many of his students in industrial positions - the museum collection was organized around topics in applied chemistry, including water chemistry, electrochemistry, synthetic dyes and intermediates, explosives, coal, oil and petroleum chemistry, lighting technology, textiles and ceramics, pharmaceuticals and fermentation chemistry, essential oils, natural polymeric materials such as gums and rubbers, and the first synthetic polymers and plastics. Most of the applications of the day are represented. For instance, there is a complete collection of synthetic drugs and dyes, representing the essence of the European origins of modern organic chemistry, including Perkin's original mauvine and original industrial samples of vat dyes and pigments. It is useful to remember that this collection reflects what was considered "high tech" in its day. Indeed, during World War I, when German resources were unavailable, the collection was used as a source of standards by industrial chemists attempting to develop America's own fledgling dye industry. Rubber samples from every part of the 19th century world; bricks, abrasives and materials of construction; early ceramic constructions and samples of aluminum metal prepared by Hall, Deville, Castner and Heroult are also to be found. The collection of old Limoges porcelains and apothecary jars forms a very special part of the museum which, because of its artistic as well as historic value, has been separated from the main collection and is now kept by Columbia University Art Properties.

The electrochemical collection is surprising, in part because it reflects the renaissance nature of 19th century chemistry as it merged into modern times. Included are voltaic piles, primary batteries and cells, and storage batteries, among which are the Edison alkaline cell and the Wallace dynamo (1877).

The photographic collection is one of intrinsic historical value. It includes large numbers of daguerrotypes and early tintypes; the works of Woodbury and Fox Talbot, Ives, Osborn, and Bierstadt. Also present are the motion studies of Muybridge, shown at the Centennial Exhibition in 1876, early Edison moving pictures, Rutherford's photograph of the Moon (1854), and the first portrait from life made on the roof of one of the Columbia buildings in 1840 by Professor Draper. There is also a collection of cameras and equipment

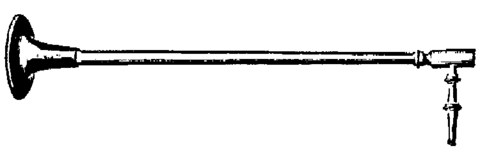


An early combustion train (2).

dating from the middle of the 19th century, including a very rare combination speed camera that "snaps" six pictures in ten minutes - provided the subject is in bright sunlight. An outstanding piece in this part of the collection is the camera owned by Karl Klietsch, a pioneer German photographer.

The extensive collection of elements and compounds includes a fine selection of rare earth elements, radioactive materials and very early X-ray photographs. Some of the X-ray glass plate negatives and positives belonged to Michael Pupin and date to within a few weeks of Roentgen's discovery. The match collection is striking.

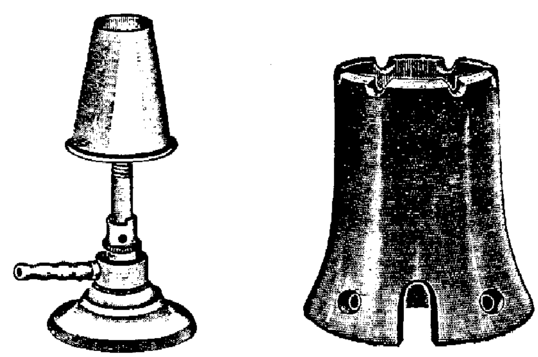
Though intended primarily as a teaching museum in chemical technology, rather than as a museum for the history of chemistry, the collection nevertheless contains a number of items of interest to the historian of pure chemistry. Historic pieces of laboratory apparatus include items that belonged to Priestley, Pasteur, Faraday, and Fritz Haber. The collection of batteries and electrical devices contains many items which were standard laboratory fare in the 19th century and the



A Plattner blowpipe with a detachable mouthpiece (3).

same is true of the collection of gas lamps, which contains a number of early laboratory models, including an all porcelain (corrosion-free) gas burner and several multiburner combustion units. Other pieces of basic laboratory apparatus found their way into the museum via displays illustrating significant advances in chemical analysis, including a complete Plattner blowpipe, and three complete combustion trains used to illustrate the development of organic analysis. These range from a facsimile of Liebig's original apparatus to a complete Pregl microanalysis train.

Other items of interest include a set of valence models from the 1870's, a collection of medallions and framed portraits of famous chemists, a collection of autographs and letters of famous 18th and 19th century scientists, a collection of presentation photographs of turn-of-the-century American and British chemists given to Chandler during his term as President of the Society for Chemical Industry, Laudy's original photographs and glass plate negatives of the 1874 Priestley Centennial Meeting at Northumberland, a scrapbook on Liebig and his laboratory at Giessen, an unpublished autographed pencil sketch of Wöhler, and several letters from Wöhler to Chandler dating from 1862. Miscellaneous items include such things as a porcelain retort, an earthenware burner guard, a collection of apparatus for the testing of oils, and, of course, an unparalleled collection of display bottles and containers.



A porcelain laboratory burner (left) and an earthenware burner guard (right) (3).

After Chandler's death in 1925 the museum underwent a gradual decline. This is not too surprising, as even by the 1920's the type of generalized industrial-analytical chemist it was designed to train was already being displaced by the professional chemical engineer, on the one hand, and by the specialized industrial research chemist, on the other. Though a curator was appointed in 1924 and again in 1928, by 1934 care of the museum had devolved on two graduate students from the department of chemical engineering and the last changes in the displays appear to have been made sometime in the 1950's. Space needs also took their toll. Part of the front of the museum was taken to create a back hallway for a new elevator and the back two corners were partitioned off for classrooms. These changes severely restricted the space available for displays so that a storage mezzanine had to be added. Finally, in the summer of 1986, the museum was cataloged, disassembled and placed in storage as part of the reconstruction of Havemeyer Hall, which had housed it since 1896. A new museum is expected to emerge in about two years, as part of the last phase of construction. We hope that Chandler will not be disappointed.

Illustrations

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