2

An Impure Law

INTRODUCTION

Like a square peg in a round hole, chemical inventions are often portrayed as having been shoe-horned into a patent law that was built upon a mechanistic and mechanical view of innovation: a view that has led to the law of chemical patents being labelled an impure law that was the 'child' or 'orphan' of 'mechanical patent law'.[1] This way of thinking about chemical subject matter is part of a wider narrative that developed and took hold over the twentieth century, which sees patent law's engagement with chemical subject matter as an inherently problematic one, primarily because of the ineffectual attempts to modify patent law to accommodate the nuances of chemical subject matter.[2] It is also a product of seeing chemical subject matter through the lens of medical and pharmaceutical patents, which, at least until the later part of the nineteenth century or thereabouts, were thought to belong outside the remit of patent protection.[3]

One of the things that the history of chemical inventions reveals is how inaccurate this way of thinking about chemical subject matter is. Specifically, it shows that while chemical inventions are often presented as having been subsumed into a patent law initially designed to deal with mechanical inventions, chemical inventions have always been a part of American patent law. Indeed, a 1911 handbook on chemical patents went so far as to claim that the first patent ever granted in the United States – to Samuel Hopkins for making pot ash and pearl ash – brought 'the first

[1] This was similar to the pejorative view of chemistry as an impure science in the sense that chemists were unable to arrive at first principles or elaborate general laws (in the way that exact sciences of physics and maths do). Bernadette Bensaude-Vincent and Jonathan Simon, *Chemistry: The Impure Science* (2nd edn, London: Imperial College Press, 2012), 63.

[2] See, for example, Paul Eggert, 'Uses, New Uses and Chemical Patents: A Proposal' (1969) *Journal of the Patent Office Society* 768, 783; William D. Noonan, 'Patenting Medical Technology' (1990) 11 *Journal of Legal Medicine* 263; Jackie Hutter, 'A Definite and Permanent Idea? Invention in the Pharmaceutical and Chemical Sciences and the Determination of Conception in Patent Law' (1995) 28 *The John Marshall Law Review* 687, 689.

[3] See Joseph M. Gabriel, *Medical Monopoly: Intellectual Property Rights and the Origins of the Modern Pharmaceutical Industry* (Chicago: University of Chicago Press, 2014).

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United States patent into the realm of chemical patents'.[4] While we need to be cautious about overstating the historical impact of chemical patents on the law more generally, and we should not underestimate the impact of the mechanical-origins narrative, it is clear that patents relating to industrial chemistry were 'one of, if not the oldest in the realm of patents'.[5]

While patent law's engagement with chemical inventions is often presented as having been problematic and troubled – primarily because of the need to retrofit chemical subject matter into a law designed for mechanical inventions and because of the ethical issues relating to the use of patents within medicine – one of the things that the history shows is how relatively seamless and straightforward the process has been.[6] Unlike other countries that limited the protection available for chemical inventions (notably Germany, which excluded patents for chemical products but allowed patents over chemical processes[7]), there have never been specific limitations placed on chemical inventions in the United States. So long as chemical products or processes satisfied the general criteria for patentability (such as subject matter, novelty, obviousness, and utility) they were eligible for protection. The decision not to exclude chemical product patents avoided the problem of having to determine what a chemical product or process was, at least one that would have stood up to legal scrutiny. As a US patent attorney wrote, 'I do not even know … whether dissolving sugar in water is a "chemical process."'[8] Any 'attempt to sort out the chemical goats

[4] Hugo Mock, *Handbook of Chemical Patents: How Procured, Requisites of, and Other Information Concerning Chemical Patents in the United States and Abroad* (Washington, DC: Mason, Fenwick, and Lawrence, 1911), 8. Mock was referring to Samuel Hopkins, US Patent Number X001, 'The Making of Pot Ash and Pearl Ash' (31 July 1790). It was also said that between 1554 and 1598 about 'forty-eight licenses or monopolies were granted in England, of which one half were truly chemical patents'. A. J. Nydick, 'Book Review of Edward Thomas: The Law of Chemical Patents' (1938) 87(1) *University of Pennsylvania Law Review* 135, 136.

[5] Seabury Mastick, 'Chemical Patents I' (1915) *The Journal of Industrial and Engineering Chemistry* 789. A report from 1792 noted a range of patent chemical industries in the United States including candle and soap, chemicals (such as Glauber salts and saltpeter), distillery products, drugs, fermentation products, and plaster; metals, naval stores (turpentine, tar, rosin, etc.); oils, fats, and waxes; paint and varnish; paper, potash; salt; sugar, molasses, etc.; and various miscellaneous products such as glue and lampblack. C. A. Browne, 'Early Chemical Industries in America' (1922) 14 *The Journal of Industrial and Engineering Chemistry* 1066.

[6] At times the assimilation of chemical subject matter into patent law was so effective that it blended into the background. As the author of a 1917 treatise on chemical patents complained, it was difficult to write about chemical decisions because chemical 'facts frequently do not appear on the face of the decision'. Edward Thomas, *Chemical Patent and Allied Patent Problems* (Washington, DC: John Byrne & Co, 1917), 8. This treatment seems to have ended by 1945. See John Boyle and Henry Parker, 'Patents for New Chemical Compounds' (1945) 27 *Journal of Patent Office Society* 831, 836 (it is 'extremely difficult to obtain from the Patent Office adequate protection for inventions and discoveries in the chemical field' predicting that 'the patenting of new chemical compounds will prove to be the exception rather than the rule').

[7] For some of the issues see the *Hearings before the Committee on Patents United States Senate on S. 2718 Sixty-Fifth Congress: First Session* (4 June 1917) discussing a Bill to suspend a German patent on salvarsan, which was used in the treatment of syphilis.

[8] K. P. McElroy, 'Product Patents' (1939) *Journal of the Patent Office Society* 550, 553.

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from the physical sheep in the composition of matter class would prove like the task of hunting polar bears in purgatory – "apt to be arduous in detail and disappointing in result". There are too many hybrids, goatish sheep and sheepish goats.'[9]

The ease by which patent law embraced chemical subject matter was also reflected in the fact that in contrast to computer-related inventions and biological subject matter, which attracted and continue to attract attention, there was comparatively little critical discussion about chemicals as patentable subject matter. As a commentator noted in 1939, the question of the standing of patents for new chemical compounds was a 'question to which little thought has been given'.[10] There were two notable exceptions where the standing of chemical patents was called into question in the United States.

The first occasion where chemical patents were questioned was in relation to their use in the medical and health fields, which were thought to be beyond the reach of patents. The main reason for this was that physicians were 'supposed to be practising from a higher motive than the despised tradesman'.[11] While the belief that patents over pharmaceuticals and medicines would have a negative impact on healthcare did impact on patenting practices across the nineteenth century, once the ethical objections to the patenting of medical innovations were overcome, pharmaceutical-based chemical inventions were readily accepted within patent law.

The second occasion where chemical patents were called into question was in the early part of the twentieth century when concerns about the dominance of the German chemical industry in the United States led to calls for patent protection for chemical inventions to be curtailed. This was prompted by concerns that the American public was being exploited by the German chemical industry who had been systematically taking out product patents in the United States with the goal not of working the invention but of stopping the growth of the American organic chemical industry and thus making the United States dependent on Germany for chemicals.[12] The move to eliminate chemical patents reached a highpoint in 1916 when Charles Paige introduced a Bill into Congress that proposed to exclude chemical product patents and in so doing limit the protection available for chemical inventions to process patents. Specifically, the Bill provided that 'no patent shall be

9 Ibid., 553–54.

10 There was 'very little sentiment for restricting the field of patentable subject matter for chemicals in the United States'. P. J. Federico, 'Patents for New Chemical Compounds' (1939) 21 *Journal of the Patent Office Society* 544, 546–47.

11 Charles Woodruff, 'Should Patent Law Discriminate against Chemical and Medical Discoveries' (1917) *Journal of the American Pharmaceutical Association* 475, 468. For the post-war period see Kathryn Steen, 'Patents, Patriotism, and "Skilled in the Art": USA v. The Chemical Foundation, Inc., 1923–1926' (2001) 92 *Isis* 91.

12 Charles Woodruff, 'Should Patent Law Discriminate against Chemical and Medical Discoveries' (1917) *Journal of the American Pharmaceutical Association* 475, 468. 'German houses have exploited America during the last twenty-five or thirty years'. Ibid., 478–79.

granted … upon any drug, medicine, medicinal chemical, coal-tar dyes or colors, or dyes contained from alizarin, anthracene, carbazol, and indigo, except insofar as the same relates to a definite process for the preparation'.[13] Despite growing support for the Bill, Congress instead passed laws that allowed for the compulsory acquisition of German patents. When the war ended in 1919 and the American Drug Manufactures came out in support of product patents, the push to eliminate chemical patents quickly lost momentum and all but disappeared from public discussion.[14]

While it is often suggested that patent law is unable to keep up with the pace of scientific and technical change, patent law was easily able to embrace the myriad of changes that occurred in chemistry across the nineteenth century and beyond. As we will see, judges, patent officials, and treatise writers were consistently willing to accommodate the idiosyncrasies of chemical subject matter. Indeed, rather than being hostile or indifferent to the particularities of chemical inventions, courts in the United States (along with the US Patent Office) were said to have shown 'special sympathy'[15] and 'unusual respect for chemical inventions'.[16] For example, in identifying and demarcating chemical subject matter, patent law readily accepted changes in the way boiling and melting points were measured and in the way chemical substances were analysed and described. As well as accommodating changes in the way chemical subject matter was identified, traced, and demarcated, patent law was also willing to accommodate more fundamental changes in the nature of the subject matter, often with little or no fanfare or debate. This was particularly the case with the adoption of structural formula in the later part of the nineteenth century. While this transformation had important consequences, there was surprisingly little discussion about the move from a material chemical substance to a more dematerialised formula-based subject matter: the changes were simply presented to and subsequently accepted by patent officials, judges, and legal commentators.

Although the process of extending patent protection to chemical substances may have been relatively straightforward and uncontroversial, this should not be taken to mean that patent law did not have to change to accommodate the specific characteristics of chemical subject matter. Far from it. This is because although the process of assimilating organic chemistry into nineteenth-century patent law was a seamless, straightforward process that attracted little discussion or scrutiny, nonetheless a number of changes were needed in order to accommodate the idiosyncrasies of the science.

