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Inventors, Patents, and Inventive Activities in the English Brewing Industry, 1634–1850

This article examines the relationship between patents, appropriability strategies, and market for technology in the English brewing industry before 1850. Previous research has pointed to the apparent paradox that large-scale brewing in this period showed both a self-aware culture of rapid technological innovation and a remarkably low propensity to patent. Our study records how brewery innovators pursued a wide variety of highly distinct appropriability strategies, including secrecy, selective revealing, open innovation and knowledge-sharing for reputational reasons, and patenting. All these strategies could co-exist, although some brewery insiders maintained a suspicion of the promoters of patent technologies, which faded only in the nineteenth century. Furthermore, we find evidence that sophisticated strategies of selective revealing could support trade in inventions even without the use of the patent system.

In traditional narratives of the Industrial Revolution, the brewing industry occupies a marginal role; yet large-scale commercial brewing in England underwent rapid technical change across the eighteenth and into the early nineteenth century. To some extent, this marginalization is a simple consequence of the industry's expansion taking place at a leisurely pace: from 1700 to 1830, the average growth of real output was about 0.5 percent per year, far lower than in the most celebrated "leading sectors" such as cotton or iron.[1] These figures, however, conceal a remarkable concentration of production that Peter Mathias, in his monumental 1959 study of English brewing in this period, highlighted as revolutionary.[2] The technical element of this revolution, Mathias wrote, consisted of two interlinked trends: the adoption of mechanized

[1] Peter Mathias, *The Brewing Industry in England, 1700–1830* (Cambridge, UK, 1959), 542–43.
[2] Ibid., 12–21.

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equipment for large-scale production and process monitoring using quantitative instruments such as the thermometer and saccharometer.

This vigorous inventive culture, however, did not lead to growth in the use of patents to protect inventions. Indeed, Christine MacLeod, in her authoritative 1988 study of the English patent system during the eighteenth century, considers brewing as the archetype of a sector in which inventive activities went on outside the patent system. Certainly, some brewing-related patents were filed, yet they were remarkably infrequent given the concentration of the market and the technical nature of the process.[3] Before the institution of the Patent Office in 1852, securing a patent involved time-consuming bureaucratic procedures and large fees (approximately £100 for England and Wales), and the outcomes of litigation were notoriously unpredictable. Therefore, some economic historians have suggested, patenting activity was skewed towards capital-intensive inventions resulting in large pieces of equipment, for which royalties were easier to collect, cases of infringement were more likely to be detected, and evidence could more easily be presented in court.[4] Since the largest and most highly mechanized breweries displayed not only conscious technological prowess, but also a very high degree of capital intensity—being, in fact, among the largest manufacturing concerns of any description—the unpopularity of patents may appear altogether perplexing.

Part of our aim in this article is to scrutinize this apparent anomaly in the light of recent broader interpretations of the functioning of patent systems. Some scholars have noted that the establishment of relatively secure, formalized property rights on innovations, such as those provided by a patent regime, represents a foundational prerequisite for the rise and consolidation of "markets for technologies."[5] The advantage of a reliably functioning market for technology, the argument runs, is that it enhances the efficient use of technological knowledge throughout the economy. In particular, it encourages the emergence of a fruitful division of innovative labor in the market between, on the one hand, firms and individual inventors specialized in inventive activities, and, on the other, firms and entrepreneurs with advanced capabilities in the development and commercialization of innovations.

[3] Christine MacLeod, *Inventing the Industrial Revolution: The English Patent System, 1660–1800* (Cambridge, UK, 1988), 108–9.

[4] Ibid, 147–49; B. Zorina Khan and Kenneth Sokoloff, "Patent Institutions, Industrial Organization, and Early Technological Change: Britain and the United States, 1790–1850," in *Technological Revolutions in Europe: Historical Perspectives*, ed. Maxine Berg and Kristine Bruland (Cheltenham, 1998), 292–313.

[5] Ashish Arora, Andrea Fosfuri, and Alfonso Gambardella, *Markets for Technology: The Economics of Innovation and Corporate Strategy* (Cambridge, MA, 2001).

From this perspective, then, the advantage of the patent system lies not only in the direct incentive to individual inventors to invest in inventive activities, but in the emergence of a general commercial and social context that makes invention and innovation more convenient. The findings of Sokoloff and Lamoreaux (1999) on the culture of late nineteenth-century US inventors have stimulated these considerations. They suggest that the American patent system, with its comparatively low fees, limited bureaucracy, and efficient administration through the courts, allowed "creative but ambitious inventors to focus on what they did best," leading to "the most technologically fertile period in American history."[6] Comparative work by Khan and Sokoloff (1998) presents the English system as much less effective in this regard.[7] The earlier investigations of Harold Dutton (1984), however, show that even the pre-1852 regime in England hosted an identifiable class of "quasi-professional inventors": individuals who specialized in inventive activities broadly considered, taking multiple patents relating to different industries.[8] Dutton's survey also documents a significant number of cases in which patent rights were traded by means of licenses or assignments.[9] It appears, then, that even the unreformed English system, frustrating as it often was to inventors and investors, functioned well enough to sustain emerging markets in invention. More recent contributions in the economics of innovation literature have pointed out that inventors may be able to exploit their inventions commercially in situations of very weak patents or even in the absence of patent rights.[10]

[6] Naomi Lamoreaux and Kenneth Sokoloff, "Inventors, Firms, and the Market for Technology in the Late Nineteenth and Early Twentieth Centuries," in *Learning by Doing in Markets, Firms and Countries*, ed. Naomi Lamoreaux, Daniel M. G. Raff, and Peter Temin (Chicago, 1999); Naomi Lamoreaux and Kenneth Sokoloff, "Market Trade in Patents and the Rise of a Class of Specialized Inventors in the Nineteenth-Century United States," *American Economic Review* 91 (2001): 39–44; Naomi Lamoreaux and Kenneth Sokoloff, "Intermediaries in the US Market for Technology, 1870–1920," NBER Working Paper no. 9017 (2002), quotation on 5; and see also B. Zorina Khan, *The Democratization of Invention: Patents and Copyrights in American Economic Development, 1790–1920* (Cambridge, UK, 2005); Arora, Fosfuri and Gambardella, *Markets for Technology*, discuss the contributions of Lamoreaux and Sokoloff on pp. 23–27.

[7] Khan and Sokoloff, "Patent Institutions," 309–13; Khan, *Democratization*, 37–39.

[8] Harold Dutton, *The Patent System and Inventive Activity during the Industrial Revolution, 1750–1852* (Manchester, 1984), 112–17.

[9] Dutton, *Patent System*, 122–42. See also Sean Bottomley, "The British Patent System during the Industrial Revolution, 1700–1852," PhD diss., University of Cambridge, 2012, 101–54.

[10] For a general discussion of "appropriability strategies" for innovations in different business contexts, including weak intellectual property rights, see David Teece, "Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing, and Public Policy," *Research Policy* 15 (1986): 285–305; James Anton and Dennis Yao, "Expropriation and Inventions: Appropriable Rents in the Absence of Property Rights," *American Economic Review* 84 (1994): 190–209, provides a theoretical discussion of effective appropriability strategies in the absence of intellectual property rights. The historical relevance of "appropriability

In what follows, we present a fresh look at the connection between patenting and inventive activities in the English brewing industry, focusing on the extent to which appropriability strategies not based on patents could be effective both for protecting innovations and for trading them in "markets for technologies." We begin with a quantitative survey of brewery-related patents in the period in question. This serves to confirm the low incidence that prior authors have noted, but it also highlights the complexities of assigning particular inventions to particular industries. Next, we survey the various alternative appropriability strategies used in brewing, before discussing how early patents were promoted, chiefly by outsiders; and how, ultimately, such patents began to be accepted in the trade.

