Introduction

Outline and aims

This thesis considers the development of the British beer-brewing industry in the light of current work in the history of science, technology, and their interactions. Coverage focuses on a period, running from the mid-eighteenth to the early nineteenth century, in which a variety of instruments, quantities, practices and theories originating in natural philosophy were incorporated into brewery culture. Contemporaneously with these developments, a specialist brewery literature began to emerge. Many of its writers professed an ethos they described as 'scientific,'[1] promoting the application of philosophical instruments such as the thermometer, the systematic recording of quantitative measurements, and the application of chemical theory to account for and predict the results of brewery operations. These writers often contrasted their work with a 'traditional' brewery culture, based on qualitative judgment and oral communication, which they represented as both secretive and unreliable.

The brewing community of the period, prior to the development of canal and rail transport networks, was characterised by a conspicuous divergence between provincial breweries and the large-scale, 'industrial' brewing operations which had grown to take advantage of the markets presented by rising populations in the cities and, above all, in London. A variety of practices and expectations had crystallised around the identity of *porter*, the staple brown beer of the major London brewers; the course of the eighteenth century saw a small number of London porter breweries rise to become colossal industrial concerns, with plant and output levels orders of magnitude greater than that of the small-scale provincial brewing victuallers. Porter, much more than traditional ale, was a 'standard' product, sold at a fixed price and associated with a single characteristic taste; reliability was therefore of crucial importance.

The 'scientific' brewery writers presented their methods as a means of controlling the production process, in order to ensure the reliability desired both by the large porter brewers and by smaller producers who sought to emulate their success. In the event,

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[1] For instance Hayman 1812: v. Richardson, who was possibly the first writer to allude to a "science of brewing," [Richardson 1788] is often characterised by later writers as notably "scientific." [Accum 1821: 70; Black 1835: 98] The precise meanings attached to 'science' and 'scientific' here will be addressed at length in the thesis conclusion.

however, the results of their quantificatory endeavours encouraged the brewers to alter the composition of their product, creating conflict with the expectations of drinkers: in particular, a shift from brown to pale malts — defined by gravimetric methods to give a better yield — robbed London porter of its characteristic colour and flavour, necessitating a reliance on 'artificial' colouring techniques to supply the desired profile.

This development coincided with, and probably contributed to, the widely-publicised assertion that beer was no longer a 'pure' product, but was grossly adulterated with additives of a useless and often toxic nature. In the early nineteenth century, therefore, claims of 'chemical' or 'scientific' credentials could be a double-edged sword: as far as many of the drinking public were concerned, they carried overtones of fraudulent 'sophistication,' reliance on the nostrums of itinerant druggists, and a disavowal of the honest techniques of 'traditional' production. These claims were, for a while, quietly encouraged by the largest brewers, who gained by presenting their smaller and more poorly-capitalised rivals as economically dependent on fraud. Chemistry, and analytical methods in general, only became firmly established as 'respectable' after 1830, owing chiefly to the propagation of laboratory methods in Burton-upon-Trent, the foremost among the provincial pale ale-brewing centres which ultimately overcame the dominance of London porter.

The aim of the thesis as a whole is, with reference to these various developments, to provide answers to the following questions:

- What does it mean for a discipline to be made 'scientific'? In the brewing case, several important factors seem to be relevant: the standardisation of products; the application of a quantitative approach; the importation of technologies (chiefly instruments) from other disciplines; and the changing self-image of brewers. What importance did the brewers themselves attach to these factors, and how were they interrelated?

- What was the nature of the 'unscientific' brewing tradition castigated by reformers? What was lost in the transition to the new methods? Given that these methods were often presented as allowing an established product to be produced more reliably, how is it possible that such products were sometimes changed fundamentally in the process?

- Who were the agents of quantification, standardising and the promotion of the 'scientific' context? Were these developments largely internal to the brewing

community, or were they transferred into the brewery by outsiders with other agendas?

- How does the conspicuous industrialisation of London's porter breweries relate to developments in the quantification and standardisation of products? Were techniques based on 'science' prerequisite for the establishment of large-scale production, or did industrialisation precede and promote the adoption of the new methods?
- Was the shift to 'scientific' practice an inevitable, self-propelling mechanism once initiated? Or was it rather contingent on certain conditions which happened to persist in the period under review? If the latter position holds, can we hold any particular external factors responsible?

Scope

The date range presented in my title, 1760-1830, serves to permit a narrative covering the introduction and rise to generality of thermometric and saccharometric measurement in commercial brewing, the emergence of a 'scientific' brewing identity, and the establishment of the brewery manual as a textual genre. It also usefully marks the thesis out as specifically relating to the heyday of metropolitan porter-brewing, as opposed to the pale ale-brewing culture of those centres such as Burton which rose to dominance in the Victorian period;[2] and excludes such later innovations as microbiology and detailed sugar chemistry, which would have rendered the survey unmanageably large.

The dates must be understood, however, purely as a loose guide indicating the focus of my research, rather than as a prescriptive methodological determinant of coverage. Since a key aim of my thesis is to deconstruct the received milestones and temporally-pinpointed 'inventions' of the brewery, in line with a prevailing historiography of science which rejects 'crucial' developments, this is probably inevitable: the nomination of precise events or publications to serve as start or end points would necessarily be somewhat arbitrary. This is particularly true of the chosen starting date: my first significant focus, in fact, is on the thermometrist Michael Combrune (Chapter 2), whose first works appeared in 1758 and 1762; Combrune's activities, however, cannot be placed in context without significant reference to earlier developments, and

[2] See Section 1.1

my survey draws on primary sources from the late seventeenth century onwards. The year 1760, then, has no crucial significance: it is, however, the date at which of the source which informed most accounts of the origin of London porter (Section 4.3.2) was first published, and in that respect serves as a useful point from which to take stock of the pre-established industry.

There is a more obvious rationale behind the choice of 1830 as a closing date. This was the year of the "Act to permit the general Sale of Beer and Cyder by Retail in England," otherwise known as the 'Duke of Wellington's Beerhouse Act' or simply the 'Beer Act,' a wide-ranging measure which reformed beer taxation and created a new class of beer-selling establishment under greatly relaxed licensing laws: the Act, or, at least, the contemporary middle-class perception of its effects, is often treated as a watershed in the history of drink in England.[3] Recent work, as I note in Section 5.5.1, has cast doubt on the supposed discontinuity imposed by the Act; it served, however, as a convenient endpoint marker for Peter Mathias' seminal 1959 survey, and has since served as an endpoint for one further volume and as a starting point for three more:[4] it is thus convenient to retain it. Where necessary, however, I have freely discussed later events: this is particularly the case in my discussion of the controversy over brewery adulteration (Chapter 5), which arose in the course of the changes described in the period of my main focus, but which was not resolved until the later nineteenth century.

Geographically, the coverage is confined to the British Isles, and chiefly to London and the common breweries of provincial England: this choice is dictated by the practicalities of a three-year research project alone. The theories and practices of continental Europe, and in particular the German states, Bohemia and Austria, have much to offer on such matters as storage, heat management, and changes in colour profile, as recent work by Mikuláš Teich has shown:[5] the limitations of research time, and the inevitable difficulties presented by the language barrier, convinced me that a more thorough and cohesive survey of narrower geographical scope would be preferable.

Finally, one significant constraint has been applied to my primary research into the brewers' perspective. I have focused almost exclusively on published brewery

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[3] Mason 2001: 121

[4] Clark 1983; Brown 1983; Gourvish and Wilson 1994; Clarke 1998

[5] Teich 2000

manuals, rather than investigating the surviving rest-books, correspondence and other manuscript materials from breweries in the eighteenth and early nineteenth centuries.[6] This limitation, again, was applied in the interests of constructing a manageable thesis: my specific concern with the techniques of persuasion employed by those brewers who carried their ideas into print necessitated a fuller, more critical examination of the published corpus of brewery manuals than has yet been attempted, and it seems sensible to leave the parallel investigation of sources not intended for public consumption to a future investigation. It is likely that many valuable insights would result from such a project, particularly since Peter Mathias, author of the standard established secondary source, by his own admission based his conclusions on only a fraction of the extant records.[7]

Arrangement of the thesis

My first chapter has the aims of a conventional literature review, outlining the state of established literature on the brewery, and in related fields, in order to establish the historiographic context of the present thesis. In this chapter, however, I also treat in overview a number of themes current in the history of science and technology, which are of quite general relevance throughout the thesis, and which it is useful to characterise before presenting the case studies which they inform.

The nature of the thesis project precludes any simple division by period or institution. Instead, I adopt a broadly thematic chapter structure which is, at the same time, loosely chronological in focus, the key conclusions of succeeding chapters providing a basis for the material which follows. Thus thermometry (Chapter 2), introduced to the brewery around 1758, is seen to be a necessary precondition for the saccharometric project (Chapter 3) which took hold in the 1780s; saccharometric evidence was chiefly responsible for the shift from brown to pale malts, causing the use of colouring to become increasingly conventional (Chapter 4) in the years leading up to the turn of the century; and the legitimation of colouring was held, by many, to have fed the growth of adulteration (Chapter 5), allegations over which continued to 1830 and beyond. Each thematic chapter, however, also covers the whole period of the thesis (and

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[6] The standard reference for details of archival holdings (now a little out of date) is Richmond and Turton 1990.

[7] Mathias 1959: xiv

occasionally, in the interests of context, prehistory and subsequent events) in at least some degree of detail.

A note on the title

The word *tun* was in the eighteenth century, and remains today, a brewery term indicating a vessel: it could refer to a standard cask size, holding 216 gallons and used for long-term storage, but could equally apply to any large brewery container, the most common instances being *mash-tun* for the vessel in which the fermentables were extracted, and *gyle-tun* for the fermenting vessel. The term *metric* does not here refer to the decimal system introduced across continental Europe in the wake of the French Revolution, which was never a feature of British brewing in the period under review (indeed, the techniques applied to encourage the adoption of the 'brewer's pound,' discussed in Chapter 3, resulted in its survival against decimal quantities in laboratory usage into the late twentieth century.) Rather, the intention is to suggest, through the device of a homophone, the potential for controversy and change occasioned by the application of new techniques to an old-established art.

A metric, according to the *Oxford English Dictionary*, may be defined as "[a] system or standard of measurement; a criterion or set of criteria stated in quantifiable terms." The 'scientific' brewers on whom this thesis is principally focused promoted as their aim the application of quantitative, textually communicable measures, legitimated and guaranteed as standards by natural-philosophical theory and practice, to the contents of their fellows' mash-tuns and gyle-tuns. The use of a verbal ambiguity (I refuse to dignify it with the denomination 'pun') to convey this point is unlikely to please every reader, but is undeniably an appropriate reflection of the thesis' supervisorial context.

Chapter 1: Review of literature and analytical themes

1.1 Introduction

This chapter, as noted in the thesis introduction, stands in place of a conventional literature review. Section 1.2 is a straightforward survey of the established secondary literature, proceeding mainly from economic-historical and social-historical standpoints, which either focuses directly on brewery issues or has a significant bearing on the events, individuals, practices and theories I discuss in the succeeding four chapters. My purpose is to indicate to the reader which works are significantly engaged by my thesis; which fields have a well-established literature to which the thesis is intended to stand in complement; and which areas are not currently well-covered and would benefit from further research.

In constructing this review, however, I found it useful to consider another category of literature: that which does not discuss my own historical cases at all, but which invokes concepts and methodologies which I have applied, or else sought to challenge, throughout the thesis. Some of this literature belongs, broadly speaking, to the history, philosophy and sociology of science and technology, and some to the economic historiography of industrial development. The material is grouped under three headings: Section 1.3 deals with debates over the nature and purpose of the factory, addressing the consequences of the privileging of textile production in received accounts of the growth of large, mechanised plants; Section 1.4 outlines prior work on the application of quantities and measurements in engendering trust and resolving disputes; and Section 1.5 analyses the relationship between science and technology, drawing in particular on George Basalla's conceptualisation of technological change as an evolutionary process, operating contingently in response to cultural climates rather than as an inevitable, unidirectional consequence of 'scientific progress.' In each section I spell out the relevance of the ideas presented to the beer-brewing case.

1.2 Secondary literature related to the history of brewing

The history of brewing is less well-developed, overall, than that of many other industries. There is, nonetheless, a considerable body of literature: much of this is chronicled in David W Gutzke's indispensable *Alcohol in the British Isles from Roman*

Times to 1996: an Annotated Bibliography (1996), although Gutzke's background in the history of temperance creates a slight tendency towards post-1830 cases and towards accounts of consumption rather than production.[8] In the following paragraphs, I attempt a brief overview both of specialist literature in the history of brewing, and of more general literature which is important in understanding the brewery case.

Beer, malt and hops were one of the key sources of indirect taxation, providing anything up to one quarter of the public revenue:[9] it is unsurprising, then, that brewing has attracted the interest most particularly of economic historians. Six years in the writing, Peter Mathias' *The Brewing Industry in England, 1700-1830* (1959) casts a remarkably long shadow. To this day, the volume is constantly cited — and its interpretations often embraced — not only in Mathias' native field of economic history, but by social historians and historians of industrial development, science and technology. No writer has attempted to supersede Mathias' contribution; indeed, Gourvish and Wilson's *The British Brewing Industry 1830-1980* (1994) was commissioned to stand as a companion volume, notwithstanding that thirty-five years of historiographic change separate the two.[10]

The durability of Mathias' work stems from its remarkably comprehensive scope. Alongside matters which would conventionally fall within the remit of the economic historian today — capitalisation, competition and entrepreneurship, taxation, distribution of the product, and the harvesting and marketing of raw materials — Mathias addresses the class relations and responsibilities of brewery staff, the physical design of breweries and their utensils, "technical innovations" including the steam engine, thermometer and saccharometer, the political tendencies of parliamentarian brewers, and the popular identity of the beer style central to his survey, namely London porter. As Ian Donnachie has noted, it also sheds useful light on the wider nature of the economic sphere in which brewers and maltsters were obliged to operate.[11]

Such a monolithic, unrivalled status for any work presents the obvious danger that its interpretations will escape the standard process of critical enquiry, owing its survival principally to convenience and the force of repetition. The 1959 text, to this day, is

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[8] My thanks to Ray Anderson for this reference.

[9] Mathias 1959: xxiv

[10] Gourvish and Wilson 1994: xix

[11] Donnachie 1979: 248

often the *sole* source for brewery-related content in those surveys, most often in economic history, which treat brewing in parallel to other manufactures. The low social status of beer through much of the twentieth century, and its association with relaxation, revelry and riot, have sometimes led it to be considered an obscure or even flippant field for historical investigation: this view does not now prevail, but has its legacy in a lack of basic awareness of brewery matters, as compared to other industries, among historians in general. Those who now recognise the social and economic importance of the brewery are thus relieved to discover that a way has been prepared for them, and cite Mathias with less circumspection than would otherwise be applied to a work of secondary scholarship which is in places half a century old.

It is therefore necessary to make explicit and justify my decision to recapitulate a tendency in Mathias' 1959 work. In addressing the period 1700-1830, and drawing particularly on London cases, *The Brewing Industry in England* is predominantly concerned with porter, the dark beer which was initially peculiar to the metropolis, brewed on a very large scale by powerful operations applying methods quite distinct from those commonly found elsewhere in England. Mathias is aware of this, consciously using the identity of porter as a framing device, just as Gourvish and Wilson, in their sequel, look principally to lighter and more northerly beers.

The present thesis further investigates the identity of porter, attempting to trace the relations between its unique status and the unique circumstances of its production. Being particularly concerned with themes of industrialisation and scale, I focus on London porter specifically because it is *not* representative of beer as a whole. Where I dissent from Mathias, as will become clear in Chapter 4, is on the nature of the relationship. Mathias suggests an almost spontaneous invention of the porter method, which then proved to lend itself to industrial growth; I assert that porter, as generally understood, evolved gradually in response to the evolving scale of operations, and was only retrospectively set up as a discrete 'invention'.

Later works in the economic history tradition have not engaged the themes relevant to my thesis to the same degree as Mathias' text. Gourvish and Wilson's 1994 volume, covering 1830-1980, focuses on marketing and corporate acquisitions as opposed to material supply and production: it is this, more than the disjunction of periods, which makes it of limited relevance to my survey. Donnachie's account of the Scottish case does give some space to technological development, but chiefly as concerns the 1850s

onwards.[12] Owen's 1978 work on the industrial development of Burton-upon-Trent, which might have placed brewing in the wider context of the emerging technologies of a Midlands industrial centre, is superficial and derivative on technical matters, dismissing or ignoring all scientific innovations except a 'right' understanding of fermentation chemistry, and thereby concluding that brewery science began with Pasteur in 1860.[13]

The Excise administration which determined and policed Britain's indirect taxation on beer, spirits and other commodities has begun to develop a literature in its own right. It is fortunate, for the purposes of the present thesis, that the newly-published volume likely to become the standard work on the subject, Will Ashworth's *Customs and Excise*, comes from a member of the history of science community engaged with current work in the study of metrology, standardisation, and the appeal to 'science' or objectivity to promote acceptance and trust. The gauging and information-processing roles of the Excise, discussed in detail by Ashworth, led to a strong involvement with mathematics and philosophical instrumentation, as demonstrated in Judith Grabiner's study of the mathematician Colin Maclaurin's work on the gauging of molasses barrels. I also draw on earlier work on taxation issues by John Beckett and Patrick K O'Brien.

