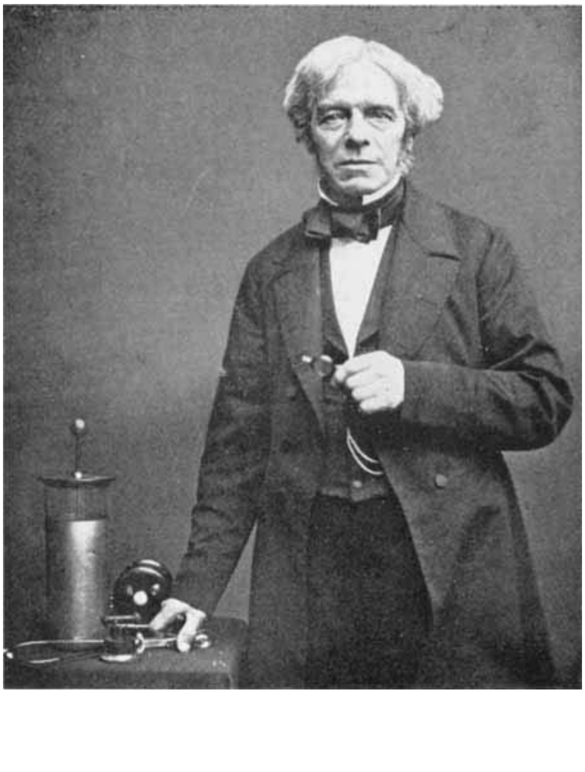
Platinum the Pathfinder

AN EXAMPLE OF OCCAM'S RAZOR AT WORK

By W. D. Mogerman

A half-dozen centuries ago, the celebrated English philosopher William of Occam invented a mental paring device which he applied to the excessive verbiage and fruitless hypotheses of contemporaries with such rigour that his invention became known as "Occam's Razor". Although William's entire attitude was a refreshing novelty at the time, it probably did not add to his popularity Nevertheless, many thoughtful men of the day evidently agreed with him that if the rising sun of new thirteenth-century learning was really going to illuminate anything—for example, if the marvellous ideas and revelations of his fellow-friar, Roger Bacon, were ever to enlighten mankind—then "*Beings ought not to be multiplied except out of necessity*". The cutting edge of this maxim was a relentless search for the fewest *Beings* or hypotheses necessary and sufficient to clarify a given observation or experiment. More than that, said William, merely cluttered up the mind and led back to the confusion and darkness of former ages.

Now even when correct, indiscriminate applications of Occam's Razor are not the best way to get elected to public office; and many men have applied it incorrectly over the years. But on the whole the stern old philosopher's criterion has served us exceedingly well since he died in 1349. It has probably served us better in science than in philosophy or politics, which are pretty much as he left them so long ago. Our present excursion will therefore be restricted to the relatively safe area where indisputable



"This beautiful, magnificent and valuable metal . . . is a very remarkable metal in many points, besides its known special uses," said Michael Faraday in the course of his famous lecture on platinum delivered to the members of the Royal Institution in 1861. The published researches of Faraday and of those who followed him in developing our knowledge of electrical phenomena show how greatly they relied upon platinum to provide a means of carrying, making and breaking current. Reliable platinum crucibles played a fundamental part in obtaining analytical data for the infant science of chemistry; platinum boilers permitted the concentration of sulphuric acid in the pioneer days of chemical industry. The development of the electric telegraph, of the incandescent lamp, and later of the thermionic valve, all involved the use of platinum, as did the early internal combustion engines, first for igniter tubes and subsequently for magneto contacts

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changes have occurred. Many significant advances have clearly been made over the years by isolating a laboratory phenomenon as well as may be and concentrating one's attack on the factors that appear to be authentically inherent. The essential factors are usually difficult enough to handle without wittingly or unwittingly introducing spurious novelties. Unessential *Beings* must still be shunned at every turn, whether these arise from mental preconceptions or from defective apparatus. It was surely reasons of this latter kind that caused Michael Faraday to speak of platinum as "this beautiful, magnificent, and valuable metal" (1).

Inherent Beings Only, Please

Now it must be realised that such warm and somewhat emotional language was not characteristic of the mild and reserved Faraday, who understood and appreciated the unique values of every element as well as any scientist going—and probably better than most. Nevertheless, it is also clear that the self-educated genius did not speak in this way of the various other metallic elements he knew so well. He spoke from retirement at the age of 71, and was probably thinking of the numerous occasions on which platinum had served him—and his extraordinary employer, Sir Humphry Davy—by eliminating unnecessary *Beings* that might have been introduced through corrosion, fusion or loss of strength at high temperatures, cracks formed during fabrication, evaporation losses, electrolytic decomposition, or other trouble-making instabilities. His mind may have turned back to the early days at the Royal Institution, when venturesome joint investigations with Sir Humphry, made in fragile apparatus, put them into separate bandages more than once. He may have been thinking also of the catalytic powers of platinum, which this prolific pair discovered independently of other workers.