Patents in the Brewing Industry, 1634–1850

Two principal sources, if carefully interpreted, offer a convenient means to identify patents relevant to the brewing industry. The first derives from the Patent Office itself. In 1854, the Superintendent of Specifications, Bennet Woodcroft, oversaw the publication of a *Subject-Matter Index* that attempted to categorize all identifiable patents according to the trades or industries to which they referred. The category for "Brewing, distilling, rectifying and preparatory processes" is further divided into subcategories including malt preparation, mashing and wort management, clarification of drink, and the more wide-ranging "Brewing and fermenting: malt liquors."[11] Woodcroft's index gives only the titles of patents, but in the 1860s the Patent Office began a long-running project to publish abridgements of specifications, again classified by industry.[12] Class 99 in this series, covering "brewing, wine-making, and distilling alcoholic liquids" in the period 1634 to 1866, appeared in 1881 under the supervision of Woodcroft's successor, Henry Reader Lack.[13]

The second major source is the practitioners' literature on brewing,

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strategies" alternative to patents during the British Industrial Revolution has also been discussed by David Landes, "What Do Bosses Really Do?" *Journal of Economic History* 46 (1986): 585–623. In particular, Landes points to "first mover advantage" as a particularly effective strategy in that historical context. For a discussion of the "first mover advantage" literature, see Fernando Suarez and Gianvito Lanzolla, "The Role of Environmental Dynamics in Building a First Mover Advantage Theory," *Academy of Management Review* 32 (2007): 377–92.

[11] Bennet Woodcroft, *Subject-Matter Index of Patents of Invention*, vol. 1 (London, 1854), 85–97.

[12] John Hewish, *Rooms Near Chancery Lane: The Patent Office under the Commissioners, 1852–1883* (London, 2000), 41–44.

[13] H. Reader Lack, *Patents of Inventions: Abridgments of Specifications Related to Brewing, Wine-making, and Distilling Alcoholic Liquids* (London, 1881).

which by the 1860s was becoming increasingly systematic and technically oriented. The monthly *Brewers' Journal*, launched in 1865, featured a regular "Brewer's Engineer" column with descriptions and engravings of recent inventions, patented and otherwise; in 1869, the *Journal* serialized a listing of "every patent from 1635 to 1868" under classified headings, a project that was updated regularly in later years.[14] The *Journal* and its rival the *Brewers' Guardian* were aimed at, and largely written by, self-consciously "progressive" and "scientific" brewers, to whom it was important to affirm a technical history for the trade. This agenda culminated in the work of Henry Stopes (1852–1902), who in the 1880s established himself both as a specialist brewers' engineer and as an analyst of the malting and brewing trades, contributing historical surveys to the *Journal* and other periodicals.[15] In 1885, alongside an epic bibliography of malting and brewing literature, Stopes published a consolidated "List of Patents" since 1634 that he deemed relevant to the industry.[16] Of the 176 patents listed by Stopes in the period up to 1850, 174 also appear in the 1881 Patent Office volume.[17]

Careful analysis of the Woodcroft, Lack, and Stopes lists, however, shows that the definition of a "brewing patent" is complicated on several levels. To begin with, a clear distinction between brewing and distilling inventions is frustrated by the fact that several operations are common to both. These include the heating of water in bulk, the crushing or grinding of malt, and the "mashing" (infusion in hot water, usually with mechanized stirring) that the malt undergoes to produce fermentable wort. In some cases, such as the mashing machine patented in 1793 by Edward Biley (himself a brewer), external evidence shows that the patentee was purely or primarily concerned with the beer-brewing market.[18] In other patents, such as one that James Tate, a London ironmonger, took out in 1794 for an "invention of applying fire to the coppers [boilers] of brewers and distillers," the reference to brewing may be entirely speculative.

A further problem arises because there was no consensus on whether inventions in malting should be considered a subset of those in brewing. Though some brewers, at all levels of production, had always made their own malt, the two processes were customarily distinguished both commercially and technically. Most malt was prepared by non-brewing maltsters who were either pure specialists or involved in various agricultural

[14] *Brewers' Journal* 5 (1869): 33–34, and subsequent issues.

[15] Lynn Pearson, *British Breweries: An Architectural History* (London, 1999), 192–94, and see for instance *Brewers' Journal* 16 (1880): 375–76.

[16] Henry Stopes, *Malt and Malting* (London, 1885), 568–607.

[17] In the list constructed by Lack, patent 10973 is mistakenly reported as patent 10963.

[18] Mathias, *Brewing Industry*, 94–95.

enterprises and who might also supply distillers.[19] It was quite possible, however, for a technological change in malting to have its chief practical effect in the brewery. The process for making highly roasted black malt, which the chemist Daniel Wheeler tried (ultimately unsuccessfully) to protect by patent in 1817, eventually became a highly restricted niche activity with no relevance to most maltsters' practice. To the major porter-brewers who adopted it, however, it was central to a drive for cheaper materials and greater consistency, which fundamentally altered the character of the drink.[20] Moreover, to the self-consciously "scientific" brewers of the nineteenth century, the single most important goal was a full understanding of the nature of malt and its possible substitution. They therefore championed greater vertical integration or at least the close involvement of the brewer in technical decisions. Correspondingly, the trade press declared its intended readership to include not only the brewers but also the "allied trades," the *Journal* adopting the full title of *The Brewers' Journal, and Hop and Malt Trades Review* in 1867. Accordingly, when Henry Stopes published his aforementioned patent list in a volume entitled *Malt and Malting*, devoted mainly to the construction and management of malthouses, he assumed that many of his readers would be brewers. Stopes made no attempt to disentangle the two trades in his bibliography, and his patent list, unlike those of the Patent Office, is uncategorized. From his perspective, all the listed patents evidenced the growth of a common technical culture.[21]

It is also important to understand that in assigning patents to industries, the Patent Office clerks worked without deep knowledge of the industries concerned and erred persistently on the side of inclusion, entering individual patents under as many categories as possible. The 1854 *Subject-Matter Index* was prepared "from Titles only" (i.e., without examination of the full specifications); any mention of malt, brewing, or distillation was sufficient to ensure inclusion. The brief descriptions, furthermore, were worded so as to favor relevance to the category, so that the patentees' intentions often appear more specialized than was really the case. Andrew Meikle and Robert Mackell's 1768 patent, for instance, is noted under "Brewing" as describing a "Machine for dressing

[19] Ibid., 466–70. An early case of vertical integration at the highest level of production is that of the Calvert family, for whom see James Sumner, "Status, Scale, and Secret Ingredients: The Retrospective Invention of London Porter," *History and Technology* 24 (2008): 289–306, on 291.

[20] William Ford, *An Historical Account of the Malt Trade and Laws* (London, 1849), 68–70; Mathias, *Brewing Industry*, 420–23. For Wheeler's difficulties see the report of *Wheeler v. Malins*, Court of Chancery, 1818, reported in the *Times*, 19 Aug. 1818; and *Rex v. Wheeler*, Court of King's Bench, 1819, reported in William Carpmael, *Law Reports of Patent Cases*, vol. 1 (London, 1843), 394–400.

[21] Stopes, *Malt and Malting*, 409.

and cleansing malt," but also addressed much more generally under "Agriculture" as a "Machine for dressing wheat, malt and other grain." Examination of the patentees' backgrounds reveals them as millwrights courting a primarily agricultural audience.[22] Milling and steam-boiler technologies, too, were incorporated on the basis of a passing mention of possible brewery or distillery application. This tendency extends to the abridgement volumes, where the most relevant sections of the specifications were abstracted for the industries in view. Even Stopes, whose professional context made him much more selective about the patents of his own time, had to rely on outline descriptions for pre-1800 patents and made some questionable inclusions as a result.[23]

It would not be useful, therefore, to draw conclusions from the listings of Lack and Stopes unmediated. In recording faithfully all patents with any suggestion of a malting or brewing context, however, the two sources provide a useful dataset from which to construct a more careful categorization. Our method has been to appraise each patent based on the full specification, where this is readily available, or, failing this, the Patent Office abridgements or summaries found in periodicals such as the *Repertory of Arts and Manufactures* and Newton's *London Journal of Arts and Sciences* (both of which reproduced many specifications in full), the *Retrospect of Philosophical, Mechanical, Chemical, and Agricultural Discoveries*, and the *Chemist*, or in published accounts of litigation. In a number of (mostly pre-1800) cases, specifications were not enrolled or cannot be traced; for these, we have performed as full as possible a cross-comparison of any descriptions available. We have also surveyed the principal secondary sources on British brewing and distilling in the period and have supplemented these with primary research undertaken by one of the authors in preparing a monograph-length study on the development of scientific concepts in the brewery.[24] In this way, we have been able to assign most of the patents listed in the Stopes and Lack selections to the following categories, chosen to minimize ambiguity.