Other relevant organised bodies in the period to 1830 are less well-covered. The only survey of the Worshipful Company of Brewers, Ball's 1977 monograph, is problematic less for its slightly hagiographic stance (the work was a Company commission) than for its sheer brevity. Although it appears, from the limited secondary material available, that the Company had little institutional power even by 1760, being reliant on its more powerful parliamentary members to articulate its collective views in later years, the mere fact of the Company's existence as a meeting-place and talking-shop for London's common brewers may give it a significance which has not as yet emerged: the limitations of my project have prevented me from making the necessary primary research, although the project would undoubtedly be a useful one.

Another body which would repay further study is the Society for the Encouragement of Arts, Manufactures and Commerce (Society of Arts), which in the 1750s and early 60s had considerable influence in promoting "commercial chemistry" projects of the type

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[12] Donnachie 1979: 181-190

[13] Owen 1978: 89

referred to in my analysis of Peter Shaw: the introduction of philosophical principles into brewing would certainly have been typical of its aims. There has been little work on the Society's industrial and natural-philosophical dimensions, Allen and Abbott's 1992 edited volume concentrating principally on art and the decorative crafts. Many relevant organisations of later date, such as the institutions set up by pharmacists and analytical chemists, and the loose 'trade defence' coalition formed in the late Victorian period, are much better covered but, for the most part, lie outside my survey (though I briefly consider the professionalisation of chemical analysis and pharmaceutical industry in relation to the brewery adulteration question.)[14]

The social history of beer, in many areas, has yet to receive comprehensive treatment. A significant exception is Peter Clark's survey of *The English Alehouse* (1983), but its focus obviously excludes the common breweries, which produced for retail rather than on-site consumption, which are central to the concerns of the present thesis. On a more general scale, Andrew Barr's *Drink: A Social History* is intended as a popular work, and as such is somewhat lacking in original research and systematic analysis. Its project — an integrated social-historical treatment of all drinks, alcoholic and non-alcoholic — has not as yet been carried off successfully in the academic sphere: John Burnett's recent *Liquid Pleasures* is, as David Gutzke notes, somewhat defeated by the scale of its own task, lacking primary research and providing a superficial (if occasionally still useful) survey of the beer case.[15] Rather more useful is Burnett's unpublished 1958 thesis on adulteration, which discusses many of the sources which inform my fifth chapter.

There is, by contrast, a large literature in social history on temperance, teetotalism and perceptions of drinkers and drinking culture: however, my timeframe prevents engagement with most of this work. As Mathias noted, opposition to beer-drinking was almost non-existent prior to 1830: rather, beer was praised as a healthy alternative, for working people, to gin and other 'ardent spirits' — not only for expediency's sake, but on account of a genuine belief in its preserving nutritive properties.[16] When the brewers were attacked in print, it was generally on the grounds that they had moved

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[14] Section 5.5. For the "Trade" movement institutionalised in response to the threat of prohibition, see Gutzke 1989.

[15] Gutzke 2000. My thanks to Graeme Gooday for drawing this review to my attention.

[16] Mathias 1959: xxv

away from brewing beer, in the pure sense of "our own Sir John Barleycorn,"[17] and begun watering it and adding drugs found in the distillery, as in the adulteration controversies discussed in Chapter 5. The political divide which saw temperance Liberals opposing an institutionally Tory beer interest, which has received some scholarly analysis, is also a product of the late nineteenth century: the parliamentary interests of earlier brewers were famously heterogeneous.[18] Nonetheless, some texts concerned mainly with the temperance question, in particular Brian Harrison's classic survey and the more recent revisions of David Gutzke, contain some useful material on pre-1830 culture and on the background to the passage of the Beer Act.

One influence from a specifically history-of-science background has been Otto Sibum's recent series of papers discussing the thermodynamicist James Joule, the son of a Manchester brewer.[19] Sibum, as we will see in Chapter 2, draws attention to Joule's Victorian brewery training as having instilled in him an ethos of, and facility for, considerable precision and accuracy in the use of thermometric devices, and an intimate understanding of their sensitivity to extraneous factors, both of which informed his work on the mechanical equivalent of heat. While endorsing Sibum's position, however, I do not find similar circumstances to hold prior to 1830: precision thermometry, by and large, entered the brewery only indirectly, as a secondary consequence of hydrometry and chemical analysis projects in later years. Sibum's analysis of the 'gestural' nature of brewery communication, however, closely informs my own account.[20]

The general-purpose overview of which I have made the most use is the 1975 *History of Brewing* of H S Corran, then archivist at Guinness's Dublin brewery. The work effectively straddles the line between academic and popular writing, employing some scholarly apparatus and proceeding largely from primary sources. Although it has been superseded in some respects (in particular, as concerns the authorship of several

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[17] *Deadly Adulteration* [1830]: 60

[18] Mathias 1959: 335-6. Most notably, the first Samuel Whitbread was a committed Tory, while Samuel II, who took his father's Bedford seat in 1790, married into the family of Charles Grey and became a prominent Radical Whig. 'The Beerage' — at first referring to brewers as a political force in the Lords — is a coinage of the late nineteenth century. [Gutzke 1984: 107]

[19] Sibum 1995; Sibum 1998a; Sibum 1998b

[20] See Sections 2.1 and 2.5.3

early texts),[21] it displays a particular focus on technological developments, and has proved a useful guide on various brewery instruments and equipment and on the technical development of porter. I have also been guided on the latter issue by Oliver Macdonagh's paper "The Origins of Porter" which, though published in 1964, is a practically indispensable contextualising aid.

Finally, there is a large and ever-growing volume of popular and amateur publications in the field, most of it useless for scholarly purposes. Mathias complained in 1959 of the "unanalytical, antiquarian character of most literature upon the history of brewing":[22] this is perhaps an anachronistic judgment on his nineteenth-century sources' intentions, but could fairly be applied to those recent sources which pointlessly recite the established secondary literature without analysis or supplementary research, introducing errors along the way.

The subject matter seems particularly to lend itself to the kind of folksy, roistering, patriotic treatment — appropriately summed up as "chatty" by Burnett[23] — which was perfected by 'John Bickerdyke' (the journalistic pen-name of a respectable barrister) in his *Curiosities of Ale and Beer* (1886) and has been reproduced, usually with less entertaining results, ever since, pervading even literature produced from a temperance perspective.[24] Problems of reliability affect even the apparently credible surveys which are often invoked in academic work by non-specialists, the most commonly cited being Monckton's 1966 *History of English Ale and Beer*. There are, however, occasional exceptions, to which I have turned where appropriate. Martyn Cornell's

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[21] Corran suggests the anonymous "Country Gentleman" responsible for *A Guide to Gentleman Farmers and Housekeepers for Brewing the Finest Malt Liquors…* (fifth edition, Dublin 1727) as a Cambridge botany professor, Richard Bradley, on the evidence of Bradley's owned translation of Chomel's *Dictionaire Oeconomique*, which apparently contains an identical account [Corran 1975: 95-8.] Jeff Stacey points out that the first edition of the work, which bears the title *Directions for Brewing Malt Liquors* (London 1700), is attributed (in *ESTC* and elsewhere) to the obscure Edward Whitaker; the reappearance of its content in various works of more general reference is easily explained as conventional scissors-and-paste piracy [Jeff Stacey, personal communication, 2 December 2003.] Corran assigns no authorship to the *London and Country Brewer* of 1734-59, which is now universally recognised as the work of William Ellis.

[22] Mathias 1959: 13 n 2

[23] Burnett 1958: 318

[24] French 1890

recent popular survey, in particular, contains significant original research on the porter creation myth, as discussed in Chapter 4.

1.3 Brewing, industry and factories

My thesis characterises the growth of the huge London porter concerns as an instance of industrial development: I feel it is therefore worth addressing the historiography of industrial change, particularly as concerns the development of the factory — which has tended, on the whole, to *exclude* the brewery. It will be useful, firstly, to account briefly for the remarkable identity of industrial porter brewing, which is discussed in more detail in Chapter 4. The zenith of the expanding scale of operations arrived in the 1810s and 20s, when annual output from individual brewery sites began to rise above two hundred thousand barrels a year. Barclay Perkins' records indicate an output for 1826 of 380 000 barrels, or roughly 109 million pints of beer.[25] The greatest of the great breweries — Barclay Perkins, Whitbread, Meux Reid, Truman Hanbury — were behemoth operations, popularly recognised as being among the wonders of the day.[26]

Were the great porter breweries factories? There has never, of course, been consensus on the precise definition of the term. One of the most influential contemporary observers, Andrew Ure, noted in his *Philosophy of Manufactures* of 1835 that some had described breweries and distilleries as factory operations: however, he considered this usage too loose. By Ure's definition, a factory must employ "the combined operation of many orders of work-people, adult and young, in tending with assiduous skill a system of productive machines continuously impelled by a central power," and is "a vast automaton, composed of various mechanical and intellectual organs, acting in uninterrupted concert for the production of a common object, all of them being subordinated to a self-regulated moving force."[27] This definition, at the time, included only the textile mills and "certain engineering works."

Ure's view has helped to secure the mill as the archetype of the early factory, despite the fact that it is based on a narrower definition than almost any subsequent writer has

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[25] Mathias 1959: 551-2

[26] See Section 4.2.2

[27] Ure 1835: 13-4

employed.[28] Donald Cardwell, for instance, whose integration of natural science into the explanation of industrial development has been particularly influential, traces the birth of the factory firmly to the early cotton mills of Arkwright and Strutt: mechanisation was possible at small scale, but "once the way had been opened for large-scale production, then inevitably the economic rewards went to the largest enterprises."[29] The form of the factory, on Cardwell's account, derives largely from the requirements of the machines, particularly as to space and fireproofing. It is simply taken for granted here, and in most accounts, that the advantages of concentration must outstrip any adverse logistical consequences.

In fact, Whitbread's brewery as described in 1819 very nearly met Ure's criteria, lacking only the continuous, regular operation: a brewing must be performed in stages. The central motive power, however, was certainly in place. The powerhouse of Whitbread's plant was a twenty-horsepower Watt engine which, by means of wheels and arms extending in various directions, drew water from the well, ground the malt, turned the oars for mashing and the rouser to keep the hops in circulation during the boil, and drove pumps to carry wort and beer around the brewery. Moreover, this centralised arrangement *preceded* the installation of steam power, being of mid-century origin (the Watt engine was installed in 1784, and upgraded in 1814.)[30] The central power source had originally been an enormous horse-wheel, through which motion from the steam engine was still communicated to the other equipment; the *Cyclopaedia* notes that, in the event of any failure of the machine, horses could be recalled to drive the wheel — an important consideration, given that loss of power whilst a brewing was incomplete could occasion enormous capital loss.

This arrangement, repeated across London and later in provincial centres, requires explanation. That high output levels should suggest a *large plant* is far from self-evident. We must ask why the capitalist brewers did not develop diffuse networks of traditionally-sized breweries across London: their product had to be dispersed to pubs and remote customers anyway, and they were obliged to develop systems for transportation (drays and draymen) and management of both finances and product in

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[28] Berg 1994: 189

[29] Cardwell 1972: 98

[30] Mathias 1959: 85

the field (the institution of 'abroad clerks' and 'abroad coopers'.)[31] Besides, as Maxine Berg notes, many industrial sites were recognisably 'factory-like' without being large:[32] but it was only as the porter breweries grew, swallowing up larger and larger patches of their localities,[33] that their factory status became distinctly perceptible.

Accounts of the emergence of the factory have tended towards two poles: a traditional focus on the efficiency advantages of large-scale production, grounded ultimately in the theories of Ure and Charles Babbage; and an alternative emphasis (most often Marxist in inspiration) on labour conditions and the hierarchical nature of the production system, stressing the control managers and owners achieve under the factory system. The polarisation was famously highlighted by the titles of Stephen A Marglin's "What Do Bosses Do?" (1974), taking the latter view, and David Landes' traditionalist rejoinder, "What Do Bosses Really Do?" (1986). The problematisations thrown up by the debate are instructive, yet both writers, I feel, proceed from a narrow, textiles-based survey of industrial production. They, and those who have followed, focus on the economics of production, or on the management of labour, but assign no role to the *management of product*.

To give a brief survey of the debate: Landes had claimed, in 1969's *The Unbound Prometheus*, that mechanisation was introduced for its productive superiority, and by itself "compelled the concentration of production in factories" through the unprecedented power requirements of the new machines.[34] Marglin retorts that the advantages supposed to be due to *mechanisation* in fact result from *organisation*. He claims that neither the minute division of labour in the putting-out system (whereby capitalists subcontracted work to dispersed small-scale producers), nor the centralised organisation of the factory system which succeeded it, took place for reasons of technological superiority, in the sense of providing greater or better output for given inputs: the standard arguments for division of labour as put forward by Adam Smith

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[31] Brewery-specific terminology is defined in the glossary at the end of the thesis.

[32] Berg 1994: 190

[33] Ritchie 1992 is interspersed with useful illustrations showing the growth of Whitbread's Chiswell Street plant.

[34] Quoted in Marglin 1976: 28. For Landes' technological determinism, see Berg 1994: 170-1.

(increased dexterity, efficiency of motion, drive to innovate labour-saving machinery) are wholly inadequate.[35]

Rather, Marglin says, the cause was capitalists — a self-consciously superfluous party — seeking to grab "a larger share of the pie." Since workers were capable of producing most goods independently, without being organised, capitalist organisers could only profit by controlling them, firstly by dividing their labour under putting-out (so that the individual worker's product had no value outside the organisation) and then, when the necessary wage-incentives turned out to reduce productivity, by the more direct means of the factory, which Marglin presents as virtually a system constructed for the discipline and supervision of a workforce.[36] Landes, in response, claims that Marglin has missed the prime advantage of division of labour, *cost advantage* (the ability to hire workers with only the minimum skills required for given specialist tasks), promulgated not by Smith but by Ure and Babbage (and subsequently by Karl Marx.)[37] It was this, above all, that made cottage manufacture under the putter-outs' direction preferable; this effectively industrialised rural Britain, and once the division of labour had been established, the possibilities opened up by mechanisation led to the factory as originally claimed.

This tendency to construe the factory as a creature evolved from the putting-out system is shared by both combatants. It is symptomatic of the aforementioned privileging of textiles in explaining industrial change — the shift to the factory system, says Landes, "took place in the cotton manufacture"[38] — and is problematic if we insist on bringing other industries into the fold. In the brewery, there was nothing that could meaningfully be put out. The division between brewing and malting (and malt- and hop-growing) was of course ancient, but any attempt to hive off parts of the brewing process itself would have been nonsensical given the bulkiness of the product and its extreme perishability when part-finished.

Thus, neither perspective accounts clearly for the rise of factory-style breweries, nor indeed for the class of acquisitive, undeniably capitalistic brewers who owned them.

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[35] Marglin 1976: 18-19

[36] Marglin 1976: 14, 21-36

[37] Landes 1986: 587-9

[38] Landes 1986: 602. Landes draws attention to his agreement with Marglin on the origins of the factory in textile putting-out.

Marglin's portrait of capitalists as firmly outside the traditional production structures, breaking the power of the guild system by means of wage-incentives, simply has no parallel in the brewery.[39] Landes' alternative, based on his research on clockmaking, has the capitalist class forming from masters brokering the work of surplus journeymen (and hence from *within* the guild system).[40] This is closer to capturing the brewery case: the large breweries developed from small breweries, and the guild apprenticeship customs of brewing survived industrialisation.[41] But, in London at least, the Brewers' Company lost its grip largely because of a proliferation of small breweries which proved impossible to police.[42]

None of this, of course, is surprising given the reluctance (derived from Ure) to accept breweries as factories in the first place. Yet claiming beer production as 'not sufficiently typical of an industrial process' is question-begging, and attempts to justify the prohibition are confused at best. "A factory," Landes contends, "is not simply a large production unit or workshop. A factory uses power-driven machines, and such units do not appear in Britain before the eighteenth century — first in silk, then in cotton." A brewery, he says, is merely a big workshop, because it is 'large' only on account of the necessities of the manufacturing process; spinning and weaving can be carried on in a cottage, but when "the machines and the engines" overcome the advantages of dispersed manufacture, the factory is born.[43] Landes' argument is faulty, relying on a vague intertwining of absolute physical size and industrial scale. All brewhouses, undeniably, are larger than spinning-wheels, but this is irrelevant: the vast porter concerns developing in London stood in much the same relation to the traditional brewhouses as the textile mills did to the cottagers' equipment. The most successful brewers had the option of acquiring multiple facilities in dispersed locations, and on the whole did not take it: instead, like the factory-owners, they intensified resources on central sites, and in some cases built on-site maltings to centralise the production of materials.

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[39] Marglin 1976: 20

[40] Landes 1986: 596-7

[41] For the survival of apprenticeship customs, see Reinarz 2001.