[13] 64th Cong, 1st Sess HR No. 11967 21 February 1916. The Paige Bill HB 11967 (to amend sections 4886 and 4887 of Revised statutes relating to patents).

[14] The Bill lapsed and by 1919 the American Drug Manufactures Association said the reasons for its introduction no longer existed. L. E. Sayre, 'Patent Laws in Regard to the Protection of Chemical Industry' (1919–1921) 30 *Transactions of the Kansas Academy of Science* 39, 43.

[15] Horatio Ballantyne, *Lecture on Chemists and the Patent Laws, The Institute of Chemistry of Great Britain and Ireland* (Cambridge: Heffer & Sons, 1922), 14.

[16] Howard Forman, *Law of Chemical, Metallurgical and Pharmaceutical Patents* (New York: Central Book Co, 1967), 247.

The aim of this and the following two chapters is to look at the way that patent law dealt with the idiosyncrasies of chemical subject matter across the nineteenth and early part of the twentieth centuries and how science and technology were implicated in that process. Specifically, the focus is on organic chemical patents in the United States from the 1840s to the 1940s or thereabouts. The 1840s being the time when organic chemistry – the branch of chemistry concerned with organic carbon-based compounds and materials – emerged as a discrete area of science. The 1940s being the time when the impact of the shift within patent law away from a reliance on physical criteria to a more dematerialised subject matter became clear.[17]

THE IDIOSYNCRASIES OF CHEMICAL SUBJECT MATTER

At the beginning of the nineteenth century, plant and animal chemistry was an experimental practice concerned with the extraction and description of organic substances.[18] In contrast to inorganic chemistry, where substances were classified and identified 'on the basis of experimentally obtained knowledge about their constitution and binary constitution', organic substances such as gums, sugars, oils, gelatines, blood, milk, and saliva were classified on the basis of their natural origins (plant or animal), their properties (sweetness, smell, etc.), and the techniques by which they were extracted. At the time, it was thought that compounds obtained from living organisms were endowed with a 'vital force' that distinguished them from inorganic materials. This also contributed to the belief that compounds obtained from living organisms were too complex to be created synthetically which, in turn, led to the bodies of living creatures being viewed as the laboratories in which the synthesis of organic compounds occurred.[19]

Over the course of the early part of the nineteenth century, plant and animal chemistry was gradually replaced by the 'new, experimental culture of organic carbon chemistry'.[20] The organic chemistry that emerged in the 1830s – which is the focus of this book – brought about a fundamental transformation in scientific culture: it changed what countered as a scientific object, the way experiments were conducted, and the objects that were studied and produced in laboratories.[21] The new organic chemistry was an industrial, applied, and empirical discipline that was

[17] Joachim Schummer, 'The Impact of Instrumentation on Chemical Species Identity from Chemical Substances to Molecular Species' in (ed) Peter J. Morris, *From Classical to Modern Chemistry: The Instrumental Revolution* (London: Royal Society of Chemistry, 2002), 188, 190.

[18] Ibid.

[19] Ursula Klein, 'Paper Tools in Experimental Cultures' (2001) 32 *Studies in History and Philosophy of Science* 265, 268.

[20] Ursula Klein, 'Technoscience avant la lettre' (2005) (13:2) *Perspectives on Science* 226, 249; Alan J. Rocke, 'Origins and Spread of the "Giessen Model" in University Science' 50(1) (2003) *Ambix* 90.

[21] Joachim Schummer, 'The Impact of Instrumentation on Chemical Species Identity from Chemical Substances to Molecular Species' in (ed) Peter J. Morris, *From Classical to Modern Chemistry: The Instrumental Revolution* (London: Royal Society of Chemistry, 2002), 188, 190.

concerned with material substances, the chemical transformations of substances, and the development of novel synthetic substances.[22] It was also a discipline that showed a growing interest in the constitution and structure of organic compounds and the experimental study of chemical reactions.

One of the defining features of organic chemistry was that it was an inherently empirical science.[23] The reason for this was that chemists did not have access to what went on below the surface of chemical compounds, nor could they explain why things happened in the way that they did.[24] While chemists and other natural philosophers had been 'pondering the invisible microworld for centuries',[25] chemical reactions remained invisible processes that lay beyond the direct reach of the chemist; they were processes that could not be seen, touched, or otherwise observed (at least directly).[26] While chemical reactions were accompanied by visible effects – such as changes of colour, smell, or temperature, or the creation of a new chemical compound – the reasons why and the manner in which these changes occurred could not be observed. Because chemists could neither access the chemical microworld nor see what was happening below the surface, they had to work backwards from the experimentally produced traces to try and identify what they had invented. That is, they had to work backwards from the results of a chemical reaction in an attempt to discern what had happened and, in turn, what had been produced.

The starting point for the study of the hidden microworld of chemical reactions was the creation of substances that revealed the traces or signs of the invisible objects of inquiry. This was done by letting a substance interact with another substance and in so doing change into a new substance. The material substances produced by this interaction were then separated from each other and processed into pure substances 'that were "readable" as meaningful signs'.[27] In this sense the substances created in the laboratory were of interest in so far as they offered experimental marks, traces, or signals of the invisible reactions that occurred when chemical substances were

[22] Ursula Klein, 'Objects of Inquiry in Classical Chemistry: Material Substances' (2012) 14 *Foundation Chemistry* 7, 8; Ursula Klein and Wolfgang Lefèvre, *Materials in Eighteenth-Century Science: A Historical Ontology* (Cambridge, MA: MIT Press, 2007), 1.

[23] Rather than working from first principles, chemistry worked from the contingent. Chemistry is a science 'which points to a new form of empiricism. It produces substances, the properties of which cannot be derived from general laws'. Andrew Barry, 'Pharmaceutical Matters: The Invention of Informed Materials' (2016) 22(1) *Theory, Culture & Society* 51, 53.

[24] Alan J. Rocke, 'Vinegar and Oil: Materials and Representations in Organic Chemistry' in (ed) Ursula Klein and Carstein Reinhardt, *Objects of Chemical Inquiry* (Sagamore Beach, MA: Watson Publishing, 2014), 47, 56.

[25] Alan J. Rocke, 'Preface' in (ed) Alan J. Rocke, *Images and Reality* (Chicago: University of Chicago Press, 2010), xiii.

[26] Ursula Klein, 'Paper Tools in Experimental Cultures' (2001) 32 *Studies in History and Philosophy of Science* 265, 273. These problems were compounded by the fact that there was no agreement or consensus about what lay below the surface of a chemical substance. Alan J. Rocke, 'Vinegar and Oil: Materials and Representations in Organic Chemistry' in (ed) Ursula Klein and Carstein Reinhardt, *Objects of Chemical Inquiry* (Sagamore Beach, MA: Watson Publishing, 2014), 47, 56.

[27] Ursula Klein, 'Technoscience avant la lettre' (2005) 13(2) *Perspectives on Science* 226, 254.

combined. Once the elements of a compound were separated and purified, these 'experimental signals were then transformed step by step firstly into analytic data and then into chemical formula'.[28]

One of the consequences of this was that it was often difficult or impossible to predict in advance what the outcomes of an untried chemical experiment would be. This lack of 'prevision' meant that chemists could not know what the consequences of mixing substances A and B would be, whether the results of that process would change if the substances were mixed at a higher or lower temperature, or what the consequences of changing the relative concentration of the substances might be: not at least until they had tried it. The only reliable way of answering these questions was by experiment: it was only by mixing the substances, altering the concentrations, or changing the temperature – and then isolating and identifying the end products – that a chemist could know what the outcome of an experiment would be.

While it was possible to work out what a machine would do a priori, 'a discovery of a new substance by means of chemical combinations of known materials' was 'empirical and discovered by experiment'.[29] As a chemical patent examiner explained to a meeting at the Patent Office in 1916, 'No prophesy is possible in chemical discoveries such as is frequently possible in purely mechanical inventions.' While from 'an inspection of the drawings and a perusal of the specification in the majority of applications for purely mechanical inventions, it is often safe to say that the invention is operative. On the contrary, it is never possible to foretell with certainty, that any untried chemical process is operative.'[30] As it was frequently difficult or impossible to predict in advance what the outcomes of an untried chemical experiment would be, it was not safe to draw inferences from past experience or analogies from known substances: instead, 'an actual trial or demonstration would be necessary to prove the inference'.[31] As we will see, the 'impossibility of predicting what will happen in hitherto-unknown situations'[32] had important consequences for patent law. Indeed, in his 1940 treatise on chemical patents, Edward Thomas went so far to suggest that the 'greater part of … chemical patent law' was said to stem from the lack of prevision.[33]

Another important characteristic of organic chemistry was that it was very much a lab-based science. Indeed, chemistry has been described as the archetypal laboratory science.[34] The fact that chemical compounds were things that needed to

28 Ibid., 253.

29 *Tyler* v. *Boston* 7 Wall 327, 330; 74 U.S. 327 (1868).

30 George S. Ely, *Chemical Inventions and Discoveries: A Paper Read November 23, 1916 before the Examining Corps of the United States Patent Office* (Washington, DC: The Law Reporter Printing Company, 1916), 4–5.

31 Ibid. Benton A. Bull, 'Prevision in the Law of Chemical Patents' (1943) 25 *Journal of the Patent Office Society* 473, 474–75.