Faraday was by no means the first investigator to use platinum apparatus for important experimental work, but he provided a rare example of one whose decisive and life-long operations on a small scale have led straight to the founding of great modern industries which now produce and use many metals and other materials on extremely large scales indeed.

It is well known that he showed little or no interest in pursuing commercial exploitation of his own discoveries. Of course, the inner workings of such a mind are inexplicable by definition. A genius is not nearly as simple as others say he is. The stunning directness of Faraday's *final* attack on a problem was undoubtedly part of his essential nature, and would have been so if he had never heard of Occam. But like many lesser men, he often reconnoitred the ramparts in silence for a long time before he launched the victorious attack which later seems so simple when described in his writings. The greatly-gifted pioneers are probably all natural wielders of the "Razor", and not to be claimed as conscious disciples of Occam. But as such admirable examples of mother wit at work cannot fail to benefit all, let us consider a few as space permits.

Little Acorns That Flourished

During Friedrich Wöhler's first attempts to isolate aluminium in 1827 he heated a mixture of potassium and aluminium chloride in a ceramic crucible. The reaction was so violent that the cover had to be wired shut. Some tiny spangles of metal were observed after the melt was cooled and leached, but there was generally not enough aluminium to yield conclusive results. Wöhler then turned to more promising paths (including the one that led to the synthesis of urea in 1828), and stayed on them for 18 years. In 1845 he finally got around to testing a suggestion about milder aluminium reduction that had been first made to him by Liebig in 1836. (In those days many investigators did not rush to mobilise their hormones or elevate their hackles until a threat to priority arose.)

Liebig's suggestion was to moderate the violence of the reaction by passing aluminium chloride vapour over hot potassium. Wöhler tried this in glassware and found that his tubes were shattered every time. He then turned to platinum containers and for the first time obtained globules of aluminium large enough to be used for the determination of the chemical and physical properties of the new metal.

Here platinum tubes openly helped Wöhler make an important discovery, but they were probably doing good by stealth also—to the reported properties of aluminium. This was shown a few years later by the able French scientist whom Faraday called "my friend Deville of Paris". Henri Deville took up the work and was able to prove that Wöhler's product contained some platinum. He proceeded to produce larger amounts of purer aluminium by improving on Wöhler's method.

But the really substantial amounts that ultimately converted aluminium from an expensive curiosity into the great modern industry it is today waited for a plentiful supply of cheap electricity for the processing of fused ores. The trail leads directly back to Faraday. For years he laboured to "turn magnetism into electricity", as he put it. He was finally successful in an endeavour that many before him had considered vain. For example, the famous Dr Thomas Young, whose authority at the Royal Institution stood much higher than Faraday's at that time, misapplied Occam's Razor to that idea and thought he had thereby shelved it as effectively as the idea of perpetual motion. In his otherwise excellent treatise on Natural Philosophy (1800), the very able Dr Young declared: "There is no reason to imagine any immediate connexion between magnetism and electricity." A giant of science is likely to make an error in proportion to his size. A full score of years passed before Oersted revealed the truth by means of a simple observation that shook the scientific world and led to great things for Faraday.

Early Batteries and Lamps

It is difficult for us now, lapped in the wealth of modern knowledge, to realise the grinding poverty of basic information during the early days. After voltaic electricity appeared it was not at all obvious to investigators that all kinds of electricity were qualitatively alike. Men such as Wollaston and Faraday devoted much time to ascertaining that currents derived from different sources—frictional, voltaic, animal, or what-not—were identical in their effects. Faraday moved on to develop his new ideas on generation only after satisfying himself on

Thomas Alva Edison, although best known for his work on the electric telegraph and for the invention of the gramophone, was actively interested in platinum, particularly for its high melting point and ductility. He purified his own platinum obtained from discarded Grove cells and reduced it to wires of only 0.001 inch diameter for use as filaments in his early attempts to develop the incandescent lamp

that score. Volta had used pairs of silver and zinc (or copper) rods in his famous "Couronne de Tasses", but this pristine device was soon found to be associated with rapid deterioration of the zinc. The necessary role of this wastage and its full significance for associated materials were not immediately realised, not even by Davy in his classical work on the cathodic protection of ship's bottoms. The search for greater durability in voltaic piles led to the use of precious metals. As early as 1803 the German scientist J. W. Ritter claimed that he had constructed a cell with accumulator virtues by using gold and silver plates, but this was shown to be an error. However, the trend toward use of the noble metals continued to find favour. Faraday and others turned to platinum and amalgamated zinc plates for some early batteries. The favourable results encouraged him to inquire, "Is there not, then, great reason to hope and believe that, by a closer *experimental* investigation of the principles which govern the development and action of this subtile agent, we shall be able to increase the power of our batteries or invent new instruments which shall a thousandfold surpass in energy those which we at present possess ?" (2).