[22] Woodcroft, *Subject-Matter Index*, vol. 1, 31, 85; John P. Shaw, "Meikle, Andrew (1719–1811)" *Oxford Dictionary of National Biography* (Oxford University Press, 2004), http://www.oxforddnb.com/view/article/18516, accessed 3 Feb. 2013.

[23] For instance, Stopes includes Walter Taylor's 1786 patent as describing a "Malt-mill." Woodcroft excludes the same patent from the brewing category, elsewhere deeming it to refer to "Machines for grinding grain" or "grinding starch for hair-powder."

[24] Mathias, *Brewing Industry*; Pearson, *British Breweries*; Terry Gourvish and Richard Wilson, *The British Brewing Industry, 1830–1980* (Cambridge, UK, 1994); H. S. Corran, *A History of Brewing* (Newton Abbott, 1975); Ian Donnachie, *A History of the Brewing Industry in Scotland* (Edinburgh, 1979); Christine Clark, *The British Malting Industry since 1830* (London, 1998); James Sumner, *Brewing Science, Technology, and Print, 1700–1880* (London, forthcoming 2013).

1. *Malting:* innovations in the malt-making process or the construction of malthouses (not including innovations in the crushing or grinding of malt, which was always carried out by the brewer or distiller).
2. *Brewing:* limited to those innovations that are by nature applicable only in beer-brewing (such as hop extraction or beer cleansing), those specified as intended particularly for beer-brewing, and those known to have been promoted only to beer-brewers.
3. *Distilling:* limited to those innovations applicable only in distilling (such as still-head constructions, condensers, and rectification techniques), those specified as intended particularly for distilling, and those known to have been promoted only to distillers.
4. *Brewing and distilling:* innovations applicable in both industries (such as mashers, boilers, and wort refrigerators) and explicitly specified or promoted as relevant to both.
5. *Milling, etc.:* innovations for the dressing, crushing, or grinding of grain, noted as applicable to malt (and thus potentially useful to brewers) but also to products used in other industries.
6. *Boilers, etc.:* boilers (including steam-boilers), furnaces, kilns, and heat transmission technologies, specified as relevant to brewing and/or distilling, but also to other industrial processes.

This categorization excludes a number of patents noted by Stopes or Lack that relate to wine- or cider-making, or that we found to describe general engineering or measurement technologies with no specific drinks-production context.

Since our main concern is with industry attitudes to the decision to patent, our selection criteria privilege the intentions of patentees, where these are known, and exclude the unintended consequences of patenting. We assign the 1780 patent covering the pattern of the Dicas hydrometer, for instance, to "distilling," despite evidence that the pattern was later used in the brewery, because the chief aim of the patent was to secure a legislative monopoly that only affected the distillery.[25] Conversely, we assign Matthew Wood's 1802 patent for a malt-based coloring agent to "brewing," despite its reference to "spirits, wines, and other liquors," since the patent was contrived specifically with an eye to the brewery market.[26]

On this basis, we have constructed two tables. Table 1 reports our assessment of the patents contained in Lack's and Stope's lists based on

[25] Mathias, *Brewing Industry*, 68–69; William Ashworth, *Customs and Excise* (Oxford, 2003), 275.

[26] Mathias, *Brewing Industry*, 420.

Table 1
Patents by Type of Invention in the Lists Constructed by Lack and Stopes (1634–1850)

Years	*1634–1700*	*1701–1750*	*1751–1800*	*1801–1850*	*Total*
Brewing	3	2	15	39	59
Brewing/distilling	1	0	6	23	30
Malting	7	7	5	20	39
Boilers, etc.	0	1	8	13	22
Milling, etc.	0	0	4	7	11
Distilling	3	6	9	88	106

Sources: H. Reader Lack, *Patents of Inventions: Abridgments of Specifications Related to Brewing, Wine-making, and Distilling Alcoholic Liquids* (London, 1881); Henry Stopes, *Malt and Malting: An Historical and Scientific and Practical Treatise, Showing as Clearly as Existing Knowledge Permits What Malt Is and How to Make It* (London, 1885).

the specifications and the descriptions contained in the contemporary literature. Table 2 reports the incidence of relevant patents in different periods, both in absolute numbers and as a proportion of total patenting. To the best of our knowledge, ours is the first attempt to reconstruct in detail the volume of brewing-related patents in this historical phase.

Overall, our results confirm MacLeod's finding that the industry

Table 2
Patents of Closest Identified Relevance to the Brewing Industry, by Share of Total (1634–1850)

Years	*1634–1700*	*1701–1750*	*1751–1800*	*1801–1850*	*Total*
Total patents	366	292	1,804	10,972	13,434
Combined "brewing" and "brewing/distilling" patents	4	2	21	62	89
Share of total (%)	1.1	0.7	1.2	0.6	0.7
Combined "malting," "brewing," and "brewing/distilling" patents	11	9	26	82	128
Share of total (%)	3.0	3.1	1.4	0.7	1

Sources: Henry Stopes, *Malt and Malting: An Historical and Scientific and Practical Treatise, Showing as Clearly as Existing Knowledge Permits What Malt Is and How to Make It* (London, 1885); H. Reader Lack, *Patents of Inventions: Abridgments of Specifications Related to Brewing, Wine-making, and Distilling Alcoholic Liquids* (London, 1881). Total patents from Bennet Woodcroft, *Titles of Patents of Invention Chronologically Arranged, 1617–1852* (London, 1854).

Table 3
Occupations of Brewing Patentees (1634–1850)

	Number	*%*
"Gentleman"	12	10.71
"Esquire"	4	3.57
Brewer	24	21.43
Chemist	8	7.14
Engineer/millwright	21	18.75
Merchant	9	8.04
Not specified	6	5.36
Other "outsiders"	28	25.00
Total	112	100

Source: Occupations have been retrieved from Bennet Woodcroft, *Titles of Patents of Invention Chronologically Arranged, 1617–1852* (London, 1854).

displayed an extremely low propensity to patent throughout the period 1634 to 1850. If we consider as genuine "brewing" patents the patents assigned to the first two rows of Table 1 (i.e., the categories "brewing" and "brewing/distilling"), we find that the share of brewing patents in total patenting is less than 1 percent (see also Table 2).

We also attempt to extend the analysis to consider the occupations of "brewing" and "brewing/distilling" patentees, drawing this information from the chronological index of English patents constructed by Woodcroft.[27] Table 3 reports the percentage shares of different occupations. As noted by MacLeod, the titles "gentlemen" and "esquire" may be regarded as an accurate description of social status only for the seventeenth and early eighteenth centuries: in later years, they were widely adopted as courtesy titles and may conceal specialist industrial backgrounds.[28] The main point of interest emerging from the table, however, is the significant share of patentees who were identifiably "outsiders" to the brewing trade. Even after excluding self-described chemists, engineers, millwrights, and merchants—groups that might have had some direct overlap with the brewery where their inventive activities were concerned—the remaining outsider occupations still account for almost 25 percent of all patents. This finding leads us to two conjectures: firstly, that "insider" invention developed principally in a manner invisible to the patent system; and secondly, that the brewing sector held a particular appeal for inventors with backgrounds in other

[27] Bennet Woodcroft, *Titles of Patents of Invention Chronologically Arranged, 1617–1852* (London, 1854). The 89 brewing patents we have identified in Tables 1 and 2 were taken by 112 patentees.