[42] Mathias 1959: 219-220

[43] Landes 1986: 603

This trend was noticeable from the mid-eighteenth century, roughly contemporaneously with similar developments in textile manufacture. There is no reason to assert that the brewers were caught by some factory *zeitgeist*, merely following where the mill-owners led.[44] The introduction of centralised power distribution began a little later, but certainly preceded the coming of the engines, as the example of Whitbread shows. Landes' fixation with the most power-intensive (and hence water-powered) industries can be seen in the comment that "power production was freed of dependence on site and could move to the centres of population" only with Watt's first rotary engines: there is no place here for the horse.[45]

Where, then, can we find the particular advantages in centralised scaling-up? Most analyses, in privileging cotton, silk and wool, exclude several features crucial to an understanding of the beer case[46] (the same could be argued for spirits, drugs, and many foodstuffs, though it is not my place to argue this here; the brewery is probably the most clear-cut.) Beer is a perishable, at times even volatile commodity: it behaves very differently as regards concentration and dispersal *in its own right*. This, moreover, was widely understood among consumers: in Section 4.2.2, I draw attention to the common perception that it was actually *impossible* to brew porter on any but the largest of scales, its distinctive taste being due to the colossal vats and cisterns used for maturation. Additionally, if an individual gyle showed noticeably unusual or undesirable flavours, a brewer with large stocks could simply blend it into the whole, thus maintaining a relatively standard and uniform product.

These advantages certainly existed prior to the importation of philosophical instruments and quantities into the brewery. Yet, with their advent, new possibilities emerged, which are most readily explained with reference to heat and the thermometer. Small variations in temperature at several stages in the brewing process, as I show in Chapter 2, would affect the character and constitution of the finished beer. While this

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[44] For the early growth of London's porter brewers see Mathias 1959: 21-7.

[45] Landes 1986: 610. In fact, to mill-owners building in established textile areas where all the suitable water-wheel sites had been taken, the horse was apparently the next resort [Cardwell 1972: 103].

[46] The problematisation of the use of cotton to epitomise revolutionary industrial change is of considerable date, though it has not been greatly acted upon. Beales [1958: 50] emphasises the atypical lack of customs and regulation surrounding what was in the eighteenth century a very new trade, and the simplicity and cheapness of early cotton machinery in comparison to other mechanised manufactures.

variability was uncontrolled, it might have been presented as an argument for *small*-scale production: a greater volume, if the brewing went wrong, would occasion a greater loss, and there was a particular perceived danger of unpredictable heat build-up in large bulks (as in the case of grass or grain, sweating in the mow, spontaneously bursting into flame.) With the introduction of the thermometer and attemperation equipment, however, heat could be controlled: it thereafter made more sense to hold large volumes together at a single temperature, minimising instrumentation and supervision. Consisting, for the most part, of bulk vessels and pipes, the centrally-powered, mechanised brewery functioned very well as a system for temperature management.

This is no coincidence: there was unmistakably a wider common context for mechanisation and heat control. Cardwell records that "the foundation of the science of heat", and particularly the establishment of the Fahrenheit scale, permitted instrument makers to produce the compensated pendulum, and other items whose behaviour compensated for the effects of thermal expansion and contraction.[47] What applied to instruments also applied to larger systems. We should note that Andrew Ure (who is cited approvingly by both Landes and Marglin, having noted the importance of both cost advantage and control)[48] also has something to say, in the *Philosophy of Manufactures*, on this temperature-control aspect of the factory system. Heat management is his chief case of the "science of the factory", which he presents as valuable practical learning distinct from the empty theorising of some "university men":

> The measure of temperature on every scale is familiar to the manufacturer… [A]s to exact mechanical science, no school can compete with a modern cotton mill. When a certain elevation of temperature is made to give pliancy to the fibres of cotton or wool, the philosophical spinner sees the influence of caloric in imparting ductility and elasticity to bodies. The thermometer to indicate the temperature, and the hygrometer the humidity of the air, give him an insight into the constitution of nature unknown to the bulk of mankind. Of the different dilatations of different solids by increments of temperature, he has daily experience in the elongation of the immense systems of steam-pipes which heat his mill apartments, often extending three hundred feet in a straight line…"[49]

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[47] Cardwell 1972: 101

[48] Landes 1986: 588; Marglin 1976: 29

[49] Ure 1835: 26

As we might expect, Ure's examples are drawn from textile cases. I certainly do not wish to suggest that temperature was not important in the cotton and woollen mills; rather that the part it played in the brewery was more conspicuous, being easily grasped by consumers as well as producers: all drinkers would have appreciated, if nothing else, the age-old prohibition against brewing in the heat of summer, which the attemperator eventually overcame. Similar processes saw a variety of other properties, quantified on the basis of scientific theory and instrumentation, established in the brewery. Besides heat, the present thesis treats only alcoholic strength, determined (or otherwise) by the saccharometer, in any detail (Chapter 3); an analysis which extended beyond 1830 would witness the routinised quantification of colour, bitterness, acidity and many other features. All such developments promoted the standardisation of product, and hence the validity of large-scale production, which in this period extended beyond London to the ale breweries of Burton and beyond.

1.4 Quantification, standardisation and trust

The particular importance of quantification to the present thesis leads me to engage with recent work on the history of measurement and standards, especially that influenced by the Polish economic historian Witold Kula's metrological survey, *Measures and Men* (1986). Kula distinguishes between *representational*[50] measures, deriving either from the human body (*anthropometrics*) or from the contingencies of production, storage, transport or distribution (for instance, the area of land which can be ploughed in a day), and *conventional* measures, abstractions designed not for convenience or familiarity in any particular case, but for uniform, objective and invariant application. The pre-eminent case of conventionalism is the metric system: having characterised the nature and practice of representational measurement, Kula charts its decline as metric conventions were established in most of Europe in the wake of the French Revolution.

Those who have been inspired by Kula generally seek to overturn or problematise what Graeme Gooday terms the *metrological fallacy*: "the view that well-defined universal standards and units are somehow necessary and sufficient to facilitate the practice of measurement and thus that the history of measurement consists in explaining how past

[50] The coinage, in its English form, is due to Kula's translator, Richard Szreter. [Szreter in Kula 1986: 3 n]

measurers overcome the lack thereof."[51] Kula's detailed studies of pre-universalist measurement practices demonstrate that measures with plural, variable or negotiable values cannot be written off as chaotic or confused: such measures were conformed to each other by shared understandings which, while exhibiting much complexity redundant to a modern user's needs, were clear and appropriate to those who had grown up with them.[52] The metrological fallacy, then, displays an unwarranted presentism, of a kind the historian of science will immediately recognise, in making the system which now dominates — and which natural scientists endorse and apply — a necessary progression from an ignorant past, rather than a contingent choice to be explained.

In Kula's analysis, this explanation focuses on social and political power, so that a plurality of measures is taken to reflect a patchwork of localised authorities; often, such authorities were involved in transactions in their own right, and would impose different measures for buying and for selling to ensure systematic profit.[53] Centrally dominant powers, by contrast, were keen to establish universal measures, as in the French Revolutionary case. Developments in British beer production and consumption certainly bear at least some parallels: localised and representational weights and measures lost ground following the establishment of the Excise, a state-sanctioned mechanism for the gathering of indirect taxes. The Excise had an interest in imposing sole standard measures: it levied but did not trade, and it positively benefited by the disruption of localisation, for localised 'understandings' meant the possibility of concealment and corruption, to the detriment of the national revenue.

What sets the case apart from Kula's principally Polish and French examples is the early date at which the Excise began to make its presence felt. The standardisation of lengths and volumes plays almost no part in my analysis, simply because it had become universally familiar, if not necessarily popular, long before the period I address. From 1649, shortly after the first institution of the Excise, its gaugers had the right of direct entry into all brewhouses to examine production.[54] These officers kept records of the volume of each and every mashing, boiling and fermentation vessel in

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[51] Gooday 2004: 11

[52] Kula 1986: 34-5; cf Gooday 2004: 13-4

[53] Kula 1986: 166

[54] Ashworth 2003: 99

the brewery; the brewer was required to notify the Excise prior to every brewing, and the itinerant gaugers would establish the volumes produced, on which the duty payable directly depended, measuring by the aid of rods, canes and plumb lines. The inevitable irregularities of the vessels had fiscal consequences, and the profession of gauging became a mathematically sophisticated one, with a specialist literature developing the principles of volumetric estimation.[55]

Whatever their localised customs, then, the brewers were forced, for their own fiscal well-being, to comprehend and allow for a very broad standardisation of volumetric policy. (Whereas Scotland and Ireland were subject to different taxation policies from that applied in England and Wales even after Union, the volumetric practices of the emerging gaugers' profession were relatively uniform across these divisions.) Attempts at fraud, such as the conveying of worts or beer along concealed pipes, led to the Excise additionally being given a say in the basic layout of the brewery apparatus, a measure enacted in 1697.[56] A similar degree of control applied in the production of malt.[57] Spatial values, then, were already heavily standardised in a brewery context by the 1760s, when my story begins. [58]

The imperative of responsibility to the Excise is one significant explanatory factor in the development of brewery standardisation and quantification. But it cannot explain those developments which are seen to emerge from within the brewery itself — most significantly the swift establishment of thermometry in the late eighteenth century, in a context of no initial Excise significance (Chapter 2 of the present thesis.) Further, any strong appeal to the state-sanctioned power of the Excise risks begging the question: legislative measures could and would be resisted by the brewing and agricultural interests unless they were deemed at least tolerable on all sides. The story I have to tell concerns, specifically, the arrival of particular quantities and measurement approaches held to be 'scientific', promoted by the proponents of standardisation, replicability, quantitative precision, analytical reduction and textual communicability.

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[55] Ashworth 2003: 210-4, 280-298; Grabiner 1998: 150-1, 154-6

[56] Ashworth 2003: 212

[57] Ashworth 2003: 214-9

[58] The relative uniformity within Britain and her colonies is cited as the reason, in the nineteenth century, why the metric system did not take hold there. [Kula 1986: 280]

It is this process which has received recent attention from historians of science and technology. Kula's own work has little to say here, beyond occasional references to the influence of the French *philosophes* in promoting metrication. Whereas he gives a plausible account of why it suited the Revolution, and later the Napoleonic Empire, to impose one standard system of measurement, we hear far less about why, of all possibilities, the Revolutionary powers imposed rigorously decimal unit measures, of unprecedented conventionality, which were not only hard for traders and artisans to understand, but highly inconvenient to those constituencies in practice.[59] The answer lies in the new measures' universality, their convenience in the most abstract of calculations, and the ready scope for extending their precision without limit: all virtues as seen from a specifically *scientific* worldview. The value of these attributes was in no way 'conceptually prior' to the alternative and much older requisites of manufacture and commerce: tension between the two agendas was immediate and persisted until the scientific perception invaded the production arena.

Dissatisfaction with appeals to the *power* of standardising bodies, or (at the conceptual level) of standardisation itself, has led to an alternative focus, in recent work by both Theodore Porter and Graeme Gooday, on *trust* as a factor in the proliferation of standards and quantities. Porter's *Trust in Numbers* (1995), as the title suggests, discusses the apparent objectivity and impartiality of numerical data: these considerations, he believes, are esteemed by the public as a more trustworthy basis for decision-making than the non-quantitative testimony of 'experts', who are by definition remote from the common experience, and may have intentions contrary to the public good — the result being, of course, that all interested parties attempt to harness 'disinterested' numbers to their cause.[60] Gooday, in *The Morals of Measurement* (2004), casts doubt on the validity of defining a 'public' which acts consistently in the manner described. In different cases, he says, both 'experts' and number-producing systems have been proposed and accepted or rejected as authorities for a variety of reasons; his project is to identify the techniques employed and the reasons for success and failure.[61]

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[59] Necessitating the "Napoleonic compromise." [Kula 256-263]

[60] Porter 1995: 51. Grabiner 1998: 140 applies this insight to the case of the volumetric gaugers.

[61] Gooday 2004: 22

Since notions of trustworthiness are socially constructed, we must expect them to vary by period and by situation. The most influential work discussing the importance of trust has been Steven Shapin's *A Social History of Truth* (1994), on the philosophical culture of seventeenth-century England: here, Shapin demonstrates, credibility of testimony depended heavily on membership of the 'right' (aristocratic, or at least gentlemanly) social circles, and on the impartiality assumed to be implied by material independence — thus excluding those who worked for a living.[62] By the Victorian period addressed by Gooday, class had not ceased to be relevant, but training and institutional background now mattered as much:[63] what had been the amateur natural-philosophical community had now fractionated into various professional interests with their own priorities, assumptions and shibboleths.

My survey falls chronologically between the two, and addresses brewery as well as philosophical definitions of 'trust.' Daryl Hafter, surveying the introduction of standard measures among eighteenth-century French cloth-merchants, notes the standardising bureaucrats' need to translate their practices into "the market-day behavio[u]r of ordinary craft workers":[64] in my survey the standardising role is taken not by outsiders but by the 'scientific' members of the brewery community itself. These brewers could not retain their fellows' goodwill without displaying their work as compliant with brewery traditions and conventions: not necessarily an easy task when their object was innovation, or indeed given that the very act of publication was, at first, deeply unconventional. Nonetheless, by skilful presentation the task was occasionally achieved: Chapter 3 focuses on the strategies of John Richardson of Hull, whose promotion of the saccharometer gives a particularly clear example of the art. Whether this appeal to conservatism was disingenuous, on the part of the innovator, is a question the historical record cannot answer; certainly, it was not carried through in practice, as the description of changing processes in Chapter 4 will make clear.

1.5 The relationship of science and technology

My institutional background straddles the fields known conventionally as 'history of science' and 'history of technology'. This, it could be argued, is reflected in my

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[62] Shapin 1994: 380, 396-7

[63] Gooday 2004: 26

[64] Hafter 2000: 71

particular focus on the relationship between the art of brewing (a technological process, in the historical and anthropological sense of the term) and the results of natural-philosophical and early professional scientific enquiry. It will be useful, then, to provide some account of the relationship between the two.

One interpretation — which, although considered old-fashioned within both specialist fields, persists in more general literature — assumes a one-way dependence relation: science is the motor driving technological change, the flow of 'pure' scientific discoveries being 'applied' to create new and improved technologies. Such an account would cast practical brewery innovators in an entirely reactive role, subordinate to the scientific theorists — not because of any social distinctions between brewers and scientists (though this might exist), but in virtue of the alleged conceptual priority and superiority of 'science' itself. The interpretation, then, proceeds from the same grounds as the claim for quantities and standards as inherently valid and inevitable 'natural' developments which was dismissed in the preceding section. Recent challenges to the interpretation accordingly echo and reinforce work on quantification and standardisation, characterising technological changes as contingent acts, established by appeal to particular audiences and cultural values, and comprehensible only in social terms. Here I make this kind of claim for the technological innovations which underpinned industrial growth in the brewery.

A particular influence is George Basalla's theory of the *evolutionary* nature of technological change. Basalla is concerned to overturn the belief (again persistent in non-specialists' accounts) in technology as a progressive force which develops in discontinuous upward leaps, through the kind of 'flashes of inspiration' traditionally ascribed to uniquely talented and single-minded inventors. This tendency is the counterpart of the telescoped, monolithic 'genius figures' and 'crucial experiments' which have been so widely discredited in the history of science; it also proceeds inevitably from the account which subordinates technology to scientific progress which I have just mentioned. If technology is merely following a necessary, inherently 'correct' scientific progress, it, too, must follow a *directed* pattern: there is a 'right' way to go, if only it can be seen. Inventors, on this view, find their way to new points along the path in fits and starts: they may make wrong turnings, but since the result of these is either embarrassing failure or shrewd backtracking, they are of no historical importance. When an inventor achieves a significant breakthrough, on the other hand, it is unsurprising that he is elevated to fame: his peers, since they are all following the

same path, find the improvement self-evident once it has been pointed out, and universally respect the insight they did not themselves achieve.

It is a long time since the history of science was written in this way: countless studies draw attention to the controversies which have raged, in all periods, over what could be deemed true, trustworthy, or worth pursuing at all; combatants' systems and terms of reference shown to be mutually incommensurable; geniuses of 'pure science' revealed as geniuses of self-promotion, mobilising social groups and cultural standards, and writing their opponents out of history. The 'directed' account of technological change, then, must fall. In its place, Basalla proposes an analogy with natural selection: changes in the use of technologies take place, as new modifications prove more successful than rival possibilities; the changes form an unbroken lineage which can fairly be termed 'development'; but there is no *progress*, because there are no universal standards. As in Darwinian nature, the proliferation and consequent establishment of a given modification are due only to its being fitted to *the particular environment in which it operates*, here represented by a variety of contingent factors — the physical environment, the wider technological systems with which it must be integrated, the humans who produce, consume or have some intermediary role in whatever the technology does, the cultural norms of the society or societies into which the technology is received. Changes in any of these could radically upset perceptions as to what the 'best' technology might be.

