SCHOOL SCIENCE AND MATHEMATICS

VOL. LI | JANUARY, 1951 | WHOLE NO. 444

ANECDOTES AND OTHER NOTES ON METALS[1]

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Gold, the glamor metal of them all, is too regal to have anecdotes in its history. Its production by transmutation, the dream of the alchemists, did, however, get many of them into trouble as imposters.

Metals were redefined by the industrialists as "the connective tissue of mechanization." In this age of aeronautics the ideal "tissue" has concern for excess baggage, so, in consequence, seeks the maximum tensile stoutness associated with the minimum weight. Such specifications open the door to metals of recent release from nature's storehouse; aluminum and magnesium.

ECONOMIC EVOLUTION OF A METAL

Aluminum's emergence above the horizon of unclaimed metals reads like a Horatio Alger story of economic success. Wöhler's first potassium-reduction of its chloride, put in the language of the money mart, rated aluminum at $150 per pound; DeVille, twenty-seven years later, by his use of sodium-reduction was able to mark the price tag $15 per pound; Castner, thirty-two years after DeVille, was happy to report that aluminum from his plant would cost only $4 per pound due to a greatly improved method of preparing the metal, sodium. Castner's market superiority was of short duration for, but three years later, Charles M. Hall patented his electrolytic method which marketed the metal at but one dollar per pound. Most readers know that, as of this year, sixty odd years after that patent, mass production places this, one time "rare" metal, in price competition with

[1] "Dramatic Moments in the History of Science," SCHOOL SCIENCE AND MATHEMATICS, 49, pp. 73–706 (1949).

so-called "plebian" iron marked in cents rather than with the dollar sign.

A Spark in Mental Tinder

Remarks made by teachers do, on occasion, start *mental* chain reactions for students. Such seems to have initiated Hall's project which eventuated in the patent. Told in the words[2] of Hall's Oberlin chemistry teacher, Professor Jewett, "In the laboratory one day . . . I said that if any one should invent a process by which aluminum could be made on a commercial scale, not only would he be a benefactor to the world but would also be able to lay up for himself a great fortune. Turning to a classmate, Charles Hall said, "I am going for that metal." And he went for it.

"He tried various methods in vain, and finally turned his mind to the idea that perhaps electricity would help get the metal out of its ores. . . .

"Soon after . . . he graduated . . . he took the apparatus (he had devised with Professor Jewett's help) to his own home. . . . He arranged a little laboratory in the shed, continued his investigations and reported to me frequently.

"About six months later he came over to my office one morning, and holding out his hollowed hand, said, 'Professor, I've got it!' There in the palm of his hand lay a dozen little globules of aluminum, the first ever to be made by the electrolytic process in this country."[3]

Aluminum for Coins, Francs

Charles Hall's French contemporary and simultaneous discoverer of the electrolytic reduction of aluminum ores, Paul Heroult, had his first memorable experience with aluminum when he and a friend, who later became his partner, had to pawn a stick of aluminum for a few francs to relieve their flat pocket books. The aluminum bar was valued highly by his friend's family because it was a personal souvenir from Saint Claire DeVille.

In Heroult's own words,[4] "We handed the bar to the pawn broker who examined it and asked, 'What is that—bar silver?'

"We answered, 'Better than that, that is aluminum.'

" 'Aluminum?' was his response, 'What is aluminum?'

"Then after he had hefted it by his hand he asked, 'Why! Is that hollow?'

"Our answer was, 'No, that's aluminum and is worth 120 francs per kilo.'

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[2] Holmes, Harry N. "Story of Aluminum." *Jour. Chem. Educ.* 7, 235 (Feb., 1930).

[3] These original globules—the "crown jewels" of the aluminum industry are now carefully preserved in an aluminum "jewel case" in the offices of the Aluminum Company of America.

[4] *Ind. & Eng. Chem.* 3, 149 (1911).

"After some thought he replied, 'Well, I'll give you two francs for it.'

"That was better than nothing so we took the money with the firm determination of buying it back—which we never did. Maybe that was one of the reasons why, later on, I had to make good and replace it."

Heroult's announcement of his successful electro-reduction of aluminum from its ores post-dated Hall's by only about three weeks. Some seventeen years after the announcement of their processes were made, patent rights were finally assured to Hall for America and to Heroult for Europe.