[28] MacLeod, *Inventing*, 117.

fields who hoped, by patenting, to benefit from some form of "trade in invention."

With these conjectures in mind, in the following sections we propose a preliminary taxonomy of the appropriability strategies, patent-based and otherwise, adopted by the inventors who targeted the industry. Our survey is based on the secondary sources mentioned above (note 24) and on primary investigations of published literature, brewing records, and correspondence held in archives. We distinguish five principal approaches. First, of course, there was the traditional recourse to secrecy. Second, there was also a traditional rhetoric of openness, invoked by those who professed to have no commercial interest in their achievements and by others who claimed that it was impossible, for various technical or economic reasons, to appropriate their work even given the fullest possible disclosure. Some inventors combined elements of these two approaches in a third, the use of selective revelation as a promotional tool. Fourth, there was patenting as applied by outsiders, who in practice often struggled to make headway against non-patenting competitors from inside the trade. Finally, however, and only towards the end of the period under discussion, there emerged a category of insiders who saw benefits in patenting themselves. The following sections consider each of these approaches in turn.

Secrecy

The most obvious alternative to patenting was silence. Traditionally, the principal techniques of beer-brewing had been considered universal common knowledge, as for baking or other domestic arts, but commentators from around 1700 began to refer to differences in the methods and products of the large well-capitalized brewhouses that served the concentrated markets of London and other major towns.[29] Technical knowledge of processes was typically protected by oral communication, direct demonstration, and guild affiliation. Some London apprenticeships around 1740 carried premiums of several hundred pounds: the Brewers' Company did not control the right to brew, but the fee bought training and a set of connections that were difficult to gain by any other means.[30]

The most notable technical change to emerge within this culture was the rise of the distinctive, well-hopped, and dark style of beer known as

[29] [Jeffrey Boys], *Directions for Brewing Malt Liquors* (London, 1700); [William Ellis], *The London and Country Brewer*, 1st ed. (London, [1735?]), 36–49.

[30] Richard Unger, *Beer in the Middle Ages and the Renaissance* (Philadelphia, 2004), 211; [Ellis], *London and Country Brewer*, 35; *A General Description of all Trades, Digested in Alphabetical Order* (London, 1747), 34–36.

London porter. Porter production combined efficient use of materials with greatly improved stability in storage, making it uniquely suited to large-scale production; the main points of the innovation were changes to the malt and hop profile and a greatly increased storage time, often by the use of newly developed storage vessels.[31] As the style spread from London to the urban centers of Britain and Ireland across the eighteenth century, porter-brewing gained a tantalizing reputation as a profitable "secret" known to few producers.[32] A popular story emerged that equated the "invention of porter" with a single discrete innovation, supposedly made by an unsung brewer of genius in 1722. This account in fact telescoped and projected backwards a century of gradual change in a culture that was not necessarily much concerned with the identification or reward of individual inventors.[33] Typical of the transmission mechanism is the case of Nathaniel Chivers, "bred to the porter brewing in London," who was paid a hundred guineas to bring his knowledge to Glasgow in 1775 under conditions (later breached) of local exclusivity.[34]

Indeed, there are several accounts by both insiders and outsiders to brewing that present secrecy as a defining element of its culture. These usually focus on the extreme lengths to which brewers would go to protect production details such as quantities of materials, times, and temperatures. Instrument-makers of the nineteenth century routinely supplied brewers with the so-called "blind thermometer," featuring a traveling index marker and detachable scale. With the scale in place, the brewer could set the marker to a particular value, such as the desired mashing temperature; he would then remove the scale before handing the thermometer to his servant who would then set the temperature without being able to communicate it.[35] Robert Brakspear, who kept a middle-sized brewery at Henley, Oxfordshire, from 1779, made notes using an esoteric system of coded symbols: a square stood for "hours," a theta for "mild beer," a diamond for "isinglass," and so on.[36] At the major

[31] The standard account is Mathias, *Brewing Industry*, 12–16, 53–62; see also the modification proposed in James Sumner, "Status." Not surveyed in this article is an important primary source on storage vessels: Victualling Commissioners to Philip Stephens, 24 Jan. 1774, in Navy Board Victualling Office out-letters, ADM 110/26 folios 101–15, the National Archives, Kew, Richmond, UK.

[32] For instance, George Watkins, *The Compleat English Brewer* (London, 1767), 122; *Gentleman's Magazine* 60 (1790): 801.

[33] Sumner, "Status," 297–99; Martyn Cornell, *Beer: The Story of the Pint* (London, 2003), 92–95.

[34] [Robert Reid], *Glasgow: Past and Present*, vol. 3 (Glasgow, 1856), 415–19.

[35] Alexander Morrice, *A Treatise on Brewing*, 1st ed. (London, 1802), appendix; John Tuck, *The Private Brewer's Guide*, 2d ed. (London, 1822), 32, 60; William Loftus, *The Brewer: A Familiar Treatise* (London, 1863), 143.

[36] Brakspear papers, II/i/1, passim, and II/i/3, Oxfordshire History Centre, Oxford, UK. See also Francis Sheppard, *Brakspear's Brewery, Henley on Thames, 1779–1979* (Henley on Thames, 1979).

London firm of Reid's, written records were "partly faked," presumably according to an agreed upon and orally communicated system.[37]

Such colorful strategies are not necessarily representative of the wider culture. The surviving evidence of brewery production logs at all scales of operation suggests that most were not intentionally cryptic. All employ some degree of esoteric shorthand, but only so far as is normal in any specialized activity. It is also easy to make too much of the exotic codes and shibboleths of guild culture, which were of declining relevance. Writing in 1760, one long-serving member of the London trade claimed that the traditional function of the Brewers' Company as a regulatory body had broken down entirely around 1730, giving way to an "anarchy" of new entrants looking to get rich quickly.[38] Protecting innovative advantage typically relied on a more mundane strategy of keeping sensitive records and equipment behind closed doors, paying high salaries to skilled staff, and otherwise trusting in the barrier formed by the high degree of tacit knowledge that was needed to turn a profit from most new equipment or methods. If brewers could be secretive, they were often skeptical of "secrets," in the sense of prescriptions that paper communication revealed. What Nathaniel Chivers's Glasgow employers contracted to buy from him, for instance, was not a written specification of the London method, as much as on-site practical demonstration.

A market for secret specifications did, however, operate to some extent. In 1762, Humphrey Jackson (1717–1801), an apothecary and manufacturing chemist, proposed a course of lectures in which he would explain methods for malting, the analysis of malt, hops, and yeast, "the real Causes of Cloudyness in Malt Liquors," "an easy practicable Method of Brewing Porter in Summer," and "a most useful new improved Thermometer adapted to the Brewery." Jackson was probably inspired by his father-in-law, Benjamin Martin, who delivered public lectures to promote sales of the scientific instruments he retailed. Jackson's course, however, was emphatically not public. "As soon as an adequate Sum is subscribed," he advertised,

> The Proposer will execute his Proposals, by way of Lecture, supported with Experiments, at any Time and Place agreed on; after which he will print them at large; and by leaving certain blank Spaces in the Book, to be filled up afterwards in Writing, or by References printed separately, they will be rendered useful to the Subscribers only.[39]

[37] Walter Pearce Serocold, *The Story of Watney's* (London, 1949), 19.

[38] *London Chronicle*, 22 Dec. 1760, 603.

[39] Humphrey Jackson, "Proposals for Communicating and Explaining the Real Causes of Cloudyness in Malt Liquors," printed circular, June 1762, papers of James Best of Chatham, U480/B874, Medway Archives, Strood, Kent, UK (hereafter, Best papers).