The analogy with natural selection is only partial — human agency is of course required, and technologies, unlike Darwinian beings, do not show a branching speciation, their more exotic hybrids often proving very fertile indeed — but does follow modern Darwinism in showing divergence as building up from minor 'mutations.' (These are most tangible in the tinkerings of innovators, but would have to occur in any case: imitation with positively no discrepancy is impossible, even when the copyist is the original maker.[65]) Basalla's case studies of mutation in action are plausible, but he is left with the task of explaining the prevalence of the alternative account mentioned above, which could be termed a 'saltation myth'. This is the view that inventions really are 'great leaps', quite different to their nearest forebears, or, occasionally, that they are unlike anything that has been seen before, as in the writer

[65] Basalla 1988: 103

William Cooke Taylor's extraordinary 1842 description of the steam engine as an invention entirely without precedent.[66]

Basalla ascribes the notion of discontinuity to a variety of contingent factors: patriotic or chauvinistic desire to tether a popular 'invention' to a particular place and time; the Smilesian ethic of industrious self-improvement, building moral lessons by the association of 'great men' and 'great deeds', which prevailed in the Victorian era; and the patent system, which could almost be regarded as a system for constructing discontinuities.[67] And the concept of science as the motor driving technology, which serves to underpin the whole notion of technological progress, is just another such construct: it was not firmly established until the twentieth century, as academic science collaborated with commerce and the State in the formation of major research laboratories, and has been projected back to periods where it is untenable — if, indeed, it is tenable at all.[68]

How, then, *does* technology relate to science? Nobody has suggested that it is actually entirely independent; yet science is increasingly perceived to be one influence among many. Basalla's account draws on the work of Brooke Hindle, who accentuates the roles of art, architecture and other 'creative' disciplines in technological innovation. Technology, including machinery, vastly predates the reductive scientific project; the principles held up by the 'men of science' "described only the smaller part of the elements and processes required to put together a working machine. In fact, even today scientific principles are no more than important data used by the machine builder…" Hindle invests sufficient power in alternative design resources as to suggest that the chief objects of his study, the steamboat and telegraph, might have arisen without most of the 'pure science' which modern scientists and engineers tend to regard as their conceptual underpinnings.[69] Along the same lines, Sungook Hong has recently drawn attention to engineers' lack of reliance on science, suggesting that "science-based industry", in the late nineteenth century, developed primarily not in

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[66] Basalla 1988: 35

[67] Basalla 1988: 57-62

[68] Basalla 1988: 91-2

[69] Hindle 1981: 132-3.

well-established branches of engineering, but in newer fields where alternative resources to science were not available.[70]

The contingency of the scientific influence is borne out by the results of my own study. Industrial porter-brewing, described above, presents a case of a technological operation which originally developed owing to non-'scientific' factors, but later — for entirely contingent reasons — moved to embrace natural-philosophical methods as well. These methods, furthermore, were not straightforwardly transferred into the brewery as the foundation for obvious industrial 'improvements': technological innovations, like quantities and standards, are accepted only when other considerations additionally hold.

To begin with, a *route* for transfer, by direct communication or by broadcast literature, is trivially necessary but not always trivially available. We need some account of *which* artisans assimilate the theories of natural philosophers and scientists, *how, why* and *where*, which I aim to provide in the present thesis. An important influence has been Hong, who offers a concise but convincing overview of science–technology relations in general from the time of the Renaissance: his "boundary objects", singled out as strong connecting forces between the two worlds, have direct relevance in the brewery case. The first boundary object is the philosophical *instrument*, retailed to experimenter and commercial producer alike: in the following two chapters I explain the significance of thermometers and hydrometers, and the texts which promoted them, in establishing an identity for 'scientific' brewing. The second boundary condition is the shared social space, in which ideas could be transmitted: Hong points to the institutions of the coffee-house and the Literary and Philosophical Society, and — as will be seen in the case of John Richardson (Chapter 3) — the 'scientific' brewer would be at home in both. By the nineteenth century, boundary interaction has created "hybrid people" who move in both worlds.[71]

There are further requirements in order for an innovation to spread. As noted at the conclusion of the last section, its proponent must show it to be conformable to the established understandings of the field, and posing no threat to members' key interests. The interests of brewers were by no means equivalent to those of natural philosophers, and might include retaining the goodwill of bodies such as the Excise and the drinking

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[70] Hong 1999: 292-3, 302-3

[71] Hong 1999: 296-301

public, whose concerns might be different again. In order to meet these criteria, 'scientific' ideas may well be modified in the course of their incarnation as brewery technology: the adaptation of brewery thermometers, discussed in Section 2.5.4, shows this effect at work.

A somewhat different consequence of deconstructing the idea of technological progress is the insight it allows us into the means by which acts of quantification become established. Customarily, assertions that a given technological enterprise is 'progressive' rest on firm numerical data evidencing improvement according to some 'objective' standard: Basalla mentions the increasing maximum speeds of vehicles, which can be measured very precisely by undisputed methods. Trust in the numbers, of the kind described by Ted Porter, engenders trust in the validity of the progress they seemingly represent. But this, we can now see, begs the question, since the act of quantification and privileging of the relevant quantity are inseparably part of the enterprise in question, whose whole basis is contingent.[72] Faster cars may not be well-fitted to the world in which they move: a quantitatively-established increase in speed is neither *a priori* progressive, nor 'better' from all practical perspectives. That this has become relatively obvious in the period since Basalla's work was published only vindicates his emphasis on cultural contingency.[73]

We might, finally, go beyond this analysis and state that the act of defining and privileging quantities, which appears to give evidence of 'progress', functions not only as a *post hoc* justification of technological change. It can itself *direct* change, as authorities direct, or competitors concur, that the raising or lowering of the trusted, privileged number shall be their goal. This is especially the case where an 'efficiency' function can be defined: Richardson's project of quantifying the extract of malt and simultaneously establishing it as directly representative of mashing efficiency, discussed in Section 3.3, was sufficient to set in train the abovementioned shift to pale malts. The process, once begun, was self-sustaining, and Richardson did not have to be around to oversee its completion. We might draw a parallel with Thomas Hughes'

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[72] Basalla 1988: 211-7

[73] For an example better suited to current fallibilities, we might take the claim that increasing processing speeds indicate a rate of improvement unique to the computer industry, which ignores all definitions of 'improvement' based on structure, accessibility, usability and so forth.

characterisation of *inertia* in large technological systems:[74] but the quantification case is complex, in that it relies not only on the momentum built up by elements of a technological system, but on trust placed in the privileged quantity, an ostensibly 'pure', abstract notion deriving from the scientific sphere.

[74] Hughes 1987: 76-7

Chapter 2: Heat and thermometry

2.1 Introduction

In 1758 Michael Combrune, an ale-brewer from Hampstead — then a village outside the metropolis of London — published a small work entitled *An Essay on Brewing, with a view of establishing the principles of the art*. His chief focus was indicated by a title-page engraving, the work's sole illustration, depicting a highly curious symbolical scene. A field dotted with stooks of barley is framed on either side by hops trailing up their poles, so as to present the two principal materials of the brewer's art. A motto, borrowed from Lucretius — *Ceres est ipsa ab Jaccho* — hints obliquely at the creation of wine from barley.[75] Above the field, the sun breaks strongly through a cloudy sky, presumably signifying the light of reason penetrating longstanding uncertainty. In the foreground, flying straight towards the reader, is a huge, spread eagle; and from the eagle's beak, rather incongruously, dangles a thermometer with a Fahrenheit scale.[76]

The *Essay* is the first known brewery text to recommend the application of the thermometer, and Combrune enjoys a pioneer's reputation in the internal history of the brewing profession.[77] An enlarged work, the *Theory and Practice of Brewing*,

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[75] In classical mythology the goddess of agriculture, Demeter/Ceres, associated particularly with the cereal crops, is the mother of Iacchus, who is sometimes identified with Bacchus/Dionysius, the god of wine. My thanks to David Levene and George Macdonald Ross for clarification on this point. The source is *de Rerum Natura*, iv, line 1168: "at tumida et mammosa Ceres est ipsa ab Iaccho". The motto has in fact been sundered rather drastically from its original, less wholesome context: Lucretius is commenting sardonically on how infatuation may affect a man's judgment of a woman's appearance, and the tone is well captured by the translation, "The fat girl with enormous breasts is 'Ceres suckling Bacchus'" [Lucretius 1994: 125.]

[76] The bird is, beyond reasonable doubt, intended for an eagle, although the accuracy of the representation is limited: I am grateful to Helen Macdonald for guidance on this point. The eagle was a familiar stock symbol, designated the king of the birds (much as the lion was of beasts), and is the bird most often found in heraldry: see for instance Boutell 1970: 75. The sun breaking through cloud is also a common heraldic device, technically known as a glory or halo. A similar illustration appears in Johann Faulhaber's *Ingeniers-Schul. Erster Tiel* (Frankfurt-am-Main 1630), where the glory is placed centrally behind the bird (probably a dove here), and illuminates the personified Arts; in the frontispiece to Emilie du Châtelet's *Institutions de Physique* (Paris 1740) the glory is touched by a human female figure, while a bird in flight decorates the title page. My thanks to Graeme Gooday for the latter reference.

[77] See for example Corran 1975: 131-2

Figure 2.1: title page to Michael Combrune, *An Essay on Brewing* (1758).

followed in 1762, and thermometry began to feature in other writers' accounts a few years later. In the commercial brewery, use of the device was commonplace by the 1780s, and effectively general by the turn of the century. This chronology may seem surprising given Otto Sibum's recent work on James Joule and the mechanical equivalent of heat: Joule's unparalleled thermometric precision and accuracy, he says, arose from a brewery background which, in the early Victorian period, was newly becoming concerned with standards, scientific instrumentation and the recording of numerical data.[78] My account, in fact, is compatible with that of Sibum, who acknowledges antecedent thermometric developments,[79] but chooses to focus on those precise, legislatively-enforced applications which arose after the instrument had entered general use, such as its application to determine 'standard heats' for Excise hydrometry.[80] Earlier brewery thermometry, by contrast, carried no rhetoric of legislative standardisation or supreme precision: its roots lay not in Victorian thermodynamics, but in Georgian chemical philosophy.

Adequate heat management was (and remains) important at several stages in the production of beer. Malted barley had to be dried by heating, which would determine its colour and the proportion of fermentable sugars that could be made from it. Changes in atmospheric temperature might speed or inhibit the rate of fermentation; either too fast or too slow a process might spoil the beer. Most significantly of all, heat had to be carefully regulated during the intermediate process of *mashing*, the infusion of malt in water to extract the fermentables to produce a sweet solution known as wort. It was generally understood that if this water were too cold, the mash would be inefficient, and an under-strength wort would result; if too hot, the mash would become *set*, clotting into a paste which retained most of the fluid. Warnings against the 'set mash' appear in most brewery literature: the form is essentially standard and unchanging across a period of more than a century.[81]

In order to obtain a suitably moderate heat, various qualitative methods were applied. These tended to have sensory or otherwise corporeal characteristics: observation of the steam rising from the surface, comparison with the heat of blood, or heating to the

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[78] Sibum 1995: 73-106; Sibum 1998a: 745-774; Sibum 1998b: 25-36

[79] Sibum 1998a: 757, where Combrune's frontispiece image is also presented.

[80] Sibum 1995: 87-8

[81] See, for example, [Whitaker] 1700: 12; Combrune 1758: 50; Reddington 1760: 13; Richardson 1788: 283-5; Accum 1821: 54-5; Morrice 1827: 137-8.

highest level the elbow or thumb would bear.[82] Such pre-quantificatory methods, as Sibum has shown, are relatively *incommunicable*: in each individual brewer's case, the means of judgment was a highly personal business, typically built up as the result of many years' experience.[83] Such experience could not simply be passed from one brewer to another, even directly; much less so through the medium of the printed page. It thus falls into the category of unrecorded understandings labelled 'tacit knowledge' by Michael Polanyi. Sibum characterises it more specifically as *gestural* knowledge, in order to capture the reliance on sensory evaluation and manual response which is localised at the level of the individual brewer's body.[84]

Against this background, my project here is to explain the nature, significance and consequences of Combrune's thermometric project. I begin, in Section 2.2, by discussing the extent to which advice about heat could be communicated without instrument-based quantitative measurement. Attempts at explicit communication about mashing heats did not begin only with the thermometer: pamphlets outlining the basics of brewing practice had circulated from the late seventeenth century, and, by the time Combrune began his researches, a brewery text of treatise length was in circulation; furthermore, the possibility for limited non-thermometric quantification of heat existed through the specification of quotients of cold and boiling water, which were mixed as a standard brewery practice.

Section 2.3 addresses the roots of Combrune's scheme, and forms the principal case study, in the present thesis, of the common context which encouraged and enabled a working brewer to embrace and promote natural-philosophical ideas. Combrune professed himself a follower of Herman Boerhaave, perhaps the pre-eminent chemical and medical authority of the early eighteenth century, and makes explicit appeals to Boerhaavian doctrines in his work. Peter Shaw, a physician and popular lecturer who had produced English translations of Boerhaave's chemistry, took a strong interest in Combrune's project, which chimed with his programme to develop "commercial chemistry." I therefore discuss how the nature of this programme led Shaw to lend his patronage to Combrune; yet Combrune's engagement with natural philosophy was not exclusively mediated by Shaw, as is particularly shown by his treatment of heat.

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[82] Mathias 1959: 65-6; Sibum 1998a: 747-8

[83] For a comparable treatment of the dominant nineteenth-century medical ethos, see Lawrence 1985: 503-520.

Section 2.4 describe the thermometric theory of beer management developed in Combrune's works, and the response from periodical and brewery writers. One of the key interpretations informing my thesis is that innovators, whether theoretical or practical, do not simply 'control' their innovations. As Bruno Latour has it, "The fate of facts and machines is in later users' hands; their qualities are thus a consequence, not a cause, of a collective action."[85] I thus account, in Section 2.5, for the outcome that Combrune's Boerhaavian chemical scheme had little impact on the brewery, whereas the thermometer itself — for which Combrune's chemistry ostensibly provided the legitimation — proliferated. Those brewers who incorporated the device into their practices mostly did so in a highly localised fashion which was 'scientific' in the eighteenth-century but not in the modern sense.

Finally, in my conclusion, I indicate how the localised and chiefly diagnostic practice of thermometry contained the seeds of its own transformation into a universally standardised practice, of the kind characterised by Sibum. The scope of the thesis precludes a detailed analysis of heat management after 1830, but I point to two developments by which the proliferation of thermometers led to the eventual privileging of their results over traditional understandings, and a new concern with standards and precision. The first is the growth, from the late eighteenth century, of attemperation equipment, used to fix heat values on the basis of thermometric data; the second, the project of brewery hydrometry, is the subject of Chapter 3.

2.2 Pre-thermometric heat regulation

2.2.1 Heat regulation before 1760

The introduction of published accounts was itself a part of the trend Combrune represented: the evidence on which to base an understanding of heat management prior to the thermometer's arrival is somewhat limited. Short pamphlets, the work of outsiders to the brewery such as the Dutch pharmacist William Y-Worth,[86] were beginning to appear by 1700: although lacking in detail, these generally demonstrate at

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[84] Polanyi 1967; Sibum 1998b: 24

[85] Latour 1987: 259. My thanks to Graeme Gooday for drawing my attention to this reference.

[86] For Y-Worth (otherwise Yworth or Yarworth), an alchemical adept and sometime associate of Isaac Newton, see Figala and Petzold 1993: 174, 179-190.

least an awareness of the need to avoid extremes of mashing heat. The method most often proposed involves firstly heating the water ('liquor' in brewery parlance) to near boiling, then allowing it to cool until the steam subsides to the point where the brewer can see his own face reflected in the surface.[87] The 1690 account of Thomas Tryon offers no operational guidance at all, stating only that the liquor must be "neer boyling hot [*sic*]."[88] Tryon, an autodidact mystic and ascetic promoter of vegetarianism, was subject to the lasting hostility and ridicule of the brewers for claiming (against an almost general common notion of the principles of brewing) that hops should never be brought to boil in the wort:[89] we should note the dangers of assuming that these authors' accounts correspond to the operations of public brewers, who had reason to guard their methods carefully.

Conspicuously absent from these sources, given the established literature on 'sensory' procedures, is the practice of gauging by touch, the literal 'rule of thumb' or dipping of the elbow.[90] The same can be said of the first dedicated brewery manual to extend beyond pamphlet length, the *London and Country Brewer* of 1734-40, published anonymously by William Ellis, a gentleman farmer who otherwise wrote on husbandry and related subjects, and who had gained some brewery experience while serving as executor to a brewing uncle's will.[91] Amid the 330 or so pages of recipes, procedural accounts, hints and tips, and commentaries on related activities such as barley-growing and malting which comprised the more comprehensive editions, we find several sets of

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[87] Y-Worth 1692: 52; [Whitaker] 1700: 12.

[88] Tryon 1690: 21

[89] Poundage 1760: 436; *Every Man His Own Brewer* 1768: 107-8

[90] To date, I have found only one, anonymous text which expressly directs the brewer to gauge mashing heat by sense of touch. [*Complete Maltster and Brewer* 1765: 56, "…as soon as you see the little bubbles rise, or rather the whites begin to roll under the top or surface of the liquor, dip your four fingers in, and if you find it bite sharp, then damp and let off into the malt."]