Aluminum Transmuted

Aluminum also made newspaper headlines, later, in Heroult's native France. This time it, under the impact of alpha particles from polonium, became one of the first artificially induced radio-active elements. The product of this transmutation was radio-active phosphorus. That took place in 1934 in the laboratory of the Institute of Radium in Paris. Its occurrence was induced under the supervision of Irene Joliot, daughter of the Curies, and her husband, Frederick Joliot. Thus aluminum got into one of the first achieved transmutations which the alchemists hoped to make possible by the use of their philosopher's stone (if they could only find it). The final stable product of this, aluminum's change, was not gold, as the alchemists desired, but an isotope of silicon.

It Might Have Been

Metals, like men, sometimes fail to achieve industrial standing by scarcely more than a "hair's breadth." The evolution of industrial aluminum's economic reduction, previously described, spots a brief appearance of the metal, sodium, as a case in point. Wöhler reduced the first compound of aluminum by use of metallic potassium; DeVille reasoned that since sodium is much more plentiful it should become a more economical reducer. He, by its use, reduced aluminum metal's cost by ten fold. In 1886 Hamilton Y. Castner, a young student in the School of Mines at Columbia University, invented a new process for the manufacture of sodium which lowered aluminum's cost by about 75% below DeVille's figure. "A large plant was immediately erected to prepare the metal on a commercial scale using Castner's process"[5] but these plants were never used to magnify the aluminum industry because Hall's electrolytic process was able to under-cut the sodium reduction cost by 75%. Had Hall been delayed a few

[5] Chandler, Charles F. *Ind. & Eng. Chem.* 3, 145 (1911).

more years, sodium metal might have become an article of commerce upon large quantity scale. "It might have been."

Laboratory Lilt

'Tis true that the first five letters of laboratory spell labor and for the most part that word well describes what goes on within those halls. However, there are days of high adventure as well as dull drudgery for the experimenters.

Sir Humphrey Davy tells of his study of electro-reduction of potash as follows:[6] "Small pieces of pure potash . . . were placed upon an insulated disc of platina connected with the negative side of the battery . . . and a platina wire . . . (positive) was brought in contact with the upper surface of the alkali. . . . A vivid action was soon observed to take place . . . at the lower or negative surface . . . small globules having high metallic lustre, and . . . similar to quick silver, appeared. . . . These globules, numerous experiments soon shewed to be the substance I was in search of."

But while Sir Humphrey was looking at the "small globules" a relative, Edmund Davy, was watching the experimenter. That person's behavior he reports as follows:[7] "When he saw the minute globules of potassium burst through the crust of potash and take fire as they entered the atmosphere, he could not contain his joy—he actually bounced about the room in ecstatic delight; some time was required for him to compose himself sufficiently to continue the experiment."

Accessory before the Fact

It is pretty generally known, by physical scientists, that radium metal shared some of the limelight of publicity received by the two Nobel prize awards to its discoverers, the Curies. The Nobel prize, in 1932, to an American, Irving Langmuir, for his work on "surface chemistry" is not generally known to be partially creditable to a behind the scenes participant, the metal, tungsten. It was a research tool in the hands of its skillful user in securing the findings that challenged the attention of the Nobel awards committee. A census[8] of the research papers for results leading to: gas filled incandescent lamps, the atomic hydrogen torch, the electron tubes of radio or television indicates tungsten used almost universally in that research. Doctor Langmuir's comment[9] is "The use of the tungsten filament presented particular advantages for (it) could be heated in high vacuum to

[6] Works of Humphrey Davy, Smith Elder & Co., Cornhill, London. 5, 60–61 (1840).
[7] *Ibid.*, 1, 109 (1840).
[8] The frequency of Dr. Langmuir's use of tungsten is roughly indicated by seventy odd specific references to it in his recently published *Phenomena, Atoms and Molecules*. Philosophical Library, N. Y. (1950).
[9] Langmuir, Irving. *Phenomena, Atoms and Molecules*. Philosophical Library, N. Y. (1950).

temperatures of over 3000°K. so that all impurities could be readily distilled out of the filament. The ease and accuracy with which any desired temperature could be produced and measured was also important." And again he says,[10] "Because (tungsten filaments melt at temperatures more than 1500° higher than platinum) it had seemed to me that tungsten furnished a tool of particular value for the scientific study of phenomena in gases at high temperatures." In legal parlance, an "accessory before the fact" receives attention from the judge at the same time the principal gets his sentence; Doctor Langmuir gets the prize but his "accessory" should get some credit also.