The book with blanks was a variation on an old guild device. In the seventeenth century, the Company of Distillers in London had circulated printed lists of process directions to its freemen with crucial information disguised by symbols that became intelligible once handwritten keys were added. The system had an obvious drawback: the text was later pirated and republished with the keys included ("for the Publike good").[40] Jackson, however, was looking to increase the pace of technical change in the brewhouse and presumably reckoned on being able to keep ahead of any printed disclosures. In the event, it seems that the proposed printing did not take place. Jackson became advisor to the major London porter brewer, Henry Thrale, and the lecture scheme was abandoned. Around 1770, however, Thrale sanctioned a partial revival of the lecture scheme, provided Jackson advised only "Country Brewers" far from Thrale's territory.[41] The brewers who were instructed under such terms could generally be trusted to keep confidentiality agreements, as any breach would potentially aid their own rivals.

Almost all attempts to gain a premium from secrecy relied on some form of direct personal interaction between inventor and client, in the lecture-room or brewhouse, but there were also attempts to promote privileged knowledge—or at least the promise of it—through correspondence, directions copied in manuscript, or even print. The brewer George Lloyd Worthington, in 1812, sold a book of guidance privately at five guineas (£5.5.0), ten times the price of a more compendious contemporary manual available to the public.[42] The intention, of course, was that the extent of the buyer's investment would itself secure his support in protecting confidentiality. George Adolphus Wigney, brewer and inventor of an unpatented refrigeration system, went much further in 1835, offering a comprehensive treatise privately to major brewers at £100. Supported by testimonials from satisfied customers and employers, he was able to meet his subscription target.[43]

Openness

Some innovators, by contrast, professed an attitude of complete openness regarding the content of their innovations, for a variety of

[40] *The Distiller of London* (London, 1639); *The Distiller of London, with the Clavis to Unlock the Deepest Secrets of that Mysterious Art* (London, 1652).

[41] Humphrey Jackson to James Best, 21 July 1770, Best papers.

[42] George Lloyd Worthington, *The Brewer's Guide: A New Work* (London, 1812); cf. Alexander Morrice, *A Treatise on Brewing*, 2d ed. (London, 1802).

[43] George Adolphus Wigney, *A Practical and Theoretical Treatise on Malting and Brewing* (Brighton, 1835); circular announcements, EK-U1453/B2/40/588, at Kent History and Library Centre, Maidstone, Kent, UK. The rise of cheap print was no barrier to the recurrence of this strategy: see George Stewart Amsinck, *Practical Brewings: A Series of Fifty Brewings* (London, 1868), priced twelve guineas.

reasons.[44] A few claimed—perhaps sincerely—to seek no reward from their discoveries beyond the glory of achievement. A key example is Michael Combrune (d. 1773), the first commercial brewer to publish in detail on trade practices. Combrune's most crucial achievement was in popularizing the use of thermometers in malting and brewing. Though he had no proprietary interest in any particular device, his system of management itself, based on tabulated relationships between malt colors, mashing heats, and the desired keeping qualities of the beer, could have been made the subject of a patent application or promoted privately as a secret. Instead, Combrune first offered his system to the London Company of Brewers, to which he belonged, to be held in common for the eyes of Company freemen only. To his surprise, Company officials (perhaps not sharing his opinion of its significance) pronounced him "at full liberty to dispence of it to the public."[45] This he did in two volumes of 1758 and 1762, which were widely excerpted in the reviewing press.[46] Combrune occasionally acted as a private consultant to other brewers, dispensing information about practical thermometry not found in his books, but made it clear that he did not see this as a principal source of income.[47] His chief aim, in publishing, was to gain acceptance as a chemical theorist.

To others, building a reputation within the trade might have more commercial significance. James Baverstock, a brewer on a middling scale at Alton in Hampshire, discovered (according to his own version of events) the use of the flotation hydrometer to measure wort strength in the 1760s. He initially approached several leading brewers privately with the knowledge. Like Humphrey Jackson, he secured the attention of Henry Thrale, who later presented Baverstock with a silver hydrometer in recognition of his achievements. Most brewers, then, were not rivals. Only those competing over the same geographical and product markets were in a position to damage each other's livelihoods, and the greatest brewers could safely exercise a paternalistic attitude towards the rest of the trade. A brewer in Baverstock's position could, by sharing his innovations, place himself effectively under the patronage of a

[44] For a discussion of openness and knowledge sharing among inventors in different historical contexts, see James Bessen and Alessandro Nuvolari, "Knowledge Sharing among Inventors: Some Historical Perspectives" in *Revolutionizing Innovation: Users, Communities, and Open Innovation*, ed. Dietmar Harhoff and Karim Lakhani (Cambridge, MA, forthcoming).

[45] Michael Combrune to James Best, 17 Aug. 1762, Best papers; Michael Combrune, *Essay on Brewing* (London, 1758), [v]–[vi].

[46] Combrune, *Essay*; Michael Combrune, *The Theory and Practice of Brewing* (London, 1762).

[47] Combrune to Best, 17 Aug. 1762, Best papers; Council minute book entries for 25 June and 16 July 1772, Royal Dublin Society Archives, Dublin, Ireland.

relative giant such as Thrale. The reward might be entry into the London market for his product (under terms agreeable to his patron) or the likelihood of employment in the event of the failure of his own business. Like Combrune, Baverstock claimed to be acting in the general interest of the trade. Yet unlike Combrune, he did not publish until John Richardson, the promoter of a proprietary hydrometer, claimed the novelty of the discovery for himself in 1784, stinging Baverstock into asserting his priority. Baverstock also responded by engaging an instrument-maker to develop a hydrometer to his own specification, but from 1786 he was managing partner in an increasingly profitable brewhouse at Windsor and apparently had neither time nor need to consider marketing innovations as a source of income.[48]

The dominant porter brewers of London were particularly inclined to make a strategic show of openness given that, by around 1800, they were heavily insulated from rising competition by the immense quantity of capital needed to break into the market at their level of production. They would often flaunt their technical innovations as statements of forward-thinking economy and reliability, aimed not only at drinkers but also at each other. In 1784, Henry Goodwyn, who ranked as London's seventh brewer in terms of output, became the first to commission a Boulton and Watt engine; an order from Whitbread, the leading brewer, followed a month later. Boulton and Watt's design itself was protected, of course, but its installation, requiring various adaptations in the brewhouse, must have generated valuable experience. We might expect Goodwyn to have sought patents or simply to have kept the information to himself. Instead, he went out of his way to offer himself as an advisor to others planning to introduce steam, including his brewery rivals.[49] The point was to confirm Goodwyn's status—notwithstanding that his output was only half of Whitbread's—within the charmed circle of large-scale brewers. Goodwyn's magnanimity was intrinsically restricted to that circle. For all their one-upmanship, the greatest brewers made collective agreements on issues such as retail pricing and were in many ways almost a cartel, safe in the knowledge that no competitor could raise the capital to oppose them.[50] Unrestricted disclosure, then, was harmless so long as no outsider was in a position to use the information disclosed.

[48] James Baverstock, *Hydrometrical Observations and Experiments in the Brewery* (London, 1785); James Baverstock, *Treatises on Brewing* (London, 1824), xvi–xix, 299–306.

[49] Mathias, *Brewing Industry*, 89–90.

[50] For the only notably successful—and yet short-lived—project to breach this capital barrier, see Mathias, *Brewing Industry*, 243–51.