[91] Ellis 1750b: 376-7. Ellis is often assumed to have been a professional brewer: an attribution to "a Person formerly concerned in a Publick Brewhouse at London" is given on the title-pages of most editions of each part of the work, the second (1736) edition of the first part having the more informative variant, "Person formerly concerned in a Common Brewhouse at London, but for twenty years past has resided in the Country." This did not prevent Ellis, however, from using in the only brewery work to feature his name on the title-page (that of 1761) the unqualified description "Brewer."

directions on attaining a suitable mashing heat, together with accounts of the effects of fire at the malt-drying stage, and of the seasons and climate on fermentation.

Ellis professes himself concerned to "explode the old Hour-glass way of Brewing," where a due degree of cooling was gauged by timing alone: this method he deems too unreliable, stating that the heat is "best known by the Eye."[92] Like earlier authors, Ellis recommends the 'face' criterion, but mention is also made of the alternative approach of lading in a quantity of cold water to the boiling or almost-boiling.[93] It is not part of the *London and Country Brewer*'s intention to give a definitive characterisation of 'correct' practices: Ellis, working to establish a common body of knowledge at a time when expectations, scale of manufacture and limited distribution worked to preclude a standard brewing practice, took for granted the localised character of beer production, relating diverse accounts from whatever sources he could obtain. His recounting of the method of Tryon ("An eminent Physician") is notably sympathetic: "paradoxical" as the non-boiling of worts might seem, suspension of judgment pending "the undeniable Test of a demonstrative Experiment" might open the possibility of "a general Improvement" that would otherwise be missed.[94] It is entirely possible that Ellis' deliberations on this matter influenced later writers with more direct philosophical connections: his pre-thermometric account, then, is not straightforwardly 'pre-scientific.'

One important point illustrated by the *London and Country Brewer*, not hitherto discussed in the secondary literature of the brewery, is that a concept of 'degrees of heat' was well-established prior to thermometric quantification. Consider Ellis' advice on mashing heats:

> Hot Water or Liquor, for amber or brown Malt, by many is taken three Degrees this Side boiling: That is, when the Water is very hot, and the Fire stirred; if then there arise a white Cloud, it is Time to let it run on the Malt… And for pale Malt the Water is heated to the next higher Degree of Heat, which is when the Water appears in small globular Particles, or little Bubbles which arise on the Top, and then it is just Time to let it run…[95]

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[92] [Ellis] 1736: preface (unpaginated.) One account featuring this method is Lightbody [1698?]: 42-3.

[93] [Ellis] 1750a: 97, 221

[94] [Ellis] 1750a: 150-6

[95] [Ellis] 1750a: 262-3

The reference to "three Degrees this side boiling" implies a system of qualitatively differentiated heat states, leading up to boiling point, as follows:

1. Appearance of steam clouds
2. Small bubbles rising to surface
3. (by implication) the 'breaking' point which heralds the onset of boiling
4. The state of continuous boil

The distinction between the third and fourth degrees is borne out elsewhere in the text by mention of dropping bran in to cleanse the liquor "when it is ready to boil or just broke", and by an otherwise cryptic reference to the second mashing liquor, in porter-brewing, being ready when it "is ready to boil, but not boil…"[96] There is no reason to assume, however, that the assigning of these particular 'degrees' had a generality beyond Ellis' work.

The above account also demonstrates that the 'correct' heat state for mashing was understood to be variable — in this case, depending as the malt used was pale (dried with a low heat) or brown (much higher-dried.) Ellis refers briefly at one point to the "fiery particles" of the higher-dried brown malt: the underlying assumption, widespread at the time, is that such malt *contains* some persistent principle of fire, and so will not require so much heat at mashing as the pale.[97] This perception carries through into Ellis' advice on the proper climates in which to ferment beers brewed from different malts. The spring is suited to pales and ambers, "tough Malts, that have the least Share of Fire in them"; October brewing, and a winter fermentation, is recommended for "the brown Sorts, whose Bodies are loaded with igneous Particles, and best reduced into a smooth, temperate Condition, by that frigid Season".[98] The concept of fire impressed within malt was highly durable, surviving, at least as a figure of speech, into the nineteenth century;[99] it also played, as we will see, a subtle but significant role in the chemical work of Combrune.

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[96] [Ellis] 1750a: 97, 221. Cf. the more explicit definition in Combrune 1758: 9.

[97] [Ellis] 1736: 103. For an antecedent treatment invoking the "fiery Particles" of brown malt, cf [Sedgwick] 1727: 30. Sedgwick's text was reproduced in Ephraim Chambers' *Cyclopædia* of 1728 [s v "Malt".]

[98] [Ellis] 1750a: 167

[99] Rees 1819, s v "Porter": "Some kinds of malt, which, the brewers say, have too much *fire* in them…" [Italics original]

2.2.2 Quantification before thermometry: volumetric heat management

William Reddington's *Practical Treatise on Brewing* was published in 1760: a posthumous work, it was most likely compiled before the appearance of Combrune's *Essay*, and as such may be the last genuinely pre-thermometric brewery text. Its section on mashing, invoking the method of mixing cold and boiling water mentioned briefly by Ellis, is decidedly quantitative. Reddington describes the proportions of the two liquids which should be applied for each mash with considerable precision, reflecting the high degree of volumetric standardisation, and sophistication in gauging techniques, which had been imposed (chiefly through Excise obligations) even at this early date. The first mash for pale malt, for instance, requires "twenty-two barrels and one firkin of boiling Liquor [to] five Barrels, one Firkin, and a half of cold Liquor":[100] there being four firkins to a barrel, the formula was specified to the nearest eighth of a barrel in a total volume of over 27 barrels. Further mashings had different specified proportions, and, just as in Ellis' account, the liquors for brown malt are recommended to be a little cooler than for pale.

Reddington, however, professes no universality for his prescription. He is well aware that local contingencies may vary the result, and his advice to correct this is as qualitative and sensory as any:

> Every Brewer should… inspect his Goods, before he takes the next Liquor, that he may know whether he has committed any Error… If part of the Worts only be let out, this can be discovered by squeezing a handful of [the malt]; and if you find [the grains] more greasy and glutinous than common, you should not take the next Liquor so sharp [hot] as usual…[101]

This adaptation bears direct comparison with a comment by Thomas P Hughes, proceeding from his insight that individuals — in this case, brewers — are *components* of the systems they manage: "A crucial function of people in technological systems… is to complete the feedback loop between system performance and system goal and in so doing to correct errors in system performance."[102] The brewers' senses, then, retained an authoritative role in Reddington's quantitative scheme. The overall volumes, we should note, are tailored to Reddington's own equipment, and the

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[100] Reddington 1760: 11

[101] Reddington 1760: 12

[102] Hughes 1987: 54

precision presumably reflects the precision to which his own operations were taken. Other brewers might attain a similar skill, but their figures would not be equivalent to Reddington's: the precision was localised at the level of the individual.

The shift towards *universal* quantitative prescriptions, which do *not* invoke the brewer's pre-established capacity for judgment, came only with Michael Combrune and with the thermometer. It is no coincidence that Combrune professed an engagement with contemporary natural philosophy not shared by Ellis, Reddington,[103] or any other brewing writer of his period. The aim, declared in his 1758 title, of "establishing the principles of the art," hints that the author's immediate concern was not to provide practical guidance to brewers, but to formulate a fundamental understanding of the discipline along the lines promoted by the philosophers of the day in their physical and chemical investigations. Accordingly, Combrune's project was co-opted by perhaps the most influential figure in British chemistry in the early to mid-eighteenth century, Peter Shaw. It is therefore necessary to say something about Shaw's chemistry, his activities in the promotion of philosophical study, and the impact of both on the work of Combrune.

2.3 The chemical roots of Combrune's heat-management scheme

2.3.1 Peter Shaw and "Commercial Chemistry"

Peter Shaw, probably best known as physician in ordinary to George II, has received surprisingly little study in the history of science given the wide dissemination of his works, which exhibit a conscious programme to shape knowledge-building activity.[104] F W Gibbs, writing in 1951, highlights in particular his agenda for the status of chemistry, which, in the early eighteenth century, was still widely considered the province of apothecaries and, as such, outside the philosophical mainstream. Shaw's goal was to raise chemistry to the status of a gentlemanly, "honourable" discipline, a necessary adjunct to the established fields of medicine and natural philosophy. In this

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[103] Reddington, according to the unsigned preface to his work [iii], "had some Acquaintance with most Sciences, but was chiefly expert in Arithmetic and the Mathematics." The sense of "Sciences" intended here is unlikely to have included philosophical chemical theory.

[104] The most recent studies relevant to the present thesis are Golinski 1983 and Christie 1994.

he presented himself as following the path indicated by Francis Bacon, Newton and Boyle, and as an ally of Herman Boerhaave, who as architect of the medical curriculum at Leyden did much to import chemistry into the practice of physicians, and who often invoked a similar lineage.[105]

One of Shaw's deepest concerns was the relationship between natural philosophers and practical operators. His chief totem, unsurprisingly, was Bacon, whose philosophical works he translated. Jan Golinski summarises Shaw's interpretation as follows: the philosopher stands in a position of intellectual dominance over the artisan, handing down to him the rules for the best conduct of his labour; *however*, the philosopher cannot formulate those rules unless guided by practical knowledge, which only the artisans themselves can provide.[106] Accordingly, Shaw made it his business to collect and distribute information on technical practices, seeking in particular "to extend the Business of Chemistry, and render it applicable to the improvement of Philosophy and Arts"[107] and to persuade more writers to address chemical subjects. He marketed a portable laboratory, which might be set up in the homes of those seeking to make their own investigations, and in 1731 presented a course of twenty lectures outlining elementary chemistry "with a view to practical philosophy, arts, trades and business."[108]

In his concluding lecture, Shaw discussed the general contribution chemistry could make in various walks of life. Here he singled out a concept of "Commercial Chemistry", the aims of which would be to increase national productivity to create a surplus for exportation; to better prepare commodities for transportation; and to supply "chemical necessaries" to those who travelled and developed the trade routes. He contended that, with better chemical organisation, England could undersell other nations in the world market.[109] This commercial and technical agenda was ultimately brought to prominence by the establishment of the Society for the Encouragement of

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[105] Some of the arguments in Shaw's 1725 account of Boyle, in fact, derive directly from Boerhaave's inaugural address on taking his chair at Leyden [Gibbs 1951: 214-5.] For Boerhaave's invocation of Bacon and Boyle, see also Lindeboom 1974, esp 43-5.

[106] Golinski 1983: 23-4

[107] Shaw 1730, preface; quoted in Gibbs 1951: 217

[108] Gibbs 1951: 217-218

[109] Shaw 1734: 418-9. Shaw also distinguished philosophical, technical and œconomical (ie, domestic) branches of chemistry.

Arts, Manufactures and Commerce (later the Society of Arts), which flourished from the mid-1750s. While Shaw's physicianly duties by this point meant he could take little active part in the Society, his connections made him a valuable advocate, and he remained an influential advisor to the group.[110]

It should be no surprise to learn that alcoholic drink was one of Shaw's particular concerns. Drink in the eighteenth century constituted a staple of the popular diet, a widely-exported commodity subject to much competition in international trade, and an item of increasing economic importance as governments began to raise excise duties in preference to the land tax.[111] Its multifarious significance is reflected in the prominence it receives throughout Shaw's work. When, in 1731, he published a set of linked essays intended to exemplify his plan for the theoretical and practical development of chemistry, the case studies discussed were Stahl's doctrines on the distillation of spirits, and the concentration of wines to demonstrate Stahl's theory of fermentation.[112] Of Shaw's twenty public lectures, four were concerned largely or wholly with malting, worts, vinegar, wine or spirits.[113] In the delineation of "Commercial Chemistry" in the concluding lecture, Shaw's specific examples were a scheme to supply malt spirit more cheaply than the Dutch, and the production of wines and vinegars (presumably from sugar) in the colonies.

Drink was also a matter in which the chemical and medical aspects were inseparable. As early as 1724, Shaw's anonymous medical tract, *The Juice of the Grape*, had discussed the curative merits of the four chief products of wine — brandy, ardent spirit of wine, vinegar and tartar — and detailed the successful use of wine-based remedies against smallpox, plague, gout, venereal disease and hysterical illness. Ardent spirit is appointed to a central role, as "the principal *Menstruum* or grand Solvent in Chymical Pharmacy"[114]. In this text, too, there are deliberations on the connection between philosophy and practice: "Physiology furnishes [Man] with Materials; chiefly by the

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[110] Gibbs 1951: 233-4

[111] For changes in taxation policy, see Beckett 1985: 285-308

[112] Gibbs 1951: 218

[113] Shaw 1734. Lecture 7, on "Fermentation and Putrefaction", treated the production of wine, vinegar and inflammable spirits; Lecture 10, on "Vegetable Curation", discussed malting and beer-worts; and Lectures 11 and 12 were specifically devoted to "Wines and Spirits" and "Distillation".

[114] [Shaw] 1724: 7

Industry of Botany and Mineralogy. These, Pharmacy hews, and fashions for his Purpose; only the harder and finer are committed to Chymistry, an abler Workman. Lastly, Anatomy shews how, and where to lay each; and Experience becomes Surveyor of the Works."[115] In an intimation of his later project, Shaw notes that he obtained some of his information from practising vintners.[116]

This focus on "wines," moreover, should not be taken as specific to the product of the grape. Shaw's lectures emphasise the claim that all products of alcoholic fermentation are subject to the same rules. Shaw himself claimed to have discovered "as an *Axiom*" that the basis of wines was not anything specific to the nature of the grape, but only "a *saccharine Substance*",[117] an interpretation which also appeared in the work of Boerhaave around the same time.[118] In his lectures, Shaw demonstrates vinous fermentation with raisins, commenting that the experiment "is universal" and can, with only superficial changes, be applied to malt, as to honey, apples and so forth.[119]

Given all this, it should not be surprising that Shaw responded to Michael Combrune's "View of establishing the Principles" of brewing chemically, nor that Shaw's name would have found its way to Combrune as that of a likely and well-connected champion. The circumstances of their introduction are unclear. It is tempting to imagine Combrune, or some brewer known to him, as one of the twenty individuals who attended Shaw's lecture course in 1731 or its repeat performance the following year — this would accord with Golinski's contention that some of those attending probably had "an occupational interest" in the processes presented[120] — although Combrune's indication that he began research only in 1741 speaks against this.[121]

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[115] [Shaw] 1724: iii, ix. Gibbs notes that Shaw, in later life, regarded the content of *The Juice of the Grape* as problematic [Gibbs 1951: 215]; on the methodological point presented here, however, there is continuity with his later work.

[116] [Shaw] 1724: 53-4

[117] Shaw 1734: 120

[118] Shaw's lectures were first read in 1731. As Gibbs points out, Boerhaave first presents the doctrine in the *Elementa chemiæ*, which was ready for press in 1729 but not published until 1732; hence we cannot say for certain whether Shaw borrowed his axiom from Boerhaave, or evolved it independently. [Gibbs 1951: 222.]

[119] Shaw 1734: 117-8

[120] Golinski 1983: 21

[121] Combrune 1762: ii. From his account, it seems clear Combrune is claiming to have begun *thermometric* research in 1741. If this is so, we must discount Mathias' belief

What is certain is that Combrune and Shaw were in personal correspondence by 1758, and that Combrune studied the text of Shaw's lectures, published in 1734 as *Chemical Lectures, Publickly Read at London…* and reprinted in 1755. Shaw's work clearly served as a compositional model for Combrune's: the *Essay*'s inclusion of a glossary of technical terms, for instance, parallels the *Chemical Lectures* directly, with a couple of entries borrowed verbatim.[122] Shaw (by now physician to the king, and a Fellow of the Royal Society) received the *Essay* to look over in manuscript, and praised it in a letter reproduced, with his permission, in preface to the published version: Shaw notes that he "should be glad to see some other Trades as justly reduced to Rule, as you have done that of *Brewing*."[123] The *Theory and Practice*, completed in 1761, contains a dedication to Shaw, stating that the enlarged treatise, "if it can boast no other merit, has that of having been undertaken and finished by your advice and counsel."[124] What this seems to indicate is that the original *Essay* was not prepared in consultation with Shaw: this becomes clearer when we consider Combrune's treatment of the thermometer.

2.3.2 Combrune, Boerhaave and the introduction of thermometry

Combrune's *Essay on Brewing* gives an account of the origins of the thermometer which, like other portions of his work, is conspicuously based on Shaw's account in the published *Chemical Lectures*. Shaw addresses in some depth the question of "how to regulate and ascertain the Degrees of Heat in Chemical Operations; so as to produce the Effects required in every Case": traditional chemists' receipts, he notes, "are full of Uncertainty; their first, second, third, and fourth Degrees of Heat, meaning no precise Degrees, measured by any Standard". Shaw himself discusses a progression of six 'degrees of heat':

First: the heat best suited to vegetation
Second: the heat of the human body
Third: the heat of boiling water

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that Combrune "first took the hint to employ the thermometer in his own brewery from Dr Peter Shaw… following the re-publication of his *Chemical Lectures and Essays* in 1755." [Mathias 1959: 66.]

[122]: Shaw 1734: *Chemical Lectures*, vii-xv; cf Combrune 1758: 1-19.