32 Edward Thomas, *Handbook for Chemical Patents* (New York: Chemical Publishing Company, 1940), 11.

33 Ibid.

34 Melvyn C. Usselman, C. Reinhart, K. Foulser and A. Rocke, 'Restaging Liebig: A Study in the Replication of Experiments' (2005) 62 *Annals of Science* 1, 45 (the very word laboratory developed from a chymical context in the early modern period).

be tested and witnessed meant that as a 'theatre of proof' the laboratory was pivotal to the success of organic chemistry: it 'did much more than merely *house* a complicated array of rooms devoted to the specific activities which produced scientific knowledge: the laboratory was *instrumental* in producing that knowledge'.[35] Chemical laboratories not only produced new entities, they also provided the space within which those new entitles 'could reliably be witnessed'.[36] The chemical laboratory, which allowed organic chemists to 'amass the huge experimental material upon which organic synthesis was built'[37] was 'essential to the material production as well as the validation of new knowledge'.[38]

Another feature of organic chemistry that had important consequences for the way that it interacted with patent law was its reliance on chemical formula. While the nature and role of chemical formula changed over the course of the nineteenth century, for my purposes here two types of formula standout: empirical and rational formula (I look at a third type of formula – structural formula – in the next chapter). The first type of formula that were important in patent law were *empirical formula*. These were the formula that set out the elements in a compound. At the beginning of the nineteenth century, chemists assumed that the identity of a substance was determined by the composition of its elements. Typically, the proportion (or ratio) of elements in a substance was determined using a Kaliapparat, an apparatus consisting of five glass bulbs that had been invented in 1831 and quickly taken up by chemists around the world. While organic elemental analysis had been practiced since the early part of the century, the Kaliapparat marked a new era in analysis in so far as it provided a fast, easy, and accurate way of analysing organic substances, which allowed chemists to identify the elements in compounds.[39]

Drawing on the law of equivalent proportions, which provides that 'all chemical reactions take place in proportions by weight represented by elemental "equivalent weights"',[40] the information about the elements in a composition provided by the Kaliapparat was used to develop the empirical formula of the compound, which was a simple way of expressing the results of the chemical analysis. Typically, the

35 Catherine M. Jackson, 'Chemistry as the Defining Science: Discipline and Training in Nineteenth-Century Chemical Laboratories' (2011) 35(2–3) *Endeavour* 55, 60.

36 Isabelle Stengers, *Power and Invention: Situating Science* (Minneapolis: Minnesota University Press, 1997), 95.

37 Catherine M. Jackson, 'Chemistry as the Defining Science: Discipline and Training in Nineteenth-Century Chemical Laboratories' (2011) 35(2–3) *Endeavour* 55, 60.

38 Ibid., 61.

39 See Alan J. Rocke, 'Origins and Spread of the "Giessen Model" in University Science' 50(1) (2003) *Ambix* 90; Melvyn C. Usselman, C. Reinhart, K. Foulser and A. Rocke, 'Restaging Liebig: A Study in the Replication of Experiments' (2005) 62 *Annals of Science* 1, 2.

40 Alan J. Rocke, 'Chemical Atomism and the Evolution of Chemical Theory in the Nineteenth Century' in (ed) Ursula Klein, *Tools and Modes of Representation in the Laboratory Sciences* (Dordrecht: Kluwer Academic Publishers, 2001), 1, 10. On Berzelius's symbols, see Helen Cooke, 'A Historical Study of Structures for Communication of Organic Chemistry Information Prior to 1950' (2004) 2 *Organic and Biomolecular Chemistry* 3179, 3180.

summary of the empirical elemental analysis was written up using the system of abbreviations that was developed in the early part of the century (which, in slightly modified form, is still used today). Under this system, for example, the formula H_2O represented the elemental composition of water: of two parts hydrogen (H) to one part oxygen (O).[41] In this sense, empirical formula were formal quantitative statements about the proportions of the components in a particular chemical substance. As we will see, empirical formula played an important role in allowing patentees to describe their novel chemical compounds and the Patent Office to classify and organise the chemical prior art.

The second type of chemical formula that were important for patent law were *rational formula*, which began to take shape in the 1840s. One of the notable things about rational formula is that the formula not only represented the elements in a compound (as empirical formula did), they also represented the internal structure or constitution of chemical compounds. In part, rational formula grew out of problems that had developed with empirical formula. Specifically, they grew out of the fact that empirical formula could not account for 'isomerism'; namely, that it was possible for different substances, often with very different properties, to share the same empirical formula.[42] While empirical formula had many benefits they could not explain, for example, why substances such as ethanol and dimethyl ether had the same empirical formula but very different properties.[43]

The realisation that different chemical compounds could have the same empirical formula eroded confidence in the assumption that the identity of substances could be determined solely by their elements. In attempt to explain isomerism and to better understand the relationship between starting materials and the products of chemical reactions more generally, chemists shifted their attention away from a concern with the composition of compounds to focus on the constitution or inner organisation of compounds: that is, with the way that the elements were organised rather than merely on the number and kind of elements that were in a compound.[44]

The discovery of isomers served to highlight a shortcoming of empirical formula, namely that while they provided information about the elements in a compound, empirical formula said nothing about the way those elements were arranged or structured. These problems were compounded by the fact that, at the same time as organic chemists were grappling with isomers, they also began to embrace the idea that organic substances consisted of two parts (one of which was a compound radical that was as stable as an element). While the idea of the binary constitution

41 Alan J. Rocke, 'Origins and Spread of the "Giessen Model" in University Science' 50(1) (2003) *Ambix* 90, 96.

42 Bernadette Bensaude-Vincent and Jonathan Simon, *Chemistry: The Impure Science* (2nd edn, London: Imperial College Press, 2012), 206.

43 Alan J. Rocke, 'Origins and Spread of the "Giessen Model" in University Science' (2003) 50(1) *Ambix* 90, 93.

44 Ibid.

of organic compounds was short-lived,[45] it served to highlight a further shortcoming with empirical formula; namely, that it was not possible to identify the building blocks of a compound and thus its constitution based on quantitative analysis alone.

It was here that rational formula came into their own. While empirical formula listed the elements in a compound, rational formula translated that information into a binary format that represented the constitution of the compound.[46] Thus the empirical formula for oil of bitter almonds – $C_{14}H_{12}O_2$ – was translated into $(C_{14}+H_{10}+O_2) + H_2$, which designated the compounds constitution of a 'benzoyl radical' and hydrogen. In selecting the rational formula for a particular compound, chemists were often faced with a series of choices. This is because it was often possible to translate empirical formula into a number of different mathematically valid rational formula. For example, the empirical formulas for alcohol – C_2H_6O – could be represented by $(C_2H_4)+(H_2O)$, $(C_2H_6)+(O)$, $(C_2H_5O)+(H)$, or $(C_2H_5)+(OH)$.[47] The only rule that chemists had to follow was that the rational formula and the empirical formula had to contain the same number of elements. In an iterative process, chemists would attempt to fit what was known about chemical reactions and compounds with a possible rational formula for the compound in question. For instance, in the case of alcohol, the formula $(C_2H_4)+(H_2O)$ was supported by the fact that it was possible to dehydrate alcohol.[48] In this way, organic chemists were able to gradually transform 'fuzzy inscriptions … into sharp ones'.[49] Once selected the proposed formula would then be tested and refined by additional experimental investigations of the chemical reaction of the compound'.[50] Once finalised, a rational formula operated as a blueprint of an organic species that denoted the binary composition of the compound and distinguished it from other organic compounds.[51]

What we see in this process is an important transformation in the role that chemical formula played in organic chemistry. This is because rather than merely functioning to indicate the elements and their ratio in a particular compound, rational

45 Alan J. Rocke, 'The Theory of Chemical Structure and Its Applications' in (ed) M. Nye, *The Cambridge History of Science* (Cambridge: Cambridge University Press, 2002), 255, 256.

46 Ursula Klein, 'Paper Tools in Experimental Cultures' (2001) 32 *Studies in History and Philosophy of Science* 265.

47 Alan J. Rocke, 'Chemical Atomism and the Evolution of Chemical Theory in the Nineteenth Century' in (ed) Ursula Klein, *Tools and Modes of Representation in the Laboratory Sciences* (Dordrecht: Kluwer Academic Publishers, 2001), 1.

48 Alan J. Rocke, 'The Theory of Chemical Structure and its Applications' in (ed) M. Nye, *The Cambridge History of Science* (Cambridge: Cambridge University Press, 2002), 255, 257. Based on chemical formula, it was possible to draw conclusions about the regroupings taking place in the reaction by comparing the composition of the initial substance with the composition of the reaction products. Ursula Klein, 'Technoscience avant la lettre' (2005) 13(2) *Perspectives on Science* 226, 253.

49 Ursula Klein, 'Paper Tools in Experimental Cultures' (2001) 32 *Studies in History and Philosophy of Science* 265, 275.

50 Ibid.

51 Ibid.

formula were now also being used, in Klein's words, as paper tools that were used to produce new representations of what was happening below the surface of the compound.[52] That is, chemists applied rational formulas not merely as a way of expressing and illustrating existing knowledge about the make-up of a compound, they also used them as paper tools for developing chemical models and classificatory systems in organic chemistry: of rendering the invisible visible.[53] In this sense, rational formulas functioned like laboratory instruments for producing new representations of invisible objects and processes.[54] The ability to manipulate formulas provided organic chemists with an 'extraordinary productive theoretical tool, a means to create endless ideas for investigation, and endless new substances to try to create'.[55] This marked a major transition in the culture of organic chemistry from what had predominately been a science that 'exhibited a natural-historical character' (in which experimental investigations of chemical reactions were extremely rare) to a science characterised by 'a highly experimental approach, with the preparation of new artificial substances placed in the foreground'.[56]

Rational formulas proved to be particularly popular with organic chemists. There were a number of reasons for this, not least because they provided an effective and relatively easy way of building models of the chemical constitution of compounds. Another reason why rational formulas were popular was because they helped chemists to navigate the 'unseen sub-microscopic chemical world'.[57] That is, rational formulas helped chemists to understand what went on beneath the surface of chemical compounds. At the beginning of the nineteenth century, when chemists were unable to access the inner workings of chemical compounds, there were a number of different ways of thinking about the invisible microworld of chemical substances. These ranged from ontological realists (such as Dalton who thought that the symbols in chemical formula actually 'signified a very small but very real billiard ball') through to those who saw chemical formula as a mere 'aid to memory in representing the empirical facts of chemical analysis and having no real referent in the microworld at all'.[58]

One of the reasons why rational formulas were so successful is because they allowed chemists to work with and think about chemical reactions and compounds without having to commit to any particular way of thinking about what went on below the surface. The reason for this was that rational formulas were based on Berzelius's theory of chemical proportions. In contrast to other ways of thinking about atoms that existed at