Partial Publication without Patenting

Some innovators sought to combine the advantages of secrecy and openness, publishing accounts of discoveries that were sufficient to demonstrate their expertise, but that could not be applied in practice without private consultancy. The most influential exponent of this approach was John Richardson (1743–1815), mentioned above as the rival of James Baverstock. Richardson had been advertising privately as a consultant for some time when in 1777 he published a short volume, modeled loosely on contemporary chemical treatises, offering "Hints" towards principles that, he said, would direct a more efficient practice.[51] In 1784, now established as a successful brewery proprietor in Hull, Richardson engaged a prominent London instrument-maker, John Troughton, to produce a custom-designed hydrometer, which he promoted through a second, more detailed treatise.[52] Richardson dubbed the new device a "saccharometer," emphasizing its particular application to the dissolved sugars in brewers' wort, and claimed to be the pioneer of wort hydrometry. In fact, some brewers had known of this approach since the 1740s, and Richardson's priority claim triggered fierce public objections from Baverstock.[53] Nonetheless, by carefully presenting himself as a champion of brewers' interests, Richardson established the saccharometer as an industry standard. To affirm that it was not merely an adapted distillery device, he published a detailed history of the instrument's calibration, as performed in his own brewhouse using barrels of brewers' wort.[54]

There is no evidence that Richardson attempted to patent the saccharometer. From a technical standpoint, he could probably have done so. The design contained novel features such as a sliding "regulator," designed to correct mechanically for differences in local water, and was at least as distinctive as a hydrometer patented by John Dicas in 1780.[55] Yet Richardson instead chose to prioritize building up his reputation

[51] John Richardson, *Theoretic Hints on an Improved Practice of Brewing Malt-Liquors* (London, 1777).

[52] John Richardson, *Statical Estimates of the Materials for Brewing, or a Treatise on the Application and Use of the Saccharometer* (London, 1784).

[53] Richard Clarke, *Notice Is Hereby Given, to all Dealers in Brandy, Rum, Malt, or Melasses-spirits, Arrack, &c. that the Hydrometer, or Brandy-Prover, Being the Production of many Years Study and Experiments, is now Brought to its Utmost Perfection* (London, [1746]); James Baverstock, *Hydrometrical Observations and Experiments in the Brewery* (London, 1785).

[54] James Sumner, "John Richardson, Saccharometry and the Pounds-per-Barrel Extract: The Construction of a Quantity," *British Journal for the History of Science* 34 (2001): 255–73.

[55] Richardson, *Statical Estimates*, 3, 30; and cf. Mathias, *Brewing Industry*, 69, no. 2; Dicas, John. Patent 1259, 27 June 1780. The date given for all patents cited is the date in which the patent was granted ("sealed").

among the brewers. His publications cast him as a "scientific" (a word that appeared in his titles from 1788) authority, while stressing that he remained a commercial brewer and would advise primarily on a commercial basis.[56] The physical technology of Richardson's saccharometer was only one element of an interlinked system, which also included the published treatises, direct instruction by personal attendance, and secret manuscripts. The text of one such manuscript found its way into print some years after Richardson's death. It does not describe any novel apparatus, but consists largely of operational directions to be carried out using conventional equipment, guided by Richardson's saccharometer and a thermometer of standard Fahrenheit pattern, along with directions for record-keeping. Richardson's 1784 treatise retailed at five shillings, and the saccharometer itself at three guineas (£3.3.0); yet the manuscript commanded 150 guineas (£157.10.0) plus a guarantee of twenty years' secrecy.[57] It is likely, therefore, that Richardson considered he had little to fear from the emulation of his technology by others, provided his authority remained intact. The name "saccharometer" and Richardson's brewery-specific scaling were, indeed, appropriated by more established hydrometer-makers in his lifetime.[58] Nonetheless, Richardson's reputation as a key brewing theorist grew and outlived him, as his consultancy, and his own brewery, prospered.[59]

Richardson's strategy was refined by later consultant brewers such as William Black, who published an extensive treatise in 1835. Black emphasized the importance of chemical theory to effective brewing, paying particular attention to contemporary research suggesting that electrical action could influence the progress of fermentation. Convinced that the unpredictable souring still widely experienced in the most up-to-date breweries was an effect of atmospheric electricity, Black began to promote the comprehensive removal of iron vessels and fittings and their replacement with electrically insulating materials.[60] The same interpretation was later to form the basis of two patents, including one by Andrew Crosse, an amateur whose electrical research was famous in his day.[61] Yet Black, despite setting up several breweries with non-metallic equipment, never patented anything himself.

[56] Richardson, *Theoretic Hints*, 1–2.

[57] Richardson, *Statical Estimates*, 241; [David Booth], *The Art of Brewing* (London, 1829), [33].

[58] George Skene Keith, "Observations on the Papers Presented to the House of Commons," *Farmer's Magazine* (1807), 476–500, on 487–88; Friedrich Accum, *A Treatise on the Art of Brewing* (London, 1820), 104.

[59] [Booth], *Art of Brewing*, 11–15; William Black, *A Practical Treatise on Brewing*, 1st ed. (London, 1835), 37; Pat Aldabella and Robert Barnard, *Hull and East Riding Breweries* (Beverley, 1997), 80–81.

[60] Black, *Practical Treatise*, 11–14, 29–31, 94–97.

[61] Crosse, Andrew. Patent 11604. 2 Mar. 1847; Van Kempen, Peter, communicating an invention of Gerrit Abraham Cramer. Patent 14015. 8 Mar. 1852.

For a variety of reasons, then, the promoters of brewery innovations—in particular, those who were themselves brewers—often focused on strategies that had no use for the kind of protection afforded by the patent system. Indeed, a consultant such as Black, who expected to live by tutoring and consultancy fees rather than royalties, might positively welcome the early appropriation of his innovations by others.

Patenting as Used by "Outsiders"

By the late eighteenth century, large-scale brewers increasingly found themselves dealing with the installation and management of patent technologies aimed at a broad range of industries, such as steam engines and milling machines. There were also a few patents by nonbrewers that, though of broad potential scope, were in practice of primarily brewery significance, such as Matthew Wood's 1802 process for making artificial coloring.[62] Humphrey Jackson, discussed above as a promoter of brewing systems under conditions of secrecy, provides an earlier example. He first came to the attention of the brewing community when he obtained, in 1760, a patent on the production of isinglass.[63] This material, prepared from sturgeon and other fish, was used in a variety of industries, but its chief use was in fining (removing cloudiness from) London porter. By one report, leading brewers combined to gift Jackson "a considerable sum of money" towards the perfection of his process.[64] Jackson was later to invoke his brewery connections in a further scheme involving a chemical process for hardening timber, patented in 1769. Though his chief intended market was always shipbuilding, his circulars to brewing clients pointed out the importance of casks and wooden storage vats to their operations, and it was Jackson's chief brewery patron, Henry Thrale, who largely funded the project.[65]

John Long (d. 1807), a few years later, made patenting more central to his approach. Long's background is obscure: he is described as a "Merchant" of Longville, County Dublin, and was apparently a protégé of John Beresford, First Commissioner of the Revenue in Ireland. He

[62] Wood, Matthew. Patent 2625. 31 May 1802.

[63] Jackson, Humphrey. Patent 749. 26 Mar. 1760.

[64] Robert Dossie, *Memoirs of Agriculture*, vol. 1 (London, 1768), 275–77. See also Mathias, *Brewing Industry*, 51–53.

[65] Jackson, Humphrey. Patent 910. 9 Dec. 1768; Humphrey Jackson, *New Art of Hardening and Preserving Wood* (London, 1770); John Appleby, "Humphrey Jackson, F.R.S., 1717–1801: A Pioneering Chemist," *Notes and Records of the Royal Society* 40 (1986): 147–68, on 152–56; Katharine Balderston, ed., *Thraliana: The Diary of Mrs. Hester Lynch Thrale*, 1st ed., vol. 1 (Oxford, 1951), 53 and 312; Abraham Hayward, ed., *Autobiography, Letters and Literary Remains of Mrs. Piozzi*, 1st ed., vol. 1 (London, 1861), 257–58; James Clifford, ed., *Dr. Campbell's Diary of a Visit to England in 1775* (Cambridge, UK, 1947), 51.