[123] Shaw to Combrune, 20 July 1758, quoted in Combrune 1758: [vii]. Emphasis original.

[124] Combrune, 1762, unpaginated front matter.

Fourth: the heat of boiling quicksilver, or oil of vitriol
Fifth: the heat of "thin Fusion" of iron
Sixth: the "highest Degree of Heat hitherto known", as induced by the burning lenses of Vilette and Tschirnhaus.[125]

The tendency to assign 'degrees of heat,' as noted in the *London and Country Brewer*, thus had a more general currency. Philosophical chemists, Shaw states, had so far been equally reliant on qualitative distinctions, effectively attempting to communicate the incommunicable: all this might be changed by the adoption of the thermometer, which would guarantee "the necessary Accuracy" in heat determination. Yet, despite the existence of established devices at this time, the project is presented as wholly conjectural; Shaw hints at a graduated scale, with limits at some freezing point and at the boiling point of quicksilver, but no numerical values are introduced.

Combrune, by contrast, advocates the Fahrenheit thermometer and its associated scale in all his published work, and so other influences beside the *Chemical Lectures* must have been in play. Although several makers and scalings were widely known by 1730, none is discussed by name in Shaw's text; Shaw's demonstrator during the public lectures was the instrument-maker Francis Hauksbee the younger, who had marketed a thermometer bearing his own (the so-called "Royal Society") scale, and we might conjecture that this was the device used.[126] Yet Combrune, carrying out his research in the 1740s and 50s, did not consider any scale but Fahrenheit's, which he held to be "the most perfect, and the most generally received."[127]

This may be traced to Combrune's desire to be seen as a disciple, specifically, of Herman Boerhaave, whose name, achievements and doctrines are cited frequently throughout his work. Boerhaave had been a notably keen and influential thermometric proponent from the first decade of the eighteenth century, recommending the device to his students in lectures and writing of its diagnostic merits in detecting the onset of fever. Boerhaave's favoured maker was Daniel Gabriel Fahrenheit, who by the 1720s was making a name for himself (doubtless thanks partly to Boerhaave's patronage) both in the Low Countries and in England, securing election to the Royal Society in

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[125] Shaw 1734: 36-7. None of this material was altered for the 1755 re-issue.

[126] Shaw 1734: 46-7; Gibbs 1951: 218, 220. For Hauksbee's thermometers and the supposed Royal Society endorsement of the scale, see Middleton 1966: 58-62.

[127] Combrune 1762: 26

1724.[128] As the name "Fahrenheit" came to be applied first to any instrument constructed on his model, and then to any bearing his scale, it became the dominant specification in both regions.

The centrality of the thermometer to Boerhaave's chemistry has been well characterised in recent work by Jan Golinski. Boerhaave construed heat in terms of a subtle elemental fire, the medium for all chemical action: the fire was "an agent of change *revealing* the chemical components of bodies and their properties." A device which could indicate the quantity of this fire, then, might be applied in the analysis or regulation of any chemical process: "the thermometer was thus a crucial instrument, key to the mastery of fire. It was, so to speak, a second-order instrument, the artefact that gave humans the control of the cosmic instrument of fire that was the basis of chemistry's claim to the status of an art."[129] Combrune, as we shall see in Section 2.4, became utterly committed to this worldview, rendering every quantity in his system (other than volumes) expressible in degrees of Fahrenheit's thermometer.

The dissemination of Boerhaave's work into English was, as both Golinski and John Christie point out, a complex episode, in which Peter Shaw played a significant role. Shaw published English-language translations, with much original commentary, of both the 1724 pirated edition of Boerhaave's chemical lectures and of Boerhaave's official text, *Elementa Chemiæ*, published to forestall the pirates in 1732.[130] When Combrune, however, cites material from the *Elementa*, his reference is not to Shaw's 1741 edition, but to the earlier translation made by Timothy Dallowe, released with Boerhaave's approval in 1735.[131] It seems plausible, then, that Combrune came to be acquainted with Shaw through a prior knowledge of Boerhaave, rather than the other

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[128] Golinski 2000: 191-2; Lindeboom 1968: 294-7; Middleton 1966: 66, 76-7, 79

[129] Golinski 2000: 190-1. Italics original

[130] The first text, prepared in collaboration with Ephraim Chambers (afterwards compiler of the seminal *Cyclopædia*) appeared as *A New Method of Chemistry* in 1727. The other, translated by Shaw alone and published in 1741, was marketed as the "second edition" of the *New Method*, somewhat disingenuously given that the sources were distinct. Many of the notes, however, were carried through from the first translation to the second; the annotation is in places voluminous and discusses many rival theories to Boerhaave's, to the extent that Shaw's editions are often considered less as translations than as commentaries. [Gibbs 1951: 216; Golinski 1983: 24-5; Christie 1994: 4-12]

[131] Combrune 1762: 169: "[T]he same author, in his *Elements of Chemistry*, vol. I, page 195 to 199, clearly proves…" No date is given, but the title and pagination are consistent only with Dallowe's edition.

way around. Certainly, Combrune shows little awareness of Shaw's other influences: Georg Stahl, whom Shaw also translated at length and invoked as an authority, is not mentioned in Combrune's work, notwithstanding Shaw's Stahlian exposition of fermentation and distillation elsewhere.[132] Presumably, then, it was in Dallowe's Boerhaave that Combrune first saw the thermometer — and with it, inevitably, the name of Fahrenheit — illustrated and commended in the following terms: "Of what infinite use… are *Fahrenheit*'s mercurial Thermometers? How certainly do they point out to us the danger that arises from the Heat in acute Diseases?"[133] This could almost be a description of the thermometer's diagnostic role in brewing at the fermentation stage.

Combrune must to some extent have kept abreast of developments in thermometry after the publication of his known sources. The differences between his 1758 account of the thermometer and Shaw's *Chemical Lectures* text (prepared around 1730) are particularly instructive. Combrune's *Essay* borrows almost verbatim from Shaw on the "very vague and indeterminate" degrees of heat traditionally recorded by "chymists"; yet the characterisation is prefaced with the words "till of late…", indicating that it is now obsolete. Combrune gives a thorough account of the Fahrenheit thermometer and the principle of its numerical scaling, by which "we are enabled to regulate our fires with the utmost precision." A list of heats of notable circumstances and transformations, based partly on Shaw's six degrees, now cites an individual value or range, on the Fahrenheit scale, for each case up to the boiling point of quicksilver (around 600 degrees), thus fulfilling Shaw's project up to the practical limit he had perceived.[134]

Note the subtle shift in meaning of the expression "degrees of heat." Shaw, addressing his general audience in 1734, still applied the term only in its traditional, qualitative sense: the graduations of his proposed thermometric scale are *not* labelled 'degrees'. By 1758, however, the generality of natural philosophers had carried the expression

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[132] Certainly, Combrune was unacquainted with Stahl's phlogiston theory, from which Shaw dissented and which was excluded from Shaw's published translations.

[133] Boerhaave 1735, ii: 245. Lindeboom [1968: 295, n 3] draws our attention to one mystery: the Fahrenheit device depicted in the *Elementa* "seems to end at 96°," which, unless Fahrenheit's scale was not then in its final form, represents normal body heat — thus, this particular instrument would be adapted neither to "acute Diseases" nor to the brewery.

[134] Combrune 1758: 25-8

across into thermometric quantification. That there may have been a great deal of continuity in this transfer is suggested by early thermometric scalings. In 1714, Fahrenheit sent to Christian Wolff a pair of thermometers with textual inscriptions, corresponding to seven qualitative degrees of meteorological significance, and disposed at four-degree intervals along a numerical scale running from 0° to 24°. Fahrenheit later recollected in a letter to Boerhaave that it was from such scalings, by subdivision and extension, that the scale of "degrees Fahrenheit" had ultimately emerged.[135] Christie and Golinski's study of the development of the chemical text in the eighteenth century emphasises how didactic form tends to be preserved across significant changes in theoretical approach: perhaps a similar explanation might be applied to the "degree."[136]

Most importantly, though, the evidence of Combrune's revisions obliges us to dismiss utterly any notion that a brewer's involvement in natural-philosophical writing, in the period in question, could amount to no more than the parroting of undigested theory. Combrune does resort in places to verbatim borrowing; this, however, was then a widespread and relatively legitimate device, and there is evidence elsewhere not only of the integration of sources, but of the independent innovation of theory, relating specifically to the brewery, on the broadly Boerhaavian chemical basis Combrune had received via Dallowe and Shaw. Combrune was bidding to be seen, not as a communicator of philosophical ideas, but as a philosopher in his own right: to see this clearly, we must now turn to an analysis of the system outlined in Combrune's published works.

2.4 Heat management in the works of Combrune

2.4.1 The 'Essay on Brewing'

The thermometer, as the title-page makes clear, is central to the *Essay on Brewing*. Combrune notes the utility of the device in determining not only mashing heats — "a point of the utmost importance with regard to brewing" — but also hop rates, the amount of yeast to employ, and the due boiling times for worts.[137] Nowhere, however,

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[135] Middleton 1966: 71, 74

[136] Christie and Golinski 1982: 243-4

[137] Combrune 1758: 44-5, 67

are invariant values prescribed. Echoing the pre-thermometric writers, Combrune states that the mashing heat, for instance, "must be properly varied according to the driness [*sic*] and nature of the Malt; to its being applied either in the first or last mashes; and in proportion also to the time the beer is intended to be kept."[138] Yet a crucial change is implied: the brewer is to be guided in managing this variation, not by gestural experience as in Reddington's scheme, but by the evidence of thermometric measurement conducted throughout the beer-making process. Combrune, then, was trying to refound the traditional relationship between the character of malt, the heats of mashing, and the period of maturation on a thermometric basis; the 1758 essay is not a volume of practical thermometric advice, but a preparatory text developing the theoretical principles of this relationship.

Combrune's expectations for the applicability of the thermometer are very broad, on account of his conviction that the state of the malt, mash or wort, at any stage, can have appointed to it a direct thermometric representative. Note, for instance, the following speculation:

> If curiosity should lead us so far, we might… determine, by [the thermometer], the particular strength of each Wort, or of every Mash; for if Water boils at 212 degrees, Oils at 600, and Worts be a composition of Water, Oil and Salt, the more the heat of a boiling Wort exceeds that of boiling Water, the more Oils and Salt must it contain, or the stronger is the Wort.[139]

Here we have an intimation of a scheme to quantify wort strength instrumentally, not by gravity, as writers of the 1780s proposed,[140] but by the thermometer. The value of malt is also to be determined thermometrically, and here Combrune turns to an analogy with grapes, applying the universalising fermentation theory — *Ceres est ipsa ab Jaccho* — of Boerhaave and Shaw.

Combrune's Boerhaavian conception of vegetable matter holds it to be constituted chiefly of acids and oils, intermixed to a greater or lesser extent. Unripe grapes are very acidic, but, as the growing season progresses, higher temperatures have the effect of drawing out oily principles: the acids are "smoothed over" by oils, producing the

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[138] Combrune 1758: 44-5

[139] Combrune 1758: 69. Combrune, probably in imitation of his chemical sources, uses the term *salt* to refer to the sweet fermentables: in the late eighteenth century most writers tended to the more specific *sweets* or *saccharine*.

[140] See Chapter 3

sweet, fermentable "acid salts".[141] Malting, says Combrune, is an artificial analogue of this process. Ungerminated barley, "viscous and replete with acids," is ill-suited for the brewing of sound liquors, the nature of acids promoting uncontrollable fermentation leading to putrescence.[142] Malting and drying the barley provides "the proper means for setting the constituent principles of the grain in motion… [thus] the grain hath fewer acids in proportion to its Oils; and, at the different stages of dryness, obtains different properties; in the first stage resembling the fruits ripened by a weaker sun, and, in the last, exceeding the growth of the hottest climate".[143]

Combrune begins to explore this process by finding thermometric values for the lowest and highest heats of drying which will produce malt. Experimentally, he establishes a certain heat below which the steeped barley is prone to regermination and spoiling, but above which it effervesces in water and cannot regerminate. It "first shews this act of effervescence, when it has been thoroughly impressed with a heat of 120 degrees… consequently this may be termed the first or lowest degree of drying this Grain for Malt."[144] To fix the upper limit, Combrune reasons once again from his chief chemical authorities. He cites Shaw's observation that alcohol is produced from vegetable matter alone, and Boerhaave's doctrine that inflammable bodies remain inflammable only so long as they contain alcohol, or some principle like it: the conclusion he draws is that alcohol resides latently in vegetable bodies,[145] and that their nature can be changed by heating only so long as the alcohol within them endures. The highest degree to which the malt may be taken, therefore, corresponds to the point at which alcohol boils and flies away from its receptacle — 175 degrees of Fahrenheit's thermometer.[146]

The next objective, as with Fahrenheit's fashioning of the general temperature scale, is to "determine and fix the properties of the intermediate spaces" between these limits.

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[141] Combrune 1758: 76, 78

[142] Combrune 1758: 137

[143] Combrune 1758: 145, 151. The influence on a wine's composition of the circumstances of its growing is alluded to in [Shaw] 1724: 5.

[144] Combrune 1758: 181, 167. Elsewhere in his work, Combrune occasionally gives 119 in place of 120°.

[145] An apparently widespread view which was subsequently attacked in, for instance, John Richardson's 1777 *Theoretic Hints on an Improved Practice of Brewing Malt-Liquors* (reproduced in Richardson 1788). See Section 3.3.3.

[146] Combrune 1758: 168-70

Combrune devotes several pages to a procedural account of an experiment in which a pan full of pale malt is gradually heated, with constant stirring, over a charcoal fire. He draws attention to the colour change, through orange and brown to black; as the thermometer showed 180°, the heap "grew black apace", and he judged all the truly-malted grains to be thoroughly charred; yet he pushed the fire on until most of the heap was reduced to cinders. On the basis of his observations, Combrune draws up a table relating colour to temperature of drying, such as would allow the brewer to assess the value of the malt he purchased.[147] The observation that some of the corns are entirely black at 175° is taken to give reasonable support to the latent alcohol theory; as a further confirmation, Combrune notes, the sensory effect of performing this experiment "greatly resembled the case of inebriation," as would be expected if boiling spirit from the malt was escaping into the surrounding air.[148]

Working from the acid-oil chemical theory, Combrune presents this range of thermometric malting values as having considerable practical significance for the brewer: it determines the times at which beer made from the various malts will fall into — and out of — drinkable condition. The palest malt, at 120°, contains many acid principles and ferments rapidly, so that the beer is ready to drink in two weeks; if stored much beyond that point, however, it will become putrid and sour. Drying to a high brown at, say, 152°, on the other hand, draws out oils to retard the fermentation, so that the beer may remain in a preservative state for many years; and yet, for the same reason, it may take fifteen months' maturation before it first becomes drinkable. Given that different traditions, locations and contingencies promoted a wide variety of different storage periods, various malting heats might be sought after.

To this end, Combrune provides a table, "shewing the Age Beers will require, when properly brewed from Malts of different Degrees of Dryness".[149] The approach, finally, is then extended to cover the beers' propensity to become fine, as the matter causing cloudiness drops out of solution. When the malt is dried to between 119° and 138°, the beer will fine itself spontaneously as it comes into drinkable condition; from 138° to 166°, the beer can be artificially fined with additives such as isinglass; above

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[147] Combrune 1758: 183

[148] Combrune 1758: 171-8

[149] Combrune 1758: 188

this level even artificial methods may not work.[150] The *Essay*'s "principles of the art," then, centred on a relationship between malting heat and maturation time, with reference to which the informed brewer could manage his overall production. Techniques for ensuring that the beer was "properly brewed" were not treated in any detail, nor was such a treatment part of the *Essay*'s agenda.

2.4.2 Response to the 'Essay'

It is hard to determine how widely Combrune's theory was propagated in the years immediately following 1758, though the dedication of the *Essay* to the members of the Worshipful Company of Brewers suggests an obvious means of transmission among fellow practitioners of the art. Combrune himself later claimed that the work had "engaged the attention [and,] I may add, the favor of some good judges [who] have allowed my principles to be, at least, plausible…"[151] This judgment is not borne out by reviews of the *Essay* which appeared in the *Gentleman's Magazine* and *Monthly Review*. The unsigned *Gentleman's* reviewer's response was to condemn the *Essay* as a wordy, impractical concoction of pretended chemical learning, assailing it in the following terms:

> [The author] has scarce given one practical direction for brewing, in any part of the process… he has told us that the whole success of the brewing depends upon the heat of the first mash, but he has no where told us what degree of heat that should be… His principal design (besides making and selling a book) seems to recommend the thermometer, which might as well have been done in 10 words as in 214 pages, of which number this work consists, and in which nothing is discovered, except that the brewers sometimes poison their beer to make it drinkable.[152]

This was followed by a summary of the book's "only propositions from which any practical truth can be inferred", a list of 49 points so tersely expressed as to cover less than three pages.[153] Though both sarcasm and synopsis were common enough devices in periodical reviews of the time, this reviewer seems specifically to have been aiming to convict Combrune of impractical, airy verbosity. The contrast with Shaw's

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[150] Combrune 1758: 199

[151] Combrune 1762: ii

[152] *Gentleman's Magazine* **29** (1759) 59

[153] ibid 59-61

endorsement of Combrune's "right application of philosophical knowledge"[154] could not be greater.