52 Ibid., 265.

53 Manuel DeLanda, *Philosophical Chemistry: Genealogy of a Scientific Field* (Bloomsbury: London, 2015), 84.

54 Ursula Klein, 'Paper Tools in Experimental Cultures' (2001) 32 *Studies in History and Philosophy of Science* 265.

55 Alan J. Rocke, 'Origins and Spread of the "Giessen Model" in University Science' 50(1) (2003) *Ambix* 90, 97.

56 Alan J. Rocke, *Images and Reality* (Chicago: University of Chicago Press, 2010), 6–7.

57 Ibid., 7.

58 Ibid., 6.

the time, the 'theory of proportions' did not make any statements 'about the mechanical properties, orientation in space, or scale of the hypothesised invisible entities.[59] Instead, Berzelius' theory of chemical proportions assumed that chemical elements and compounds were made up of discontinuous bits or portions, which were defined by their invariable and characteristic combining weight. A Berzelian chemical (as opposed to physical) atom was simply a packet of elemental matter of a certain relative weight;[60] it made no commitment about what this matter was or whether it really existed. In line with this, each of Berzelius's letters, which symbolised an invisible chemical entity – 'a proportion, portion, equivalent, atom, or whatever' – stood for a recombining unit of a specific chemical element or an 'elemental building block'. Thus, the three entities in Berzelius's 'preferred water formula H_2O referred to a quantity of matter', the 'real micro-characteristics of which were deliberately elided'.[61]

As rational formulas were metaphysically non-committal, they could be used by both pro- and anti-atomists.[62] Importantly, this made it possible for chemists to develop a building block image of chemical portions without having to invest in (physical) atomic theory.[63] The idea of chemical portions allowed chemists to move back and forth between the external macroscopic and internal microscopic worlds as needed. Importantly, as the agnostic nature of the rational formula allowed chemists to take for granted that the formulas were true representations of the composition of the substances being investigated, they also allowed chemists to 'go on with their experiments and identification of material substances without having to answer many theoretical problems … their mode of comprehending chemistry was independent of an explanation of chemical combination at a deeper level'.[64] In this way rational formulas were used to identify and demarcate the distinct building blocks of the substances that combined in the reaction.

Rational formulas played a number of important roles in patent law. As well as providing information about the composition and make-up of compounds, as paper tools rational formulas helped chemists generate the novel organic chemical compounds that patent law was called upon to protect. Patent law also drew upon rational formula – or more specifically the agnosticism that allowed chemists to treat rational formula as if they were accurate representations of reality – to accommodate some of the idiosyncrasies of these novel compounds, particularly the lack of prevision that characterised organic chemistry.

59 Ibid., 276.
60 Ibid., 6–7.
61 Ibid., 6.
62 See Emily Grosholz, *Representation and Productive Ambiguity in Mathematics and the Sciences* (Oxford: Oxford University Press, 1991).
63 Ursula Klein, *Experimental, Models, Paper Tools: Cultures of Organic Chemistry in the Nineteenth Century* (Stanford: Stanford University Press, 2003), 35.
64 Ursula Klein, 'Objects of Inquiry in Classical Chemistry: Material Substances' (2012) 14 *Foundation Chemistry* 7, 10.

Another important characteristic of nineteenth-century organic chemistry was that the substances that were presented to the law for scrutiny were very fickle: a slight change in ingredients or in the experimental conditions in which a substance was created could 'profoundly and critically alter the result'.[65] With some compositions, changing quantitates, proportions, purity, or conditions (solid, liquid, gaseous) of the materials could dramatically change the resulting compound. Likewise, changes to the conditions under which experiments were conducted, including altering temperature, pressure, or time could have a profound effect on the resulting compounds. The fickleness of chemical compounds had important ramifications for patent law, particularly in terms of the exactness of the definitional detail that this necessitated in patents. The fact that even a slight change in the composition of the elements or how they were combined could fundamentally change the resulting compound also had an impact on the way the courts viewed the subject matter. This can be seen for example in the decision of *Mathieson Alkali Works*, which concerned the patentability of an invention for the bleaching of cellulose materials using a chlorite in an acid solution. In light of the fact that the prior art disclosed the use of a chlorite in an alkaline solution, it was argued that the substitution of a chlorite in an acid solution was an obvious and therefore unpatentable step. The court rejected this argument on the basis that it was substantially the same as arguing that 'hydrogen peroxide (H_2O_2) is an obvious substitute for drinking water (H_2O) or that carbon monoxide (CO), the deadly poison which is present in automobile exhaust gases, is an obvious substitute for dry ice, carbon dioxide (CO_2)'. As the court said, if 'the suggested substitution was obvious it would seem even more obvious to covert graphite into diamonds because their atomic contents are not merely similar but exactly the same [which no one has yet done] … Slight atomic changes or rearrangements in the constituents of chemical combinations produce profound changes in their properties and reactions'.[66]

Yet another characteristic of nineteenth-century organic chemistry that shaped the way it interacted with patent law was the rate and speed of change. Organic chemistry, which originated in Germany, France, and the United Kingdom, quickly spread to the United States across the nineteenth century.[67] (There is work needed on the role patents played in this process.) As well as spreading geographically, there was also a phenomenal increase in the size of the science, particularly in terms

65 George S. Ely, *Chemical Inventions and Discoveries: A Paper Read November 23, 1916 before the Examining Corps of the United States Patent Office* (Washington, DC: The Law Reporter Printing Company, 1916), 10.

66 *The Mathieson Alkali Works* v. *Coe* 99 F.2d 443 (1938) CD 105, 497 OG 768.

67 R. Dolby, 'The Transmission of Two New Scientific Disciplines from Europe to North America in the Law Nineteenth Century' (1977) 34 *Annals of Science* 287. For discussion of the early twentieth century see Peter. J. Hugill and Veit Bachmann, 'The Route to the Techno-Industrial World Economy and the Transfer of German Organic Chemistry to America before, during, and Immediately after World War I' (2005) 3(2) *Comparative Technology Transfer and Society* 159; Kathryn Steen, 'Confiscated Commerce: American Importers of German Synthetic Organic Chemicals, 1914–1929' (1995) 12 *History and Technology* 261.

of the number of organic chemical compounds in existence. As organic reactions often resulted in a cascade of different products, each of which potentially generated other products, the number of chemical compounds grew and continued to grow exponentially across the century. While it has been suggested that in 1820 only about 120 organic compounds had been described in the literature, by the 1860s there was talk of there being billions of compounds. The scale of the increase was captured by the French organic chemist Marcellin Berthelot who calculated in 1863 that the '1.4×10^5 possible esters of sorbitol would fill 14,000 libraries each containing a million books comprising a campus that would require an area the size of Paris'; this was just to list the names, not even a description of their properties.[68] While these figures were crude, nonetheless they capture the enormous growth that occurred in organic chemistry across the nineteenth century. The rapid and dramatic increase in the number of organic compounds created a number of problems for patent law. As well as contributing to the 'chemical identity crisis'[69] that plagued both science and the law across the nineteenth century, the number of organic compounds in existence also created problems when navigating the prior art for the purpose of determining whether a chemical compound was novel.

One of the reasons for the rapid growth of nineteenth-century organic chemistry was that the new experimental science allowed chemists to produce artificial substances in an unprecedented way. The creation of artificial material substances included both the development of products not found in nature such as acetylsalicylic acid (aspirin) and new dyes (such as mauveine), along with the artificial creation of pre-existing natural products such as urea, acetic acid (vinegar), and glucose. Many of these new compounds transformed existing industries or laid the foundation for new industries across the nineteenth century.[70] The creation of artificial substances, which became a defining feature of nineteenth-century chemistry and a key concern of patent law, was based on the insight that as the properties of substances were dependent on their molecular architecture, new synthetic substances could be created by changing the nature of that architecture. Specifically, it was based on the concept of substitution, where one portion of a compound was replaced with another portion to produce unexpected and novel compounds.[71] Organic chemists used a range of different experimental techniques to alter or transform the molecular architecture of substances in order to create novel synthetic substances. These included experimenting with the substances that were mixed together, the relative

68 Alan J. Rocke, 'Origins and Spread of the "Giessen Model" in University Science' (2003) 50(1) *Ambix* 90, 94.

69 Catherine M. Jackson, 'Chemical Identity Crisis: Glass and Glassblowing in the Identification of Organic Compounds' (2015) 72(2) *Annals of Science* 187.

70 Joachim Schummer, 'The Impact of Instrumentation on Chemical Species Identity from Chemical Substances to Molecular Species' in (ed) Peter J. Morris, *From Classical to Modern Chemistry: The Instrumental Revolution* (London: Royal Society of Chemistry, 2002), 188, 190.

71 Ursula Klein, 'Paper Tools in Experimental Cultures' (2001) 32 *Studies in History and Philosophy of Science* 265, 284.

concentration of substances, and the conditions under which the substances were mixed (by doing things such as changing temperature or pressure).[72]

As well as producing novel artificial compounds for use in industry, another important output of organic chemistry was the creation of compounds that were used as research tools to create other compounds. Here, novel chemical compounds, particularly those that were highly reactive, were used to generate new compounds rather than as ends in themselves.[73] Initially, organic substances were primarily derived from substances extracted from plants and animals. From around the 1850s, coal tar, which was a by-product of the coal gas and coke industries, became an increasingly important source of carbon compounds. Overtime, however, the majority of new substances were derived from artificially transformed synthetic organic compounds that emerged during the experimental study of organic chemical reactions.

Yet another output of organic chemistry was chemical knowledge. As well as producing knowledge about experimental techniques, the research process also produced knowledge about the synthetic pathways that led from starting materials to the final product and the characteristics of the resulting compounds, including information about their constitution, their melting and boiling points, along with how they looked, smelt, or tasted. While there was no attempt to protect this knowledge, it did play an important role in allowing patentees to identify and demarcate chemical inventions.

DEALING WITH A FICKLE, CHANGING, AND EMPIRICAL SUBJECT MATTER

In the introduction to his 1940 *Handbook for Chemical Patents*, Edward Thomas set out to explain why a separate book on chemical patents was warranted. For Thomas, the answer was straightforward: as chemical subject matter was fundamentally different from other types of patentable subject matter, it raised questions that did not arise with mechanical or electrical inventions. The key reason for this can be traced to the fact, as Thomas said, '[c]hemistry is essentially an experimental science, and chemical prevision is as impossible today, in spite of the accumulation of the great knowledge as it was in former times'.[74]

One of the notable things about nineteenth-century patent law was that judges, patent examiners, lawyers, and legal commentators all unquestionably accepted

72 Ibid., 290.

73 Ursula Klein, 'Technoscience avant la lettre' (2005) 13(2) *Perspectives on Science* 226, 253. 'Chemists cannot study the substances under investigation by means of chemical reactions without producing new substances'. Wolfgang Lefèvre, 'Viewing Chemistry through Its Ways of Classifying' (2012) 14 *Foundations of Chemistry* 25, 29.