The affirmative answer to this question Faraday provided himself through his subsequent work on electromagnetism. The bar magnet which he used to determine whether a magnet really would turn around a fixed conductor was loaded at the bottom end with platinum and floated in mercury. The magnet did revolve as he had hoped, and it literally started the whole world turning. In a short time, flowing electricity in great quantities became available for those prepared to use it. There was an embarrassment of such riches before the many problems of distribution and convenient consumption were solved.

The new generators could supply current cheaply based on coal. The carbon arc light was soon developed for outdoor uses. The next acknowledged problem was "to subdivide the current" so that it might be safely brought indoors, even into the ordinary household. As John Tyndall, Faraday's successor at the Royal Institution, put it almost a century ago, "It is Faraday's spark which now shines upon our coasts (in lighthouses), and promises to illuminate our streets, halls, quays, squares, warehouses, and perhaps at no distant day, our homes" (3). All of these places are now copiously lighted and otherwise treated by electrical means—the end result of more than a century of slow work with the aid of Occam's Razor. A good many unnecessary *Beings* multiplied by the first workers had to be discarded before success was achieved. The deteriorating rigours of high temperature incandescence caused some early lamp investigators like Sylvanus P. Thompson and Werner Siemens to give up the search, although they had been very successful in related work.

Other men turned to the use of platinum group metals, with or without the aid of vacua. Sir William Grove, Warren de la Rue, Sir Joseph Swan, Thomas A. Edison and Auer von Welsbach were among the inventors of proven ability who used platinum metals or alloys in their early efforts with incandescent lamp filaments.

Of course, these very able men also used platinum in other ways during their extensive careers, especially Grove in his pioneer fuel cell of 1839 and Edison in various detection devices, but we are now speaking only of their successful efforts to establish a great new electrical lamp industry.

After some years, the path led to the use of carbon in vacuum, and finally to the coiled filaments of ductile tungsten in the gas-filled lamps of today. But the familiar pathfinder served well until displaced by cheaper new materials.

On the other hand, platinum has been called to replace cheaper materials where it turned out that much more was needed than a durable hot filament. For example, coated platinum filaments replace tungsten in electron microscopes where the advantages of low emission temperature and slow evaporation rate, uniform field of illumination with little drift, as well as a small electron source are wanted.

There remain any number of instances where the highest general reliability is the only possible criterion, and is often taken for granted by users. The naval writer, Dudley Pope, has described what it meant to the daring men who subdued the Graf Spee during the "Battle of the River Plate" to have electrical bridges of an iridium-platinum alloy unfailingly ready to ignite the cordite in their guns (4).

If one decides to oppose the superior 11-inch armament of a German pocket battleship with the 8-inch guns of British cruisers, it is clearly desirable that the smaller guns go off every time.

Future Directions

The production of molecular beams, so important for and so characteristic of work in modern physics, requires a high temperature source able to eject particles by evaporation, usually in a vacuum vessel that is rapidly rotated. A source that will not make adventitious contributions of its own is wanted. For such purposes the German scientist Otto Stern used a platinum wire coated with a silver layer, which supplied the pure and volatile molecular beam in this instance. On the other hand, the low temperature pioneers Sir James Dewar and Kamerlingh Onnes both made use of platinum wires in their cryogenic resistance studies which ultimately led to the discovery of superconductivity by Onnes, with all of its mighty potentialities.

It is, of course, much too early to foresee what practical advantages will one day derive from two such remarkable phenomena at opposite ends of the temperature scale. Much close work with Occam's Razor lies ahead before the full truth stands forth. But perhaps one may be forgiven the observation that these two new areas have chosen a material pathfinder that others before them have found uniquely useful and reliable.

References

1 "Faraday's Lecture on Platinum", reprinted in *Platinum Metals Rev.*, 1961, 5, (1), 26

2 "Experimental Researches in Electricity", by Michael Faraday; Chapter on "Electricity of the Voltaic Pile", 1844, 1

3 "The Electric Light", by John Tyndall, A Discourse delivered at the Royal Institution of Great Britain, January 17th, 1879

4 "The Battle of the River Plate", by Dudley Pope, 1956, 157