The reviewer's tilt against the absence of concrete directions deserves some attention. Combrune, unlike Ellis, was active in brewing at the time of publication. The implication is that he was careful, in practice, to maintain all the secrecy of the traditionally closed brewery community, in order to avoid antagonising his peers and, no doubt, with a view to his own livelihood: thus, having codified reliable and textually communicable mashing heats with the thermometer, he did not publish them — as would appear to be required by the natural-philosophical ethos of openness he claimed to represent — but jealously hid them away. The point is made more explicitly in a 1763 comment, also in the *Gentleman's*, on an account of brown stout brewing published, in line with Shaw's proposals, by the Society of Arts:

> The success of brewing depends wholly upon the heat of… the first mash; it is therefore to be wished that those who brew would determine this heat by something more definite and certain than the direction here given: If a thermometer was used the first time, and the brewing succeeded, the great point would be ascertained with the utmost precision, and the first trial that succeeded would become a standard for ever. This is the arcanum which the brewers, by profession, keep to themselves, and which a late treatise on brewing, that explains every other particular of the process, leaves wholly undetermined.[155]

To any brewer (even at the present day), however, this claim would seem to have an obvious flaw: a successful mashing heat would not "become a standard for ever" because materials and post-mashing conditions were immensely variable, depending on the malt and hop supplies, brewery utensils, atmospheric conditions, Excise duties and procedures, tastes of the drinking public and a myriad of other factors. The brewers among Combrune's readership would immediately have recognised the local and contingent nature of a numerical mashing heat. We might, however, ask why Combrune did not publish his own values, with that proviso, as exemplars, as Reddington did with his water volumes: it is possible that, on this matter, he was guided not by brewery tradition, but by his ever-present chemical authorities.

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[154] Shaw to Combrune, 20 July 1758, quoted in Combrune 1758: [vii].

[155] *Gentleman's Magazine*, December 1763, 592. Whereas both Reddington's *Practical Treatise* and Combrune's second work, the *Theory and Practice*, were in print by the time this comment appeared, the mention of thermometry coupled with an absence of explicit mash temperatures (which the *Theory and Practice* provides) suggests that the reference is to the *Essay*.

Although Boerhaave recorded thermometric data for his own use, and encouraged others to do likewise, there is (to a modern commentator) a conspicuous lack of figures in the *Elementa* or in his medical works.[156] It should further be noted that commercial value of data is a consequence, implicit but inevitable, of Shaw's agenda for commercial chemistry. The conventions of brewery literature were still undeveloped, and Combrune might fairly have claimed his mashing heats and procedures as 'trade secrets.'[157]

What is interesting is that Combrune did not invoke such privileges. His next work, the *Theory and Practice of Brewing*, could almost be specifically designed to meet the *Gentleman's* criticisms, as its very title suggests. The work is in two parts: the first, the *Theory*, is the 1758 *Essay* in largely unamended form. The second and entirely new part — the *Practice* — lays out explicit, arithmetical computations of the relations between malt character, mashing heats, hop rates and fermentation times, on a basis which is entirely thermometric. The scheme Combrune now proposes, it must be admitted, is intensely complex, introduces novel elements of chemical theory with no counterpart in any of Combrune's authorities, and was later widely dismissed as incomprehensible. Yet it is also presented as the theoretical underpinning to the first explicit thermometric mashing heats expressed in print, and deserves examination for that reason alone.

2.4.3 The 'Theory and Practice of Brewing'

First published in 1762, with a substantially revised "New Edition" in 1804, the *Theory and Practice* makes one key modification to the chemistry of the original *Essay on Brewing*: malt-drying heat is no longer deemed the sole determinant of longevity. Returning to the grape analogy, Combrune notes that the fermentability of the fruit depends on the latitude of temperature they receive over the whole of their growing: those which undergo the greatest rises in temperature from spring to summer ripen the most. In the grain case, therefore, the representative quantity must reflect the whole process of brewing, including the mash.

In the *Essay*, the series of Fahrenheit figures Combrune tabulated against maturation times were straightforward malt-drying temperatures; in the *Theory and Practice*, they

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[156] Lindeboom 1968: 296.

[157] Cf Mathias 1959: 66; Sibum 1995: 85.

"express, not only the degrees of dryness in the malt, but also those of heat in the extracting liquor, to the medium of which the degree of power in the hops is likewise to be added."[158] By "medium" Combrune here intends a straightforward *arithmetical mean* of the Fahrenheit values for the heat to which the malt is dried and the heat of the water in which it is mashed. The "power of the hops" is a correction factor: in Combrune's view, hop value may also be assessed thermometrically. For clarity's sake, I will here refer to the corrected mean which indicates maturation time as the *governing medium heat*, though Combrune introduced that name only in the 1804 New Edition of the work.

Being an arithmetical mean, the governing medium heat is equally affected by changes to the mashing as to the malting heat, and hence so is the maturation behaviour; but this symmetry does not hold in determining colour, taste or strength. Malting heat alone determines whether a beer will be pale or brown, or whether it will have the characteristic taste of a high-dried brown malt; as to strength, Combrune states that the optimum malting heat is at the bottom end of the permitted range, whereas the mashing heat must be carefully steered between the familiar, traditional danger zones of inefficient extraction and the 'set mash.'[159] These differences mean that 'right mashing heats' can be determined from the character of the beer desired. Typically, the malting heat is set according to the intended colour; the required governing medium heat is found from the requisite maturation properties of the brew; and the mashing heat, the unknown quantity, is then established arithmetically from its relationship to these two knowns. The relationship is discussed in terms of four chief modes of brewing:

1. Malt dried as low as possible, in order to optimise strength, but the mash is taken much higher, so producing a relatively high governing medium heat. This beer will become drinkable at length, thus giving the advantages of a period of ageing, but will still become fine spontaneously. This is the process for pale keeping beers.

2. Low-dried malt, mashed at low temperatures, giving a low governing medium in order that the drink will be fine and drinkable as soon as possible, as is required for common small beers, brown ales and other high-turnover running beers.

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[158] Combrune 1762: 135.

[159] Combrune accounts for 'setting' as the result of excess heat causing the air present, "which is a principal agent in resolving the malt," to be expelled. [Combrune 1762: 9]

3. High-dried malt mashed at a yet higher temperature, producing a high governing medium. This beer can endure a long maturation time and will fine only when precipitated, thus improving controllability. These conditions are characteristic of London porter and strong brown keeping beer.

4. Very high mashing temperatures, ensuring a high overall variation throughout the process which produces soft, sweet drinks analogous to "wines formed from grapes ripened by the hottest sun", as required in amber and twopenny ale.

Thus, the established methods for brewing *all* the main beer styles then in use are presented as rational consequences of Combrune's chemical theory. A series of worked examples is given: the delineation of mashing heats for pale keeping beer, for instance, is digested numerically in a column of figures which may be summarised as follows.

- "From its name" (and also to maximise strength), the palest malt is used, giving a malting heat of 119°;
- the intended governing medium heat is the highest permitting spontaneous fining, 138°;
- beer in this style must be well-hopped: Combrune specifies 10lb of fine hops and, presumably proceeding empirically, states the "value of the virtue of the hops" at 3°, which reduces the governing medium to 135°;
- the mean mashing heat should thus be 151°, 135° being the mean of 119° and 151°.[160]

It should be noted that, conventionally at this time, brewers subjected each load of malt to *several* mashings, at different temperatures, and that Combrune's formula indicates only the mean of these values. The variation from coolest to hottest mash is determined by a further and highly involved set of calculations which sometimes lack clear justification in Combrune's narrative, and are replaced by entirely different stipulations in the 1804 New Edition.[161] They do, however, result in concrete figures: 138° for the first mash, 164° for the last.

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[160] Combrune 1762: 138-140

[161] Combrune's theory states that the interaction of oils drawn out by heat with the malt's acids renders it not only fermentable but *saponaceous* (again referring to the soluble sugar, or sapo, of the malt) and hence transparent. The difference of 38

For porter, the same arithmetical process is applied with different constraints. The beer is darker, so a malting heat of 138° is specified. The governing medium heat must also be higher, since this style of beer is customarily fined artificially: assuming a typical maturation period of eight to twelve months, Combrune selects 148°. Porter has a high hop rate which Combrune takes as equating to 3¾ degrees: the corrected governing medium heat is then a little over 144°, giving a mean mashing heat of 150°. Combrune's rules for mash variation establish the first mash at 144° and the last at 162°, an *ad hoc* addition of 2° being made to both values "for what is lost in [the extracts'] parting from the malt."[162] In the section on small beers, more empirical corrections are added to take account of the heat of the air, determined thermometrically, since these beers are the most acidic in nature and prone to spoilage in hot weather. A table lists the appropriate malting and mashing heats for atmospheric temperatures ranging from 35° to 60°.

Much of the finer detail of Combrune's arithmetical system and its chemical underpinning alters considerably between 1762 and 1804; both versions feature empirically-derived or wholly unexplained correction factors, and neither would be easy to apply in practice. We cannot assume, however, that Combrune *did* intend to give any imitable demonstration of how to derive the relevant heats: to satisfy both his

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"saponaceous degrees" between the lowest heat of malting (119°) and the onset of blackness or charring (157°) is deemed to represents the greatest divergence in heats which should be applied across the brewing process "for any intended purpose." [Combrune 1762: 135-6] Combrune's formula to find the lowest mashing heat, which invokes this divergence, is especially difficult to follow in the worked example for pale keeping beer, since certain distinct variables have equal values. The computation invokes, obscurely, the chosen governing medium heat figure *without* the correction for hops, ie 138°: since the malting heat is 119°, the mash heat which would theoretically give this medium of 138° is 157°. This figure is named as the "highest saponaceous extract"; subtracting the abovementioned 38 saponaceous degrees from 157° gives the "lowest saponaceous extract" of 119°. The "middle sapo" or mean of these two values, namely (once again) 138°, is nominated as the heat of the first mash. Since the mean of the mashing heats for this beer has to be 151°, the highest mashing heat is thus 164°.

[162] Combrune 1762: 156-7. The process is as above, except that porter possesses less than the full 38 "degrees of saponaceousness": from another empirical table, Combrune gives a value of 32°. The uncorrected governing medium is 148°, which, with the malting heat at 138°, entails a theoretical highest mash of 158°. This is the highest saponaceous extract: a range of 32 saponaceous degrees gives us a lowest saponaceous extract of 126°, and a middle sapo (the mean of 136° and 158°) of 142°. Thus 142° should be the lowest mashing heat, and 160° (to give a mean of 151°) the highest. As discussed in the main text, however, Combrune adds 2° to each value, giving 144° and 162°.

critics and his own original intent, it was necessary only to provide a concrete list of thermometric mashing heats for each mode of brewing, and a plausible explanation for the reliability of those heats in natural-philosophical terms. In Combrune's numerous arithmetical demonstrations — which are presented in a columnar form that probably echoes familiar brewery book-keeping conventions — the mashing heats tend to appear in the middle steps of calculations, rather than on the bottom line, as if to confirm that the chief intent is not to explain their derivation, but to convince the reader of their validity. Combrune assumes an audience unfamiliar with algebra,[163] and the formula for determining an unknown mashing heat directly is never given.

Performing the necessary rearrangement would, in fact, produce the following:

$$\textbf{mean mashing heat} = 2 \times \left[\textbf{governing medium heat} - \textbf{value of hops}\right] - \textbf{dryness of malt}$$

This relationship illustrates an important point. As noted earlier, brewery tradition had it that heat ("fiery particles" in Ellis' terms) was impressed upon, or stored within, the malt, in proportion to the heat applied to dry it, and that consequently the higher-dried malts would require lesser mashing heats. Combrune, in fact, dismissed this belief as incompatible with chemical reasoning: fire is of a highly "subtile" nature, prone to flying off from solid bodies, and cannot be contained for any length of time even in much "closer" materials than malt.[164] But, notwithstanding this objection to the traditional view, Combrune's method conspicuously preserves its operational consequences: for any given governing heat, higher-dried malt is still best managed by a cooler mash.[165] Whilst the heat itself could not be preserved in the malt, the Boerhaavian, oil-acid chemical effect of its application could; and, in Combrune's scheme, the latter betokened and was elided into the former.

This ambiguity may be read as a legacy of the fundamental disagreement, amongst natural-philosophical authorities, as to the nature of fire or heat. Boerhaave, and many other continental writers, held it to be a fluid; Bacon, Boyle and their English-speaking descendants considered it as a mode of motion, and therefore fundamentally different from any quality which could, even in principle, be impressed in matter. If Combrune

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[163] At one point in the New Edition, Combrune does present a simple algebraic equation: its symbols are heavily glossed, and its import translated into worked arithmetical examples over several pages. [Combrune 1804: 271-5]

[164] Combrune 1804: 87-8, 98-9

[165] It is only in the New Edition that the use of higher mashing temperatures to offset the characteristics of lower-dried malt is prescribed explicitly: Combrune 1804: 177.

ever consulted Shaw's 1741 edition of Boerhaave on this matter — as seems more than likely, given Combrune's evident knowledge of Dallowe's Boerhaave, his correspondence with Shaw, and the much wider distribution of Shaw's text than Dallowe's[166] — he would have found the translation of Boerhaave's writings on the nature of fire to be buttressed with a very long footnote pointing out this disparity, and describing in detail the rival mechanical view, largely with reference to the works of Boyle.[167] This tendency is typical of the book and, in John Christie's view, "massively undercuts" its function as an exposition of Boerhaavian theory.[168]

Recapturing the traditional relationship did not, however, mean that Combrune was obliged to follow it: by his formula, it holds only so long as the governing medium heat (and thus the intended mode of brewing) is unchanged. Porter, though brewed with brown malt, conventionally had distinctly *higher* mashing temperatures than pale keeping beers. This is no problem for Combrune's system, since its governing medium is also higher; neatly, several of the identifying features of London porter (heavy hopping, long storage, artificial fining) were bound up in its governing heat. Some aspects of this identity were a matter of a few years old when Combrune began his researches; perhaps, then, his scheme was deliberately developed to accommodate newly-developed urban practices which seemed to go against traditional wisdom. Although following an unprecedentedly prescriptive agenda, then, Combrune was still careful to be seen to echo the full range of brewers' gestural practices.

2.4.4 Response to the 'Theory and Practice'

The *Theory and Practice*, like the *Essay*, was addressed in the *Monthly Review*, in slightly more complimentary yet still distinctly sceptical terms. Unlike the *Gentleman's* writer of 1763,[169] the reviewer keenly comprehends the variability and contingency of the brewing process — to the extent of arguing that it would be better to maintain the art entirely disjoint from natural philosophy. "The principles of the sciences are permanent; and no advances in them are valid, farther than they are warranted by positive data, and established rules. Here, and here only, truth is visible

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[166] Lindeboom 1974: 56-7

[167] Boerhaave 1741, i: 206

[168] Christie 1994: 6

[169] Section 2.4.2

to conviction… [The] mechanic arts… are liable to such infinite variations from contingent circumstances, and none more so than those of the Brewery, that no general rules can be universally applicable to them; and particular ones will be too numerous for retention, and for application, consistent with proper dispatch of business." Thus, while Combrune's scheme might be valid, and indeed a useful contribution to the knowledge of the (gentlemanly) "public," it was unlikely to be taken up by the brewers: "calculations and rules *so philosophically, so critically, nice*" would baffle the less adept, and to the "expert artist" would prove so time-consuming that his tacitly-established, "mechanically shorter" modes of management would be preferred.[170]

The life and attainments of the artisan brewer were simply too different from those of the philosopher: "good natural parts, and the exercise of their professions" on a constant basis, gave him "an intuitive dexterity" — unquestionably what might now be termed gestural knowledge — which *more than compensated for* any lack in theoretical finesse. Therefore, it was "feared that in brewhouses where any considerable business is carried on, the introduction of a thermometer to regulate every transaction, will be considered rather as an impediment to their operations, than as the means of assisting and forwarding them."[171] This 'fear,' we should note, was presumably the surmise of the reviewer, who may have had no brewery connections whatsoever; as we will see, it was in houses of "considerable business" that the thermometer first took hold. Yet the first brewery texts to appear after Combrune's appear to echo the reviewer's position. The anonymous *Complete Maltster and Brewer*, of 1765, includes a statement that suitable materials, rather than rules of management, should be the brewer's chief concern, while George Watkins' work two years later reiterates the assessment of Combrune's research as "more philosophical than practical."[172]

1768, however, saw the arrival of a much larger work, *Every Man His Own Brewer* (aimed at those who wished to brew in private families), which shows the appearance of having been revised before publication in the light of, and along the lines of,

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[170] *Monthly Review* (1762) **26** 122-3. Italics original

[171] *Monthly Review* (1762) **26** 122

[172] *Complete Maltster and Brewer* xvi-xvii; Watkins 1767: 3

Combrune's innovations.[173] The anonymous writer mentions Combrune by name, occasionally quoting him verbatim, and includes a table paraphrasing (with occasional alterations) Combrune's values for the relations between malt dryness, colour, time taken for the beer to be in order and precipitation potential.[174] No exactitude is claimed for the figures: the reader is referred to the ease of experimentation with the thermometer to produce sound local results. The writer comments that "[t]he thermometer recommended as the best, is said to be formed on the projection of Fahrenheit; but as this has been long conceived, I may suppose the like fashion is every where attended to, and no great difficulty in providing the right [*sic*] at any instrument-makers in London." His figures are exclusively on the Fahrenheit scale.[175]

This was the first in the series of texts, descended directly or indirectly from Combrune's, which established thermometry and the degree Fahrenheit as general among all but the smallest brewers by 1830. In the transition, however, most of the identifiable features of Combrune's scheme — ostensibly necessary justifications for the application of the device — were lost. The purpose of my next section is to account for this process.