74 Edward Thomas, 'An Outline of the Law of Chemical Patents' (1927) 19 *Industrial and Engineering Chemistry* 176, 177.

that chemical subject matter was the product of experiment: there was no doubt even amongst the harshest of critics that prevision was not possible and that organic chemistry was, at heart, an empirical science.[75] As Justice Grier wrote in 1868, 'a machine which consists of a combination of devices is the subject of invention, and its effects may be calculated *a priori*; while a discovery of a new substance by means of chemical combinations of known material is empirical, and discovered by experiment'.[76] Patent law mirrored the practice in chemistry of treating organic substances as 'experimentally defined objects throughout, from the bottom, that is their individuation and identification, up to their classification'.[77] With one notable exception (discussed below), there was also no question that the law should change to accommodate the experimental nature of the science.[78]

The willingness of judges, lawyers, legal commentators, and patent examiners to accept that chemistry operated 'by trial, not by reasoning' had a number of consequences for patent law, particularly in terms of how the subject matter was viewed.[79] While it is sometimes said that the experimental, empirical nature of organic chemistry disadvantaged chemical patentees, this was rarely the case.[80] This was particularly evident in relation to the doctrinal requirement that to be patentable an invention needed to be useful (or have utility). While meeting this requirement was not a problem for the small number of chemical inventions that had a direct industrial application (such as a new anti-fouling paint or dye) in the vast majority of cases, however, as chemical compounds had no direct industrial use, utility could have posed a problem. This was not the case however. Indeed, rather than being a problem, 'usefulness was assumed by the Patent Office for both chemical processes and compound inventions'.[81] The reason for this was that patent law latched onto

[75] The fact that 'chemistry is a mysterious science and that no one can tell exactly what will happen until he has tried it' meant that 'patents are sometimes granted for chemical inventions in instances where it would appear that the amount of ingenuity exercised on behalf of the chemists would have been called "mere mechanical skill" had he been working in a mechanical art'. Bruce K. Brown, 'The American Patent System Aids Chemical Industry' (1938) 31 *Industrial and Engineering Chemistry* 580, 584.

[76] *Tyler* v. *Boston* 74 U.S. 327, 330 (1868).

[77] Ursula Klein, 'Shifting Ontologies, Changing Classifications: Plant Materials from 1700 to 1830' (2005) 36 *Studies in History and Philosophy of Science* 261, 272.

[78] The courts had 'come to regard synthetical chemistry as compounds of the very essences of under determinability and unpredictability'. Charles E. Ruby, 'Are True Chemical Compounds, as Such, Inherently Unpatentable Subject Matter: Part II' (1941) *Temple University Law Quarterly* 321, 335.

[79] As a patent examiner noted, the 'courts have frequently recognized the futility of an attempt to prophesy or foretell in chemical procedure'. George S. Ely, *Chemical Inventions and Discoveries: A Paper Read November 23, 1916 before the Examining Corps of the United States Patent Office* (Washington, DC: The Law Reporter Printing Company, 1916), 5. The judicial willingness to accept the empirical nature of organic chemistry was reflected in the comment of the Supreme Court that with chemical research, there was 'no "of course" as to what nature can do, except as proved by observation and experimentation'. *Minerals Separation North America Corp*. v. *Magma Copper Co* 280 U.S. 400 (1930).

[80] A chemist was said to be in an 'unusually favourable position' in relation to subject matter and novelty, 'since he is less exposed to attack by analogy.' Harold E. Potts, *Patents and Chemical Research* (Liverpool: University Press of Liverpool, 1921), 141.

[81] Paul H. Eggert, 'Uses, New Uses and Chemical Patents: A Proposal' (1968) *Wisconsin Law Review* 901.

the fact that chemical compounds had the *potential* to act both as building blocks in the creation of other compounds and also as a means for establishing chemical knowledge to declare them useful enough to warrant protection.[82] In so far as compounds 'could be regarded as intermediates in the preparation of other compounds', utility was assumed.[83] The fact that these chemical inventions were 'baldly empirical'[84] did not matter so long as the compound was able to be identified.[85]

CHEMICAL SUBJECT MATTER AS THE PRODUCT OF INVENTIVE PROCESS

Dealing with a fickle, empirically based, and rapidly changing subject matter posed a number of challenges for patent law including how to give shape to the intangible chemical property, how to define the boundaries of what was being examined or protected, and once this was done, how that subject matter was to be identified. Overall, there was very little discussion about the changes that were needed to accommodate the idiosyncrasies of organic chemistry or about what the consequences of those changes might have been. One notable exception to this was Charles E. Ruby who in a series of articles written for both legal and scientific audiences from 1939 to 1941 mounted what was effectively a single-handed and unsuccessful campaign against chemical product patents. Following the publication of an article in *Science* that set out his basic argument that chemical compounds should not be entitled to patent protection because they were not inventions, Ruby, who was a Member of the Massachusetts and Federal Bars, wrote to the readers of the Journal of Chemical Education, alerting them to his article in *Science* with the aim of eliciting 'criticisms *pro* and/and or *con*' from the readers of the journal as he was preparing an 'exhaustive treatment of the thesis and [Ruby] want[ed] to 'incorporate all such criticism in this proposed longer paper'.[86]

This longer paper eventually emerged as a series of articles where Ruby argued that patents for chemical compounds such as US Patent Number 644,077 for

[82] *Potter* v. *Tone* 36 App DC 181 (DC Cir 1911) (a compound was regarded as possessing utility if it was 'useful to chemist as an educational device or as a research vehicle in the formation of other compounds)'. Paul H. Eggert, 'Uses, New Uses and Chemical Patents: A Proposal' (1968) *Wisconsin Law Review* 901, 905.

[83] A. M. Lewers, 'Composition of Matter' (1921–22) *Journal of the Patent Office Society* 530, 542.

[84] Edward Thomas, 'An Outline of the Law of Chemical Patents' (1927) 19 *Industrial and Engineering Chemistry* 176, 178.

[85] '[A]ll that the law requires is that the invention should not be frivolous or injurious to the well-being, good policy or sound morals or society … in contradistinction to mischievous or immoral'. *Lowell* v. *Lewis* 15 F Cas 1018, 1019 (CC Mass 1817). The application of this 'lower' standard continued until 1940. See John Boyle and Henry Parker, 'Patents for New Chemical Compounds' (1945) *Journal of the Patent Office Society* 831, 831–32, discussing the change adopted at the Patent Office that saw the introduction of a stronger utility requirement, which was challenged in *Application of Nelson* 280 F.2d 172 (CCPA 1960).

[86] Charles E. Ruby, 'Patents for Acts of Nature' Letter to the Editor (1939) *Journal of Chemical Education* 498.

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acetylsalicylic acid (aspirin) and Patent Number 1,533,003 for mercurochrome[87] were an abuse of the patent system or, as he put it, 'the most preposterous patent monopoly that have ever been foisted upon the public with … the sanction of some of our courts'.[88] While Ruby accepted that chemical compounds were 'indubitably' compositions of matter, he felt that they constituted a very special kind of composition of matter that did not warrant or deserve to be protected.

There were a number of reasons why Ruby believed that product patent protection should not be available for chemical subject matter.[89] In an unconvincing form of originalism, Ruby argued that chemical product patents should be excluded from protection because when Congress introduced the term 'composition of matter' into the categories of patentable inventions in 1793, Congress could not have intended to include chemical compounds because the science was not yet in existence. Drawing on the fact that 'man is … largely ignorant'[90] of chemical compounds, Ruby also argued that chemists were not in a position to disclose their inventions in a way that met the requirements of patent law. As he said, the fact that the 'molecules of any true chemical compound defy conception … since they are unknown' meant that chemical compounds 'necessarily lack, and will always lack, the completeness demanded of conceptions of inventions in patent law'.[91] As 'no chemist can "know" the actual structure of any true chemical compound as the "inventor" of a machine … knows the structure of his "invention"' … 'no chemists can make a completely adequate disclosure of an alleged "invention" of any true chemical compound'.[92]

While these arguments were important, the main reason why Ruby objected to the patenting of chemical compounds was because they were 'not "inventions" as defined … in the patent law in the United States'.[93] Rather, he believed that chemical compounds were 'quintessentially discoveries'.[94] For Ruby, an invention was 'a specifically human affair' that evolved out of the inner consciousness of its creator who then embodied it in a tangible substance: the immaterial (conception) was created by the human inventor and then given shape in a material tangible form. As he said, an invention was 'necessarily a creating or contriving by man – some things or some actions or series of actions performable upon materials that man can, and does,

[87] 'In 1902 the US Circuit Court of Appeals for the Third Federal Circuit upheld US patent No. 444,086 for aceytlphenetidine (phenacetin) and, in 1910, the US Circuit Court of Appeals for the Seventh Federal Circuit sustained US patent No 644,077 for acetyltsalicylic acid (asprin)'. Charles E. Ruby, 'Patents for Acts of Nature' (28 April 1939) 89 (2313) *Science* 387, 388.

[88] Ibid.

[89] Ibid.

[90] Charles E. Ruby, 'Are True Chemical Compounds, as Such, Inherently Unpatentable Subject Matter: Part II' (1941) *Temple University Law Quarterly* 321, 336.

[91] Ibid., 330.

[92] Ibid., 333.

[93] Charles E. Ruby, 'Are True Chemical Compounds, as Such, Inherently Unpatentable Subject Matter: Part I' (1940) *Temple University Law Quarterly* 27, 31.