was thus able, on traveling to England in 1789, to tour the major breweries and distilleries, making investigations into their operations that inspired his two patents of the following year.[66] Long's specifications are notable as the first to describe an entire system of brewing, including innovations in large parts of the process, as opposed to a method or apparatus for an individual task. Most of Long's proposals involved the use of submerged pipe coils, similar to distillers' worms, through which hot or cold water would circulate to achieve temperature control in various brewery vessels. In Long's case, again, we see that patenting was not always viewed as the optimum strategy. Returning to Dublin in 1792, Long petitioned the Irish Parliament, stating that he was in possession of a full systematic knowledge of English production, and he was willing to negotiate disclosure based either on the granting of an Irish patent to himself or on remuneration in exchange for a general public disclosure to the Irish brewers. Parliament favored the latter course, which probably explains Long's appointment as "General Examiner and Inspector of Breweries" by 1800.[67]

Another patentee of a system of brewing was Richard Shannon, who styled himself "M.D." but was apparently active as a chemist, distiller, and metalware dealer. Shannon's system of 1798, like Long's, focused on temperature control, but relied on steam-jackets and similar enclosures to convey hot water, cold water, or air.[68] In 1805, he issued a treatise on brewing, distilling, and vinegar-making that was, for its time, the most extensive and expensive work on the subject, running to over one thousand pages of lavishly produced quarto and sold by subscription at £2.12.6. The apparently comprehensive work was, in fact, simply a promotional device on a grand scale. The text was built around Shannon's patent specifications and other descriptions of his equipment, bulked out with lengthy quotations from Richardson, Baverstock, and other authors.[69]

The activities of such outsiders inevitably attracted the suspicions of some within the trade, to whom a reliance on patenting might suggest impracticality or imposture. Humphrey Jackson's involvement with Henry Thrale ended in disaster. Thrale over-committed himself

[66] Long, John. Patent 1754. 4 June 1790; Long, John, and Thomas Harris. Patent 1769. 28 July 1790. The second patent, registered jointly with a distiller, consolidates the specification of wort-cooling apparatus described in general terms in the first. For biographical details see *Monthly Magazine* 24 (1807): 413.

[67] *Votes of the [Irish] House of Commons* (Dublin, [1792]), 365–66, 446–47; *Parliamentary Register, or, History of the Proceedings and Debates of the House of Commons of Ireland* 12 (1793): 259–60, 299; John Long, *A Treatise on Malting* (Dublin, 1800), title page.

[68] Shannon, Richard. Patent 2212. 1 Feb. 1798.

[69] Richard Shannon, *A Practical Treatise on Brewing, Distilling, and Rectification* (London, 1805).

financially to the timber-hardening scheme, and the brewhouse staff blamed Jackson when, in 1772, one of the wooden storage vessels burst apart and the remainder of the year's production was found to be sour, leaving the firm on the brink of collapse.[70] Instructors and innovators with a brewery background had an obvious interest in excluding the outsiders. Jackson was also attacked by John Richardson who produced an anonymous pamphlet assailing his "secret system" as dangerous quackery.[71] John Long, in similar fashion, ran afoul of George Blake, a trained ale-brewer who operated as a traveling consultant, initially in private. Long had approached Blake as a potential partner, but Blake derided Long's patent system as absurdly impractical and was moved to publish for the first time in order to dissociate himself from it.[72] (The experience apparently converted Blake to the value of print. In later years he published a volume describing the innovations on which he advised privately, again without patenting.)[73] Shannon, it appears, was more convincing: the seven hundred subscribers to his treatise included most of the trade's conspicuous leaders in London and provincial centers such as Burton upon Trent .[74]

Patenting as Used by "Insiders"

No patentee of an evidently brewing-related invention gave his occupation as "brewer" until 1784 when Sutton Thomas Wood of Oxford took out a patent on an approach that could be applied to wort-boiling and to comparable boiling stages in other manufactures. The boiler was to be covered and the steam conveyed by pipes to perform various useful tasks, such as working a steam engine or providing heat elsewhere in the process.[75] The specification built on a slightly earlier patent in which Wood described modifications to steam-engine design, and it was followed by another extending the approach to various other manufactures. A few years later Wood obtained a fourth and final patent on a steam-driven weaving engine.[76] Wood's innovations did not, therefore, focus notably on brewing. He might rather be classed with the

[70] Balderston, *Thraliana*, 1: 53, 312; Hayward, *Autobiography*, 1: 257–58; Hester Piozzi, ed., *Letters to and from the Late Samuel Johnson*, vol. 1 (London, 1788), 78–79.

[71] [John Richardson], *Observations on the Art of Brewing Malt Liquors, in a Series of Strictures on a Secret System* (London, 1775).

[72] George Blake, *Strictures on a New Mode of Brewing* (London, 1791).

[73] George Blake, *Theoretical and Practical Remarks on G. Blake's System of Malting and Brewing* (London, 1817).

[74] Shannon, *Practical Treatise*, [xxvii]–xxxii.

[75] Wood, Sutton Thomas. Patent 1455. 17 Nov. 1784.

[76] Wood, Sutton Thomas. Patent 1447. 20 Aug. 1784; Wood, Sutton Thomas. Patent 1492. 27 July 1785; Wood, Sutton Thomas. Patent 1860. 15 Mar. 1792.

numerous contemporary engineers concerned with improving the efficiency of steam-heating.[77] A self-described "brewer," in this period, could be anything from an expert in brewhouse technology to a sleeping partner whose interests lay elsewhere, and without firm biographical evidence it is difficult to assess how far Wood could appeal to brewers as a knowledgeable insider. Nonetheless, when the largest breweries began to install steam engines in the 1780s, Wood was in contention as a potential rival manufacturer to Boulton and Watt.[78]

From Wood's time, as suggested by Table 3, a significant minority of brewery-relevant patents came from identifiable brewers. In 1787, James Walker of Dover took out the first patent covering a mechanized mashing-rake. William Ker (d. 1807), said to have erected "one of the completest breweries and distilleries" in Peebles, patented in 1788 a scheme to capture and condense the steam from hop-boiling in order to recover the essential oil of hops that would otherwise be lost to the atmosphere.[79] Walker's patent specified particular technical contrivances for carrying out known tasks; Ker's patent outlined the general principle of a proposed reform that could be carried out by various means. Both innovations inspired a number of later patentees, but it is impossible to gauge to what extent the patents were actually worked. The same is true of the patent obtained fifty years later by Peter Walker, a Liverpool brewer. Walker's fermentation cleansing apparatus has since been claimed as the origin of the Burton Union system, a distinctive mode of arrangement and management of fermentation that stands as an icon of the nineteenth-century wave of brewery industrialization centered on Burton and the West Midlands. Paul Bayley's review of the literature, however, suggests that Walker's prominence may simply be an artifact of the relatively high survival and traceability of patent specifications. The development of the Burton Union system, like that of London porter, evidently involved the gradual assimilation of numerous innovations. One of these, developed by the London brewer R. W. Dickinson around 1823, received not a patent but a Society of Arts medal for the disclosure.[80]

The first London brewer to patent was Richard Hare, whose porter brewery at Limehouse had been in his family since at least the 1730s. In

[77] MacLeod, *Inventing*, 178.

[78] Richard Hare to Boulton and Watt, 11 Jan. 1785. In "Industrial Revolution: A Documentary History" (microfilm series. Marlborough: Adam Matthew Publications, 1993 onwards), series 1, part 13, reel 243, 3/392, item 16.

[79] Ker, William. Patent 1641. 4 Mar. 1788; John Sinclair, ed., *The Statistical Account of Scotland*, vol. 12 (Edinburgh, 1794), 8.

[80] Paul Bayley, "An Evaluation of the Number and Distribution of Burton Unions," *Brewery History* 129 (2008): 39–72; Walker, Peter. Patent 7658. 31 May 1838; "Apparatus for Clearing Beer," *Transactions of the Society, Instituted at London, for the Encouragement of Arts, Manufactures, and Commerce* 42 (1823): 23–25.