WHEN MINERS PROSPECT AND EXPLOIT THE SEA

When "ships go down to sea" it is usual to expect that they may return with cargoes of fish or whale blubber as their tribute from the realm of Neptune. When metallurgists "go down to sea"—well, that's a bit aside from the expected! Traditionally metals have been land-bound either in native form or as constituents of ores which are insoluble in water.

So it is a bit sensational, as well as historical, to read,[11] "On Tuesday, January 21, 1941 (the Dow Chemical Company's) great new plant at Freeport, Texas produced the first commercial ingot of any metal to be taken from sea water at any time in the history of the world!" The novelty of this announcement was not that a metal was being extracted from water. "For years (Dow's) had been mining Michigan brine for magnesium as well as for bromine and chlorine." The innovation was that the source this time was *sea* water rather than *well* water.

The Dows had previously exploited Father Neptune's resources, in 1930, by successfully extracting bromine from raw ocean water at Kure Beach, North Carolina. But, superficially, there doesn't seem to be such a stretch of credulity expected when liquids are taken from water sources as that of bringing forth metals.

It is interesting to note that the choice of Freeport as the place for the extraction plant was, to a large extent, based upon a "trinity of basic inorganic chemical raw materials—salt, sulfur and lime." The salt, with its constituent magnesium, came from the sea; the lime from oyster shells dredged from the bottom of the Galveston Bay and the sulfur from the Frasch wells which are plentiful in Texas and neighboring Louisiana.

In chemical language, lime, made by heating the shells, was used to precipitate the magnesium from the sea water; this magnesia lime precipitate was then transformed into a chloride (similar to table

[10] *Ibid.*, page 104.
[11] Kirkpatrick, S. D., *Chem. & Met. Eng.* 48, 130–133 (Nov. 1941).

salt) by the use of hydrochloric acid and the magnesium chloride, in turn, was deprived of its magnesium by electro-reduction.

Successful was it? Report has it that by 1941's year end production was at the rate of 54,000,000 pounds; about seven times the production of 1940 and over fifty times that of seven years previous to that. This upsurge in production dropped the price from five dollars per pound in 1915 to twenty-two and one half cents per pound in 1941.

Some Impulses Are Fruitful

Winkler, in 1885, was asked to make a thorough quantitative analysis of a mineral called argyrodite. He found the elements in it that had been previously reported but he "invariably came out seven per cent too low. He concluded the ore must contain an unknown element."[12] His first attempt to isolate it assumed that it belonged, analytically, with arsenic, antimony and tin. He was able to remove the first two by traditional methods of separation but attempts to get the new element from the filtrate, after arsenic and antimony's removal, gave no precipitate other than sulfur. He worked four months in a vain endeavor to bring the elusive element into view.

"On February 6, 1886, he filtered off the precipitated sulfur,[12] as he had done so many times before and, reckless with discouragement poured into the clear filtrate a large quantity of hydrochloric acid. To his delight a heavy, flaky white precipitate immediately appeared. This substance (was) the sulfide of the new element." Thus the first isolation of a new element was accomplished and later identified and named germanium. So the third, of three elements Mendeljeff had previously postulated and described to fill gaps in his periodic chart of the elements, had been isolated by what might be called a rash act committed in semi-desperation. The agreement of germanium's properties with those proposed by Mendeljeff added substantially to that Russian's prestige and esteem of his fellow chemists.

We may talk of metals as products of skillful technology; as illustrative of sub-atomic structures that help to rationalize many of their unique qualities or in terms of stock-piling in anticipation of emergencies. Such attention is, very commonly, considered practical, down-to-earth, eminently worth while. On the other hand the stories in the preceding paragraphs might be labelled "metal gossip" by the cynically inclined. However, there is a common element in each of the incidents previously related—in every one there is a situation involving a human relationship. Their justification for the space they have used is: human relationships are significant from the standpoint of the teacher.

[12] Weeks, Elvira. *Discovery of the Elements.* (First Edit.) Mack Printing Co. pp. 225–227 (1933)