[94] Charles E. Ruby, 'Are True Chemical Compounds, as Such, Inherently Unpatentable Subject Matter: Part II' (1941) *Temple University Law Quarterly* 321, 335.

make or perform – in short, a purely human accomplishment; it is above all *not* something that nature, and only nature, can create'.[95] Here, Ruby drew upon the comment of the Supreme Court in *United States* v. *Dubilier Condesor Corp* that invention is the 'result of an inventive act; the birth of an idea and its reduction to practice; the product of original thought; a concept demonstrated to be true by practical application or embodiment in tangible form'.[96] Given that inventions were conceptions that 'evolved from the inner consciousness of "inventors" and embodied by them in a tangible substance', this meant that inventions were predeterminable and predictable. It also meant that conception necessarily preceded embodiment chronologically.[97]

For Ruby, for something to qualify as an invention, it was necessary to be able to show that a human agent had exercised 'substantial control' in the development of the invention,[98] without which there could be no 'true' reduction to practice of the alleged invention.[99] While 'the role of the discoverer is essentially a passive one, for the discovery itself is never the creation of the discoverer, who merely observed it in his act if discovery',[100] in contrast, the role of the inventor was 'essentially an active one, for the invention is the creation of the inventor, who truly contrived it and gave it its existence'.[101] As Ruby said:

> the inventor creates or contrives or contrives to create his invention according to a conception thereof evolved by him out of his inner consciousness. This doctrine implies that the inventor knows exactly what he is inventing, that he truly participates creatively in the act of inventing. He actually imparts to his invention its existence, he exercises choice, albeit limited in scope, in selecting the appropriate means, materials, operating conditions, *etc*, in order to effectuate his invention, and he exercises a substantial measure of control over all of the factors of the act of inventing and of his invention itself.[102]

While Ruby believed that mechanical and electrical innovations satisfied this definition of invention, he felt that this was not the case with chemical compounds. As he said, if 'there is one thing that man cannot "invent", it is a true chemical compound'.[103] Ruby's argument against protection largely turned on the way he saw chemical compounds. Drawing on the law of constant composition of chemical compounds that had been developed by the French chemist Joseph Proust in 1794, Ruby argued that chemical compounds were unchanging 'invariants' that

[95] Charles E. Ruby, 'Patents for Acts of Nature' (28 April 1939) 89(2313) *Science* 387, 388.
[96] *US* v. *Dubilier Condesor Corp* 289 U.S. 178, 53 Sup Crt 554 (1933).
[97] Charles E. Ruby, 'Are True Chemical Compounds, as Such, Inherently Unpatentable Subject Matter': Part II' (1941) *Temple University Law Quarterly* 321, 335.
[98] Charles E. Ruby, 'Are True Chemical Compounds, as Such, Inherently Unpatentable Subject Matter: Part I' (1940) *Temple University Law Quarterly* 27, 50.
[99] Ibid.
[100] Ibid., 36.
[101] Ibid.
[102] Ibid., 37.
[103] Charles E. Ruby, 'Patents for Acts of Nature' (28 April 1939) 89 (2313) *Science* 387, 388.

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were ‘predetermined by violations of nature’;[104] they were ‘unique molecularly-homogenous substances of invariant composition and fixed properties, unalterable by man’.[105]

While a chemist could ‘put together mutually reactive substances’ (in a way that might constitute a patentable process), Ruby believed that the chemical compounds that were produced by those processes ‘depend wholly on the violation of nature’. The reason for this was that ‘Nature, and nature alone, fixes the structure, the composition and the inherent properties of every true chemical compound that is producible by processes devised by man, and neither you or I nor anyone else can alter any of them. Obviously no true chemical compound, as such, can be an “invention”’.[106]

Although the processes by which chemical compounds were ‘first ushered into existence’ were ‘almost invariably … man contrived’,[107] Ruby believed that chemical compounds always remained the product of the handiwork of nature. While a chemist could select the appropriate reactive materials and ‘contrive suitable conditions of operation which yielded novel chemical compounds’, chemical compounds were always expressions of the violations of nature rather than the work of the chemist.[108] This was because if ‘properties of matter alter when substances are subjected to treatments in man-contrived processes, such alterations of properties of matter are not caused by man himself, but occur in obedience to the laws of nature’.[109] As Ruby said, the intense sweetness of saccharine did not evolve out of the inner consciousness of its ‘inventor’ Professor Ira Remsen in 1879 to be thereafter embodied in matter. Rather the ‘unique ensemble of properties embodied in matter and known as saccharin’ was ‘qualitatively and quantitatively indissoluble’[110] … ‘nature, and only nature, can create and embody in, or impart to, matter those properties intrinsic to matter itself’.[111] That is, it was nature not Remsen who had created saccharine. While a chemist could

[104] ‘In the unions termed “compounds” nature imposes laws on herself and on us so that no chemist can make compounds in new proportion’ … a ‘compounds is a privileged product to which nature has assigned a fixed composition. Nature never produces a compound, even when through the agency of man, otherwise in hand, *pondere et mesura* … we must recognise the invisible hand which holds the balance in the formation of true chemical compounds … These ratios, always the same, these constant proportions which characterize the true chemical compounds of art or nature … are no more left to the power of chemists than is the law of election (i.e., affinity) which governs all of these combination … Between pole and pole, true chemical compounds are identical in their proportion’. As cited in Charles E. Ruby, ‘Are True Chemical Compounds, as Such, Inherently Unpatentable Subject Matter: Part I’ (1940) *Temple University Law Quarterly* 27, 34.

[105] Charles E. Ruby, ‘Patents for Acts of Nature’ (28 April 1939) 89 (2313) *Science* 387, 388.

[106] Ibid.

[107] Ibid.

[108] Charles E. Ruby, ‘Are True Chemical Compounds, as Such, Inherently Unpatentable Subject Matter: Part II’ (1941) *Temple University Law Quarterly* 321, 334.

[109] Charles E. Ruby, ‘Are True Chemical Compounds, as Such, Inherently Unpatentable Subject Matter: Part I’ (1940) *Temple University Law Quarterly* 27, 60.

[110] Charles E. Ruby, ‘Are True Chemical Compounds, as Such, Inherently Unpatentable Subject Matter: Part II’ (1941) *Temple University Law Quarterly* 321, 340.

[111] Ibid., 342.

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'select chemical elements at his pleasure, but himself cannot actually place them in designs of any character whatsoever, either man-contrived or nature volitionated, and they will not arrange themselves into designs other than designs predetermined by violations of nature, and undeterminable by the will of the chemist'.[112]

The fact that chemical compounds were 'determined, not by the will of man (the chemist), but by the violation of nature' meant that they could not 'evolve out of the inner consciousness of the chemist'.[113] The invariant nature of chemical compounds also meant that '[n]o chemist can exercise even the most limited choice in determining the actual structure of any novel true chemical compound'.[114] Because chemical compounds were the 'handiwork of nature'[115] rather than the result of the work of a human agent, Ruby said it was 'fatuous' to speak of someone inventing a chemical compound.[116] The upshot of which was that chemical compounds were nothing more 'than an ensemble of unpatentable properties of matter, created and quantitatively embodied in tangible substances solely by nature'. As chemical compounds were 'inherently a principle of nature, or an ensemble of principles of nature' they were 'unpatentable subject matter'.[117] For Ruby, to accept chemists as inventors was to give them an attribute of the Deity.[118]

Overall, the response to Ruby's argument that chemical compounds did not qualify for patent protection because they were not inventions was muted.[119] To the

[112] Ibid.

[113] Ibid., 326.

[114] Ibid., 333.

[115] Ibid., 327.

[116] Ibid.

[117] Charles E. Ruby, 'Are True Chemical Compounds, as Such, Inherently Unpatentable Subject Matter: Part I' (1940) *Temple University Law Quarterly* 27, 39. In *Schering Corporation* v. *Gilbert* 153 F.2d 428, 432 (1946) the appellants argued that a claim for a synthetic chemical compound was invalid because 'it was a claim for a product which was nothing but a molecule that has resulted from inevitable chemical reactions governed by the laws of nature'. This meant that the molecule was the 'inevitable result of the action of the so-called laws of nature which are immutable by man and remain free for the use of all unrestricted by patent law'. The argument was dismissed: 'the opportunities for changes in the atomic structure of the molecule within is chemically represented by the so-called benzene ring are theoretically to be numbered in the millions and are practically legion'. *Schering Corporation* v. *Gilbert* 153 F.2d 428, 432 (1946).

[118] Charles E. Ruby, 'Are True Chemical Compounds, as Such, Inherently Unpatentable Subject Matter: Part I' (1940) *Temple University Law Quarterly* 27, 58. Chemical compounds 'can be neither created or contrived by man by a fashioning and fitting together of parts actually designed and created or contrived by man, in the manner that man fashions and fits together the man-designed and man-created or man-contrived parts of a man-contrived machine; nor can they be fashioned by man as man fashions a man contrived true manufacture; nor are they subject to even such limited control by man as are those compositions of matter whose compositions are susceptible of variations in a continuous manner by man, with resulting corresponding variation of the intrinsic properties of such compositions of matter. ' Charles E. Ruby, 'Are True Chemical Compounds, as Such, Inherently Unpatentable Subject Matter: Part II' (1941) *Temple University Law Quarterly* 321, 322–23.

[119] In 1939 the Journal of Patent Office Society reprinted an article on product patents by the Washington based Patent Attorney, first published in April 1918 in the Journal of Industrial and Engineering Chemistry (at the time when there was talk of amending the patent laws to exclude patents for chemical products).

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extent that his arguments were addressed, they were dismissed; they certainly did not get any traction with patent examiners, judges, or policy makers.[120] While Ruby's arguments against product patent protection for chemical compounds were unsuccessful, nonetheless they were still important in so far as they highlighted an important question: namely, how was it that chemical compounds with all their specific and unique qualities were able to be perceived as inventions?

Unlike the case with plants and software-related inventions where there was considerable debate about the status of the new subject matter when they were first presented to the law for consideration, the standing of chemical compounds as inventions was largely ignored. Instead, commentators were able to rely on the inertia that arose from the fact that chemical compounds had been part of the patent system since its outset and that 'new compounds and results of chemical reactions had been continuously patented'[121] to simply assert that chemists were inventors.[122] In line with this, and in contrast to Ruby who saw the development of chemical compounds as discoveries that were inherently non-patentable, there was also a willingness to accept 'discoveries' as patentable subject matter.[123] This is reflected in the comment in *Badische Anilin and Soda Fabrik* v. *Kalle* that in chemistry, where 'prevision was not certain' and 'progress … was reached largely through experiment', patents were 'often upheld where the inventor stumbles upon a discovery'.[124] And, as a principal examiner at the Patent Office wrote in 1916, while it was generally the practice to speak of patent laws as having been designed to protect inventions, the Constitution refers to discoveries. 'If there be a discovery, there need be no inquiry as to how it was made or how much ingenuity was needed to embody the discovery' … 'quite a considerable portion of the work in the chemical divisions of [the US Patent] Office relates to discoveries rather than inventions'.[125]

[120] Federico said that Ruby's 'argument that all new compounds exist implicitly or potentially in nature, and hence cannot be "invented", but only discovered, has been presented in an endeavour to make the prohibition appear more logical'. P. J. Federico, 'Patents for New Chemical Compounds' (1939) 21 *Journal of the Patent Office Society* 544, 546.