1790 it was ranked the fifteenth-greatest in London on an annual output of 23,000 barrels, putting it on a par with the largest provincial breweries.[81] Hare's patent of 1791 describes a closed boiler whose stated purpose, as in Ker's patent, is to minimize the loss of volatile hop oils, although the design was probably more inspired by Wood's engine: Hare had consulted Wood in 1758. Hare installed a version of his apparatus at his own brewery, and when he sold the business in 1792, he licensed the invention to his successors for an annuity of £100 for the remaining term of the patent. On learning of Wood's prior activities, however, the successors suspected that Hare's patent was not secure, and by ceasing to pay the annuity, they triggered an action from Hare in 1803. With Wood testifying on their behalf, Hare's patent was duly voided. While the specified purpose of Hare's apparatus was unquestionably distinct from Wood's, its operation was held to fall entirely within the detailed conceptual scheme Wood had submitted.[82] Later surveys noted that "Hare's apparatus is now universally employed in all extensive breweries: the construction is more complete than Wood's."[83] The art of patenting, like that of brewing, contained many traps for the inexperienced and the poorly connected.

The two brewers with the highest profile to hold patents were Edward Biley and Henry Goodwyn, Junior, who both enrolled mashing machines in, respectively, 1793 and 1797. Members of the coterie of major brewers were evidently somewhat amenable to paying each other royalties under the patent system. Whitbread introduced a Biley masher after 1796.[84] Goodwyn, son of the above-mentioned steam-engine pioneer, was the sixth- or seventh-greatest producer around the time of his patent. Yet the very greatest and most highly capitalized brewers such as Whitbread, Barclay Perkins, and Meux Reid held no patents despite the fact that their frenetic growth led to numerous innovations. Patenting was one possible revenue stream among many and an uncertain one at that. The London giants' attentions were far more focused on building larger and more reliable markets by "tying" public houses to their product through leaseholding or loans to publicans.[85] Nonetheless, the major brewers' interest in steam enmeshed them indirectly in some of the highest-profile debates on the nature and scope of patent protection. While most of its competitors dealt with Boulton and Watt, Meux

[81] Thomas Pennant, *Of London* (London, 1790), 279.

[82] *Repertory of Arts*, 2d ser. 3 (1803): 232–35. A subsequent action confirmed Hare's right to the money already paid out: *New Reports of Cases Argued and Determined in the Court of Common Pleas [from 1804 to 1807]* vol. 1 (1826), 260–63.

[83] *Report from the Select Committee on the Law Relative to Patents*, 12 June 1829, 195.

[84] Mathias, *Brewing Industry*, 95.

[85] For the origins of the tied trade in London see Mathias, *Brewing Industry*, 117–38; and for its subsequent growth, Gourvish and Wilson, *British Brewing Industry*, 128–46.

Reid commissioned one of Hornblower and Maberley's engines; this was the principal case cited when Boulton and Watt successfully sued their rivals for infringement.[86]

This case is also significant for the light it sheds on the beginnings of what became the specialist class of "brewer's engineer." The engineer appointed to the project, Arthur Woolf, found the Meux Reid site particularly productive for testing new refinements. The brewers, for their part, found various uses for his talents, so that Woolf stayed on as a salaried resident consultant until 1806, cementing the relationship by marrying Mrs. Meux's maid.[87] Woolf's projects at Meux's included an apparatus for heating water by waste steam erected in 1800.[88] His first patent, for a tubular boiler in 1803, was based directly on his experience of installing two boilers at Meux's. These boilers were initially designed to replace open-firing of the brewing coppers, the invention being adapted later to supply steam engines.[89]

From the early nineteenth century, there began to emerge a number of dedicated "brewers' engineers" who typically had general mechanical engineering training and might or might not work exclusively on brewery projects. Unlike Woolf, these practitioners were not retained by an individual firm, but served a wide variety of brewers as consultants. They were as likely as other mechanical engineers to take out patents, working them directly, with their consultancy clients providing a captive market. One of the most active was William Tizard, who positioned himself in the 1840s as an experienced brewer who no longer had vested interests in any one brewery, prepared to consult for anyone who agreed to his terms. Tizard took it for granted that his inventions should be protected under patent. His first specification, in 1841, describes a system of innovations across the whole process from malt-crushing to fermentation, including the whimsically named "hystricon" (a rotary device to agitate the grain while sprinkling it with water), "Caloriphagon" (a lamp enclosed in a cooling water jacket to avoid heating the fermenting room), and "Pneumatic Life-protector" (a signal light to show excess build-up of carbonic acid gas in subterranean vaults).[90] Tizard described all these innovations in detail in an extensive

[86] Henry Dickinson and Rhys Jenkins, *James Watt and the Steam Engine* (Oxford, 1927), 69, 307.

[87] Mathias, *Brewing Industry*, 95–96.

[88] "Description of an Apparatus for Heating Water by Waste Steam, Invented by Mr. Arthur Woolf," *Journal of Natural Philosophy* 1 (1802): 203–4, and see Thomas Harris, *Arthur Woolf: The Cornish Engineer, 1766–1837* (Truro, 1966).

[89] "On Mr. Arthur Woolf's Improved Apparatus, Applicable to Steam Engines and Other Purposes of Art and Manufacture; Including a Description of Two Boilers Now Erecting at Messrs. Meux's Brewery," *Philosophical Magazine* 17 (1803): 40–47; Woolf, Arthur. Patent 2726. 29 July 1803.

[90] Tizard, William. Patent 8921. 5 Apr. 1841.

treatise on brewing, first published in 1843, in which he adapted the strategy adopted earlier by Richard Shannon. However, where Shannon had merely bulked out his specifications with hack borrowing, Tizard based his work on an exceptionally comprehensive survey of the literature, carefully updating the text between editions to showcase his mastery of the latest knowledge—and to denigrate the approaches and apparatus offered by rivals.[91] Tizard never licensed his patents, instead managing the installation of all apparatus privately on his own account, alongside his more general advisory consultancy.

Conclusions

Recent studies of patenting activities, both contemporary and historical in focus, have pointed to significant intersectoral differences in the effectiveness of patents as a tool for protecting inventions.[92] Our study shows that it is important to acknowledge differences in appropriability strategies even within the same industry. The case of the English brewing industry displays widespread and persistent behavioral heterogeneity. We might perhaps regard the industry as a complex ecological system in which inventors could successfully develop different strategies fit to ensure their survival in specific niches. No one approach, therefore, was "typical" or "characteristic" of the industry at any given time.[93] There is, however, evidence of a widespread insider presumption against patenting, which was often associated with unreliable outsiders, until around the turn of the nineteenth century. To account adequately for the later shift to embrace patent protection would require further study, although it seems reasonable to suppose that the increasing appeal to brewers of technologies developed in more patent-friendly settings—most obviously, the steam engine—played a major role.

Perhaps our most important finding, as demonstrated by the case of John Richardson, is that careful selective revealing of information, and a sophisticated approach to the communication of inventions, could allow a "trade in inventions" to thrive even without the use of the patent

[91] William Tizard, *The Theory and Practice of Brewing Illustrated*, 1st ed. (London, 1843). Further editions followed in 1846, 1850, and 1857.

[92] Wesley Cohen, Richard Nelson, and John Walsh, "Protecting Their Intellectual Assets: Appropriability Conditions and Why US Manufacturing Firms Patent (or Not)" NBER Working Paper no. 7552 (2000). For some nineteenth century evidence, see Petra Moser, "Innovation without Patents: Evidence from World's Fairs," *Journal of Law and Economics* 55 (2012): 43–74.

[93] For an insightful discussion of the persistent heterogeneity of innovation strategies within industrial sectors, see Martin Shrolec and Bart Verspagen, "The Voyage of the Beagle into Innovation: Explorations on Heterogeneity, Selection, and Sectors," *Industrial and Corporate Change* 21 (2012): 1221–53.

system. Furthermore, even when inventors opted for an appropriability strategy based on patent protection, patents were only one ingredient of the mix. Promotion through technical books and pamphlets, drawing on the past strategies of both patenting and non-patenting innovators, remained a key strategic factor. Given the growing interest in markets for technologies, it would be instructive to establish whether this pattern was peculiar to the English brewing industry or is representative of a more widespread phenomenon.

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