[121] P. J. Federico, 'Patents for New Chemical Compounds' (1939) 21 *Journal of the Patent Office Society* 544, 547.

[122] '[A]lmost every research chemist is an inventor in the legal sense, in that he is making patentable improvements'. Harold E. Potts, *Patents and Chemical Research* (Liverpool: University Press of Liverpool, 1921), 141. George S. Ely, *Chemical Inventions and Discoveries: A Paper Read November 23, 1916 before the Examining Corps of the United States Patent Office* (Washington, DC: The Law Reporter Printing Company, 1916), 2. P. J. Federico, 'Patents for New Chemical Compounds' (1939) 21 *Journal of the Patent Office Society* 544, 546. Anon, 'The Mortality of Chemical Patents in Court' (1946) 34 *The Georgetown Law Journal* 504, 508.

[123] A 'chemical invention is what the patent statute refers to as a patentable discovery as distinguished from inventions which are mechanical in nature'. Edward Thomas, 'An Outline of the Law of Chemical Patents' (1927) 19 *Industrial and Engineering Chemistry* 176, 177.

[124] *Badische Analin & Soda Fabric* v. *Kalle & Co*. 104 F. 802, 803 (2d Cir. 1900) 94 Fed 163 (CCSD NY 1899). *Dow Chemical Company* v. *Coe* 545 OG 905, 55 USPQ 166 (1942).

[125] George S. Ely, *Chemical Inventions and Discoveries: A Paper Read November 23, 1916 before the Examining Corps of the United States Patent Office* (Washington, DC: The Law Reporter Printing Company, 1916), 2.

Another tactic that was used to enable chemical compounds to be treated as inventions was to shift the focus of attention away from the role that chemists played in the development of compounds, as Ruby had done, to focus on chemical compounds as ends in their own right.[126] The focus on the objects of chemistry echoes Bachelard's idea of chemistry as a science where the 'human mind deals no longer with nature but with its own creations … chemistry is a science dealing with artifacts, a science of the "factitious"'.[127] This was the approach used by the Professor of Physical Chemistry at the Pennsylvania State College, J. H. Simons, to challenge Ruby's argument that chemical compounds were not human creations but 'entirely acts of nature', saying that in this regard Ruby was 'entirely incorrect'. In a letter written to *Science*, Simons argued that although many chemical compounds were naturally occurring, 'the synthetic methods of chemistry enable many very useful pure substances to be produced that are not found in nature. The conception and eventual construction of new and useful chemical compounds are accomplished only and entirely through the application of human mental and physical activity. This most certainly constitutes invention'.[128] While Ruby had focused on the relationship between inventors and their outputs (requiring the invention to emanate from the inventor and the inventor to exercise control over the shape, function, or form of the resulting invention), Simons sidestepped the question of the role chemists played in creating a compound to focus on the novelty of the compound. Justice Joseph McKenna was even more explicit in the Supreme Court's *Diamond Rubber* decision when he said that a 'patentee may be baldly empirical seeing nothing beyond his experiments and his results; yet if he added a new and valuable article to the world's utility he is entitled to the rank and protection of an inventor'.[129] And, as Judge Coxe explained in *Badische Anilin and Soda Fabrik* v. *Kalle*, to be patentable a discovery had 'to have the attributes of an invention, but the mental operation is somewhat different in one who invents a machine and one who discovers a process' … 'He may not understand the law upon which the process operates and may be unable to explain the cause of certain phenomena, nonetheless if he is the first to give the world as a result his method a new and valuable article of manufacture he is entitled to protection'.[130] That is, it

[126] *Bender* v. *Hoffman* 85 OG 1737 (the focus was not on the action of the agent/inventor, but on the invention and whether it was new & technical). George S. Ely, *Chemical Inventions and Discoveries: A Paper Read November 23, 1916 before the Examining Corps of the United States Patent Office* (Washington, DC: The Law Reporter Printing Company, 1916), 9.

[127] Bernadette Bensaude-Vincent, 'Chemistry in the French Tradition of Philosophy of Science: Duhem, Meyerson, Metzger and Bachelard' (2005) 36 *Studies in History and Philosophy of Science* 627, 642. While experimental sciences like chemistry create its objects in the laboratory, observational sciences like natural history or astronomy simply observe their objects in nature.

[128] J. H. Simons, 'Patents for Chemical Compounds' (9 June 1939) *Science* 535.

[129] *Diamond Rubber Company* v. *Cons. Rubber Company* 220 U.S. 428 (1911).

[130] *Badische Anilin and Soda Fabrik* v. *Kalle* 104 F. 802 (2d Cir. 1900) 94 Fed 163, 173–74 (CCSD NY 1899).

did not matter that the chemical compound did not emanate from the 'inner consciousness of the chemist' so long as the resulting compound was new.[131]

The focus on chemical subject matter as an end in its own right, rather than on the labour that the chemist had expended in creating the compound, was evident in the way subject matter was evaluated when deciding whether it fell within one of the four types of subject matter recognised under US patent law, namely, compositions of matter, processes (or methods), machines, and articles of manufacture.[132] While chemical subject matter was sometimes categorised as articles of manufacture,[133] for the most part patentees presented their chemical compounds as 'compositions of matter'.

In patent law, a composition of matter arises when two or more substances are combined to form a new composite article, whether by way of chemical union (such as baking powder or Goodyear's vulcanised rubber) or mechanical mixture (such as alloys or Nobel's dynamite). In the case of chemical compounds, the ingredients were an essential part of the formation of the composition of matter. This was because the integrity of a chemical compound depended 'upon the preservation of the precise union and co-operation of those elemental forces which are furnished to it by its essential ingredients'. While the fickle nature of chemical substances meant that exact ingredients were essential to the formation of compositions, once a composition was formed, the role of the ingredients changed. The reason for this was that a chemical composition was something in which the ingredients necessarily 'lose their identity and individuality when combined as to be no longer capable of being distinguished in the combination'.[134] Unlike a machine or a manufacture, where the parts were usually identifiable after they had been combined together (they were discernible in their 'independent as well as in its combined condition'),[135] when ingredients were intermingled in a chemical composition, the individuality of the constituent elements were 'removed from human observation'.[136]

Importantly, in coming together in a chemical union the ingredients of a chemical compound formed a new thing. In this sense the whole was greater than and different to the parts: a 'whole that yielded 'effects beyond the sum of the effects producible by all the elements in their separated state'.[137] For example, nitroglycerine was said to be a patentable composition of matter because when the original ingredients were mixed together they 'reacted so as to form an entirely new compound

[131] *Bender* v. *Hoffman* 85 OG 1737 (1899).
[132] The categories of patentable subject matter, *viz.*, 'art, machine, manufacture, or composition of matter' etc. (which persisted unchanged since 1793 in the statutory patent law of the United States through the Patent Act of 1836, the Patent Act of 1870, and the Revised Statues of 1875).
[133] A. M. Lewers, 'Composition of Matter' (1921–22) *The Journal of the Patent Office* 530, 531.
[134] Ibid., 532.
[135] William C. Robinson, *The Law of Patents for Useful Inventions: Vol 1* (Boston: Little Brown and Co, 1890), 278.
[136] Ibid., 410.
[137] Ibid., 225.

having distinct properties of its own'.[138] In line with this, a chemical composition was treated as a discrete and separate entity or in Robinson's words as 'a unit' with 'new properties of its own'.[139]

To qualify as a composition of matter, it was necessary to show that the ingredients combined together to form a new composite article. Importantly this was done by focusing on the end-product and its relationship to its composite parts: there was no consideration given to the role that the chemist played in the formation or creation of the chemical compound. As Lewers said, the 'fact that in chemical compounds the component elements will combine only according to certain definite laws as to proportion, which is not true of non-chemical compositions, is no good reason for excluding them'.[140] They are 'certainly not simple substances and they meet the definition and tests of a composition as laid down by [treatise writers] and the courts'.[141] A similar approach was evident in *Schering Corporation* v. *Gilbert* where in response to the argument that since new molecules were the result of laws of nature, immutable by man, they should be free for the use of all unrestricted by patent, the court 'refused to be led astray by the law of nature argument'. Instead it reverted to the long-standing definition of composition of matter (as the mixture of two or more ingredients that develop different or additional properties or properties that the several ingredients individually do not possess in common) to find the invention patentable.[142]

Another reason why chemical compounds were able to be accommodated as inventions within patent law related to the way that the labour of the organic chemist was viewed. This is evident in the writings on chemical patents by the influential nineteenth-century treatise writer, William Robinson. For Robinson, inventions were 'a class of agencies employed by man for the production of physical effects'.[143] Like Ruby, Robinson believed that every 'invention has its origin in man. It is his addition to the agencies already existing in nature, and owes to him its generation, its birth, and its application to the purposes for which it was designed'.[144] While Robinson and Ruby both believed that invention was the product of the agency of the human inventor, they differed in terms of how that agency (and thus invention)

[138] Joseph Rossman, 'What the Chemist Should Know about Patents' (1932) 9(3) *Journal of Chemical Education* 486, 490.

[139] William C. Robinson, *The Law of Patents for Useful Inventions: Vol 1* (Boston: Little Brown and Co, 1890), 278. Harwood Huntington, *Some Notes on Chemical Jurisprudence: A Digest of Patent-Law Cases Involving Chemistry* (New York: Blanchard Press, 1898), 16.

[140] A. M. Lewers, 'Composition of Matter' (1921–22) *The Journal of Patent Office* 530, 531.

[141] Ibid.

[142] A 'precise claim for a new and useful compound which has been adequately described in the specification is no less valid because the compound happens to be a new molecule'. *Schering Corporation* v. *Gilbert* 1 53 F.2d 428, 68 USPQ 84, 88 (CCA 2d, 1946).

[143] William C. Robinson, *The Law of Patents for Useful Inventions: Vol 1* (Boston: Little Brown and Co, 1890), 115.

[144] Ibid.

was viewed.[145] In particular, while Ruby had a fixed view of agency that was modelled on mechanical invention (an approach Robinson called 'crude notions of physical agencies'), in contrast Robinson, who was writing some 40 or so years before Ruby, argued that the idea of agency and with it the invention had to change to accommodate new types of scientific and technical innovation.[146]

For Robinson, a chemical compound was 'a force applied' that depended on 'the union and co-operation of certain other forces which are manifested through the properties of the individual ingredients'.[147] While Ruby's belief in the invariant nature of chemical compounds meant that there was no room for chemists to exercise any creativity in the development of new compounds, Robinson argued that the work of the chemist could be creative. As he said, the 'inventive act by which the composition is created … consists in the discovery of the ability of these elemental forces to unite in the production of the new force, and the contrivance of such a method of commingling them as will develop the new forced desired'.[148] For Robinson, the 'invention lay in' … 'the creative act of bringing components together' to unleash 'some new or as yet unawakened energy'.[149] That is, Robinson was willing to accept that the chemists' art consisted of 'managing populations of molecules in order to bring about the desired reactions'.[150] At the same time, Robinson was also willing to accept that the chemist's art also consisted in being able to identify when a valuable new compound had been created. As he said: 'the patient labours of a lifetime, the unpremeditated flash of an original thought upon the mind, the revelation made to *an appreciative intellect* by some trivial accident all stand upon equal footing both in character and merit and are entitled to the same reward'.[151]

Much like the French chemist Antoine Lavoiser who saw elements as 'actors in chemical operations' that were 'defined by how they act and react in a network

145 'In asserting that chemical compounds cannot be inventions, Dr. Ruby proposes to narrow a meaning of the word "invention"'. P. J. Federico, 'Patents for New Chemical Compounds' (1939) 21 *Journal of the Patent Office Society* 544, 549, n 10. McElroy was critical of Ruby arguing that 'invention' was a non-nuclear noun: which had no nucleus of definite meaning accepted by everybody … it was 'a mere verbal peg on which patent people hang correlations of fact'; 'it was something on which to join issues and kick about'. K. P. McElroy, 'Invention' (1931) 13 *Journal of the Patent Office Society* 565. See also K. P. McElroy, 'Elements in Patent Law' (1929) *Industrial and Engineering Chemistry* 608.

146 In dealing with new subject matter, patent law was forced 'to penetrate more and more deeply into the mysteries of nature' and the 'essential characteristics of inventions'. William C. Robinson, *The Law of Patents for Useful Inventions: Vol 1* (Boston: Little Brown and Co, 1890), 115.

147 This is similar to Bachelard who said that in 'modern chemistry, synthesis is the very process of invention, a process of rational creativity in which the rational plan for making an unknown substance is posed from the beginning as the problem that leads to the project. We can say that synthesis represents a process of penetration for modern chemistry, progressively penetrating in the course of realizing the project'. G. Bachelard, (1953) quoted in Bernadette Bensaude-Vincent, 'Gaston Bachelard (1884–1962)' in (ed) D. M. Gabbay et al., *Philosophy of Chemistry* (United States: Elsevier, 2011), 141, 147.

148 William C. Robinson, *The Law of Patents for Useful Inventions: Vol 1* (Boston: Little Brown and Co, 1890), 412.

149 Ibid., 228.

150 Ibid.

151 Ibid., 127.

of relations with other chemical actors',[152] Robinson saw the process of inventing a chemical compound as a collaborative or joint effort between the chemist and nature (not unlike Roald Hoffmann's view of chemical synthesis as being like a game of chess played between the chemist and nature). The joint invention of chemical compounds (which Ruby recognised if only to ridicule)[153] occurred either when an inventor 'sets into operation certain forces acting on certain materials and so conditions the force in action that their resultant produces a new product in consequence of intra-molecular changes, he has made a patentable invention',[154] or when the inventor recognised those new products. By configuring invention as a process whereby the chemist could work alongside nature in the generation of chemical compounds, Robinson was able to justify the recognition of empirically based chemical compounds as patentable inventions.

Patent law's willingness to configure the invention so that it was able to accommodate the empirical nature of chemical subject matter revealed itself in a number of ways, the most notable being when determining when an invention came into existence. The need to determine when an invention was first created arose because US patent law (then) operated on the basis of a first-to-invent system of registration, which meant that it was often necessary to determine the priority of inventions among competing 'inventors'. In determining when an invention was first created, patent law traditionally distinguished between the initial conception of an invention and the subsequent reduction of that conception to practice, which was the point in time when, at least for mechanical inventions, the invention was considered to have come into existence.[155]

In discussing 'conception' and 'reduction to practice', Robinson noted that while in many cases the act of conception was clearly distinct in point of time from that of

[152] See B. Bensaude-Vincent and J. Simon, *Chemistry: The Impure Science* (London: Imperial College Press, 2008), 203. For Gaston Bachelard 'artificial products, including natural substances in a chemically purified form, are social productions in the evident sense of implicating the structured co-operation of humans in their elaboration'. Cited in Bernadette Bensaude-Vincent and Jonathan Simon, *Chemistry: The Impure Science* (2nd edn, London: Imperial College Press, 2012), 50.

[153] If 'man' could be 'a co-inventor with nature, of novel true chemical compounds, (certainly a most generous concession), then patents granted solely to, and in the name of, man, a "joint-inventor" with nature, would be void'. Charles E. Ruby, 'Are True Chemical Compounds, as Such, Inherently Unpatentable Subject Matter: Part II' (1941) *Temple University Law Quarterly* 321, 349. Ruby also spoke of nature as sole inventor: 'if chemical compounds are solely the handiwork of nature, and are not in the slightest measures, the products of man's inventive ability, then, by inexorable logic, we arrive at the faintly amusing conclusion that nature, or whatever entity directs the scheme of things is the sole inventor of each and every true chemical compound'. Charles E. Ruby, 'Are True Chemical Compounds, as Such, Inherently Unpatentable Subject Matter: Part II' (1941) *Temple University Law Quarterly* 321, 349.

[154] George S. Ely, *Chemical Inventions and Discoveries: A Paper Read November 23, 1916 before the Examining Corps of the United States Patent Office* (Washington, DC: The Law Reporter Printing Company, 1916), 18.

[155] Robinson saw the inventive act as a continuous process which 'begins with the conception of the idea of means; it ends with the embodiment of that idea in a practically operative art or instrument'. That is, 'conception of the idea was sometimes instantaneous, sometimes gradual; the reduction to practice being in one case easy and rapid, in another slow and difficult'. William C. Robinson, *The Law of Patents for Useful Inventions: Vol 2* (Boston: Little Brown and Co, 1890), 537–38.

reduction, in some cases it was not possible to separate conception from reduction to practice. In these cases no date could be fixed 'as that before the conception was complete and after which the reduction to practice was begun'. For Robinson, this often occurred with inventions that were the result of experiment, 'where the inventor, instead of evolving the entire art or instrument out of his own thought, conjectures that such an act of substance will subserve a given purpose, and having tried it, finds that it accomplishes the end'. While Ruby had dismissed this as non-inventive, Robinson said that the 'production of a new means by this method is, equally with the former, an inventive act, but at no instant before the experiment succeeds can it be said that the conception of the invention exists in the inventor's mind. Until that instant it is mere speculation, at most a probable deduction from facts already known; and the same act which reduces it to practice gives to the conception its definite and final form'. Hence the date of the conception 'in such cases is the date, not when the experiments begin, but when they end; and the first to bring the art or instrument into successful operation is the first conceiver of the entire invention'.[156]

Robinson's proposal that to accommodate empirical-based chemical compounds, invention had to be reconfigured was taken up by the Court of Custom Patent Appeals in the 1940 decision of *Smith v Bousquet*,[157] a dispute about the priority of an invention for the use of a chemical compound as an insecticide. Drawing on Robinson, the court said that in the 'experimental science of chemistry and biology' the 'element of unpredictability frequently prevents a conception separated from actual experiment and test. Here the work of conception and reduction to practice goes forward in such a way that no date can be fixed as subsequent to conception but prior to reduction to practice'.[158] This meant that the fact that someone had formed a hypothesis that a group of chemical compounds might exhibit insecticidal activity did not matter. This was because conception did not occur until the inventor successfully completed experiments showing the feasibility of the idea and, as a result, conception and reduction to practice were inseparable. In other words, it was not possible for a chemist to predict the effectiveness of the compounds unless they actually performed experiments. Prior to this, the idea remained 'mere speculation or possibly a probable deduction from facts already known' but not conceived for the purposes of patent law.[159]

[156] Ibid. Where an invention is reached by a series of experiments, the one who first succeeds, not the one who first begins, is the first inventor. *Taylor* v. *Archer* (1871) 8 Blatch 324, 4 Fisher 456; *National Filtering Co* v. *Artic Oil Co* (1871) 8 Blatch 416, Fisher 514.

[157] *Smith* v. *Bousquet* 111 F.2d 157 (CCPA 1940), 45 USPQ 347. Given that chemical inventions had long been patented, this reconfiguration was in response to the rise of the mechanistic model of invention that had taken hold by this time.

[158] Ibid. See also *Dunn* v. *Ragin* v. *Carlile* Final Hearing in the US Patent Office; Patent Interference No. 77,764 (6 December 1940).

[159] *Smith* v. *Bousquet* 111 F.2d 157, 159 (CCPA 1940). The need for different standards reflects 'the fundamental differences between invention in engineering-related disciplines and the empirical sciences, such as pharmaceuticals and biotechnology'; Jackie Hutter, 'A Definite and Permanent Idea? Invention in the Pharmaceutical and Chemical Sciences and the Determination of Conception in Patent Law' (1995) 28 *The John Marshall Law Review* 687, 688.

Despite Ruby's best efforts, his attempts to undermine chemical patents on the basis that they were not inventions failed. With little or no fanfare, patent law was able to configure the invention in such a way that it was able to accommodate the empirical nature of chemical subject matter. In so doing, the law was able to accommodate an important feature of chemical subject matter. In Chapter 3, I look at the way patent law dealt with a fickle, empirical, and rapidly changing subject matter.

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