2.5 Thermometry after Combrune

2.5.1 The legacy of Combrune's chemistry

Combrune's name certainly survived into subsequent generations: he is frequently, though not generally, mentioned when the origins of brewing thermometry are discussed. Substantial quotations from the 1758 *Essay* appear, duly attributed, in the second edition of the *Encyclopaedia Britannica* (1778-83).[176] Among the material reproduced are Combrune's tables on the relationships between heat of malting, colour and the longevity of the finished beer; the whole is carried through into the third edition of 1797. From a somewhat shaky start, the *Britannica* was at this time

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[173] *Every Man His Own Brewer* 1768: 44-5, 58-9, 108-111, 180-187

[174] *Every Man His Own Brewer* 1768: 37

[175] *Every Man His Own Brewer* 1768: 184.

[176] *Encyclopaedia Britannica*, 2nd edn, ii, 1378-1385. The entry is a typical piece of scissors-and-paste journalism derived from three sources: unacknowledged, the brewery material from the *Cyclopaedia* of Shaw's co-translator Ephraim Chambers (probably a hack production itself); Combrune's *Essay*; and (also acknowledged) John Richardson's *Theoretic Hints* of 1777.

becoming established, its system of long, synoptic entries on broad topics setting a pattern for later works of reference literature.[177] Its subsequent pre-eminence may in its own right have secured the preservation of Combrune's progenitor status.

This kind of persistence in general-interest texts, however, could not by itself ensure the acceptance of Combrune's theories, particularly as brewers became more circumspect about encyclopaedia literature;[178] Combrune's Boerhaavian acid-oil theory receives undeniably limited coverage in subsequent brewery texts. This does not by itself imply rejection: some authors were content to regard the *Theory and Practice* (as Combrune himself intended it) as a treatise establishing philosophical principles which, having once been published, did not have to be reiterated in their own more practical texts. The author of *Every Man His Own Brewer* clearly finds merit in Combrune's chemical reasoning, vastly preferring it to Tryon's earlier qualitative approach, which he also surveys, and suggests "may or may not be right, as meer [*sic*] assertion dictates."[179] When one of Combrune's tables (relating the atmospheric temperature to the optimum heat for yeast pitching) is reproduced, the author provides the following interesting gloss:

> I must confess, that there seems to be some mistake in this table; but as it is the calculate of an ingenious man, and perhaps false printed, and as an investigation would be too curious for the present design, I must wave [*sic*] my opinion until experiment shall evince its rectitude, or give me opportunity of forming another more correct.[180]

Combrunian doctrines *are* reproduced in several works of the 1810s and 20s. The brewer George Blake acquired a copy of one of the English editions of Boerhaave, and was so taken with the treatment of "the mysterious nature and wonderful effects of Fermentation" as to reproduce it in full in his 1817 treatise.[181] Combrune is one of the chief sources in Forsyth's miscellany of second-hand extracts,[182] while Hayman, without acknowledging his source, presents in paraphrase what is evidently Combrune's salt-oil chemistry and thermometric system.[183] Some writers attempt

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[177] For the early history and organisation of the *Britannica* see Yeo 2001: 170-187.

[178] Worthington 1812: iv

[179] *Every Man His Own Brewer* 1768: 107-8

[180] *Every Man His Own Brewer* 1768: 44-5

[181] Blake 1817: 50-70

[182] Forsyth [1823?]: 61-81, 93-102

[183] A quotation, unreferenced, from Combrune 1804: 166 is given [Hayman 1819: 15.]

updated work on Combrunian lines. Hayman gives a new table stating optimum mashing temperatures for various malts, with the thermometric malt colour values of Combrune's original replaced by descriptions of the mixed malt grists in use in the 1810s. The chief point of Combrunian chemistry is preserved perfectly: paler malts require hotter mashes.[184] John Levesque, a brewer claiming over 40 years' experience, first published in 1836 a scheme of gradations of malt colour (six are nominated) clearly influenced by Combrune, which is also nominated as a basis for mash heat calculations.[185] Levesque's devotion to the "rule of proportion"[186] was such that, in one of his numerous tables, relating hop rate to atmospheric temperature, the proportionation is developed in a way that effectively takes the Fahrenheit scale as *absolute* — the number of pounds of hops required is a simple multiple of the number of Fahrenheit degrees.[187]

Such writers were the minority, however: by and large, the temperature-determined, Shavian-Boerhaavian chemical scheme proposed as an underpinning for thermometry fell by the wayside. Most of those later writers who addressed Combrune pointed to flaws in his thermometric results, even as they reprinted them: none exhibited the diplomacy of the *Every Man His Own Brewer* author.[188] The non-brewing chemists, Accum and Donovan, attacked the experimental validity and the whole theoretical basis of the malt-drying results. Donovan, who was chemist to the Company of Apothecaries in Ireland, in 1830 has this to say of the treatment in Combrune's 1804 New Edition:

> The management of the heat has been considerably misunderstood… it was believed that the degree of heat is what decides the hue [of malt]: now, however, it is ascertained that it is not the degree of heat, but the period of time employed to communicate this degree, that determines the colour. A heat of 175°, slowly applied, will leave the malt pale; while the same degree, quickly applied, will scorch it quite brown. Unacquaintance with this fact led Mr. Combrune into the mistake of supposing that, at this temperature, malt is blackened and burned; and the mistake led him into a variety of others…[189]

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[184] Hayman 1819: 12, 17, and cf Worthington 1812: 50

[185] Levesque 1847: 119

[186] Levesque 1847: [vii]

[187] Levesque 1847: 79.

[188] Accum 1821: 31-2; Stopes 1885: 162

[189] Donovan 1830: 86

The Fahrenheit scale and thermometer, then, could *not* be appointed the representative and determinant of colour. Elsewhere Combrune's experiments are "ill executed and deceptive", and his statements "complex, obscure and affected";[190] the relation between malting and mashing temperature is unpicked — and practically inverted — on the following grounds:

> [I]f the malt has been exposed to a high heat… the starch is more or less scorched… [and so becomes] more soluble in hot water without thickening it… The higher the temperature at which the malt has been dried the hotter the water made use of for mashing may be, and the less must be the possibility of its setting. Hence pale malt, as containing much unaltered starch, must be mashed at a moderate heat; amber-coloured malt, as containing starch in a slight degree scorched, will allow a hotter water; and very brown malt will admit water of any temperature without injury…[191]

Implicitly responsible for this hostility — though nowhere cashed out with specific reference to brewing chemistry — is the rise to dominance of chemical theories incompatible with Boerhaave's conception of heat, which began around the time of Combrune's first publications. So, for instance, Donovan objects that, if a direct heat of 175° was enough to char the malt, the typical mashing process (at similar temperature) would have the same result. Combrune would have had an answer to this in terms of the Boerhaavian doctrine of action through a menstruum; Donovan, in 1830, does not consider this worthy of comment.

Golinski, in his piece on the thermometer, neatly covers the relevant aspects of the move away from Boerhaave. Joseph Black's work on heat capacities around 1760, by establishing the conceptual distinctness and non-proportionality of heat content and bodily expansion, fatally undermined the belief that chemical activities and fermentative motions could be codified in terms of the instrumental action of heat alone, and therefore that the rise and fall of a thermometer could provide a quantity directly representative of chemical state.[192] In rather different ways the oxygen-caloric theory of Lavoisier, which begins to appear in brewery texts after 1800, helped to exclude Combrunian thinking. George Adolphus Wigney, for instance, is keen to overturn the view that the malt's character "is effected [*sic*] by heat alone," stressing the role of atmospheric oxygen in the relevant chemical action: citing the analogy of

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[190] Donovan 1830: 146

[191] Donovan 1830: 145-6

[192] Golinski 2000: 193-200

rust and arterial blood, he ascribes to oxygen the direct colorific responsibility Combrune applied to thermometric heat.[193]

Thus, the evidence seems to suggest, the principal cause of the disappearance of Combrune's theory was not resistance from brewers to natural philosophy, but changing beliefs among natural philosophers themselves. Combrune's marginal status relative to the philosophical community is not totally irrelevant, of course: it presumably limited his ability to innovate and keep abreast of current chemical developments, with the result that his 1804 New Edition (which must have been written towards the end of his life), though substantially revised, nowhere addresses the objections to Boerhaavian heat theory which had arisen in the preceding half-century. Yet the decline of Combrune's thermometric chemistry contrasts strongly with the growth in application of the thermometer itself after 1762, which I trace in the next section.

2.5.2 The spread of thermometry in practice

It is impossible to recapture in any detail how, and when, the thermometer made its way into the large common breweries: as Mathias points out, the devices were small, inexpensive compared to the outlays normally recorded in brewery ledgers, and may in any case have been the brewers' personal property.[194] The only known source on the introduction of an individual thermometer concerns James Baverstock, best known as a writer on the later quantitative technique of brewery hydrometry: on the evidence of his son, Baverstock was an early user, probably some time in the 1760s, and was obliged to conceal the device from his own father, who objected to "experimental innovations."[195] The writer of *Every Man His Own Brewer*, noting the "inconveniencies" of pre-thermometric mashing methods, suggests that the device had been universally adopted in the London porter brewery by 1768,[196] addressing his detailed description of the device (borrowed from Combrune) chiefly to private

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[193] Wigney 1835: 65-6

[194] Mathias 1959: 65-6

[195] James H Baverstock in Baverstock 1824: xiii. The Clows' *Chemical Revolution* asserts that Michael Combrune had to hide his own thermometer from a conservative father [Clow and Clow 1952: 544-5, and hence Sibum 1998a: 757.] This, as Mathias points out, appears to be an artefact [Mathias 1959: 67, n 1.] In primary literature, the anecdote appears only in connection with Baverstock.

[196] *Every Man His Own Brewer* 1768: 39-40

brewers.[197] This chimes with Baverstock's passing comment that "about the year 1780… hydrometers became nearly as generally used as the thermometers"[198] among commercial London brewers, indicating acceptance somewhat prior to that date.

As will be demonstrated in Chapter 4, however, the world of the huge, industrial metropolitan porter concerns was very different from that of small provincial common brewers such as Baverstock's father, and of the yet smaller brewing victuallers and domestic brewers.[199] We may assume the dissemination was a gradual process. The aforementioned texts of 1765 and 1767 make no mention of the device at all: Watkins invokes the venerable criterion of allowing the steam to subside until the brewer's face could be seen in the mash-liquor on a number of occasions.[200] This criterion survived in pamphlet form for many years.[201] John Richardson of Hull, one of the most zealous of early thermometrists, referred in the 1780s to "the long-continued use of this instrument, in my own practice" as against "its occasional use elsewhere," while William Ploughman reckoned the thermometer was "now getting into general use among public brewers" as late as 1797.[202] William Cobbett, attempting to revive the art of domestic brewing in his well-known *Cottage Economy* of 1822, states that the mashing heat should be gauged by a thermometer if it is available, but that, failing this, the 'face' criterion "by which so much good beer has been made in England for hundreds of years" would suffice.[203]

Some impression of the route by which thermometry gradually infiltrated brewers' practice may be gained from contemporary brewing records. A well-preserved running account survives in manuscripts from the Bankside Distillery, London, covering the period May 1765 to June 1772.[204] The distiller's background, requiring an understanding of temperature-dependent hydrometer readings, would have necessitated a familiarity with the thermometer not seen in beer-brewing; what is interesting is the

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[197] *Every Man His Own Brewer* 1768: 180-5

[198] Baverstock 1824: 191

[199] See Section 4.2.2

[200] Watkins 1767: 50-1, 70, 113 and elsewhere, passim.

[201] See for instance *Complete Family Brewer* 1789: 9.

[202] Ploughman 1797: 20

[203] Cobbett 1916: 31

[204] British Library: Additional Manuscripts 39683. Mathias 1959: 67 n 4 notes evidence in the manuscript that one Thomas Cooke was the distiller in question.

gradual transition by which the unknown author or authors begin to incorporate temperature readings for the heat of the mash, which had to be steered between inefficiency and setting just as in the brewery.

At the beginning, only the heat in the underback, *after* mashing and draining (potentially significant to the progress of the fermentation) is recorded thermometrically: the mashing water is characterised by the quantities of "Hot Gallons" and "Cold Gallons". These volumetric figures are retained throughout, but from October 1768 there is an additional column which is ultimately identified as "1st Mash Heat."[205] Whereas the underback heat varies between 36 and 51 degrees (clearly Fahrenheit), the mashing heat varies only from 136 to 138: clearly, although the mash liquor was still mixed from hot and cold water, it was being positively set by reference to the thermometer, ironing out the effects of seasonal variation. The temperatures of second mashes (less critical to the outcome) are not recorded for each brewing, but there is an occasional note of an average figure, generally between 150 and 152°F, so we must assume that this too was held approximately constant.

A set of directions on brewing, also in manuscript and apparently prepared with a view to publication, is bound with these figures: while the absence of a firm date limits its utility, it includes the beer-brewing as well as the spirits case and usefully illustrates the evolutionary nature of the thermometric transition. Some directions are non-thermometric, using proportions of boiling to cold water: the volumes of each which will be required are cited, no doubt on the basis of calculation, to a precision of 0.1 gallon (where seventy or a hundred gallons might be used.) Yet the writer then adds:

> It is true that in this way of proportioning, there will frequently be a great difference in the heat of the first Mash, the Cold Liquor being hotter or colder every day than other as the Air is influenced by heat or cold. Judgment must be used in this respect, the Grist also will vary in degree of heat according as it is ground… the Thermometer only can determine what should be done, and I think there can be no Perfect Work made without the use thereof, when thereby a great degree of nicity may be attain'd…[206]

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[205] It seems likely that the surviving manuscript entries were compiled or copied some time after the original observations were made: they are noticeably 'clean', and one sheet bears an additional summary dated 1791. However, it is safe to assume that the recorded mashing heats really were observed thermometrically at the time, and not calculated retrospectively: any such process of calculation would require so much guesswork as to defeat the object.

[206] The material discussed and quoted here appears in "Chapter 4th, of Mashing."

This is followed by an empirical judgment on the best mashing heats for given seasons, but also by a simple calculation to display the principle of raising the mash liquor's heat to account for the coolness of the grist.

From around 1790, most texts at least mention the thermometer: the handful which do not are generally aimed at the domestic brewer. This, as we can see from Cobbett's account, does not necessarily imply that thermometry was impractical or unhelpful at the smallest of scales: rather, several of those writing for a private audience were keen *not* to represent brewing as a complex or philosophical operation, suggesting the process was as simple as "making a pot of tea."[207] David Booth, in 1829, said the thermometer was "unknown to nine-tenths of the private brewers," implying a contrast with its general acceptance in the commercial brewery.[208] But this view was not general: we may contrast Shore, a private brewer himself, who suggests the proportionation of cold and boiling, but confesses that "great variation in the produce" of his own operations has led him to introduce a thermometer of the kind essential in "large brewings."[209] By 1835 William Chadwick, a butler writing for a domestic audience, saw no reason why a private brewer should not possess both a thermometer and a saccharometer;[210] thermometry even features in the picturesque anachronistic house-brewing depicted by *Blackwood's Magazine*'s 'Christopher North.'[211]

Given the finding that the brewers themselves did not by and large find Combrune's 'philosophical' approach unseemly, their growing use of the instrument he commended is in one sense unsurprising: but our explanation of the theory's decline opens up a wider question. Combrune's unprecedented contributions in the *Theory and Practice*, crudely, may be broken down into two elements: an explicit set of thermometric mashing heats, and a theoretical underpinning for the same. Why, when the second of these elements was demolished by respected chemical authorities, and the once-clear

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[207] Poole 1790: 3

[208] [Booth] 1829: 11

[209] Shore 1809: iii, 61-2

[210] Chadwick 1835: 1

[211] Quoted in Bickerdyke 1886: 61. The piece is undated, and I have not had the opportunity of tracing the original. The work of 'Christopher North' (a sometimes fanciful persona adopted by John Wilson) appeared in *Blackwood's* from 1817 to 1854.

associations between Fahrenheit values and the behaviour of malt and worts were no longer available, did the brewers come to trust the thermometer?

The most obvious answer seems, in this instance, to be the correct one: the thermometer could be applied productively without being universalised. That is to say, the instrument and its 'standard' degree scale could be applied in an intensely local manner: the brewer would set the heat of his wort using the old-established methods of his choice; record a value on the thermometer scale; and, if the result was successful, bring the heat to the same value for the next brewing. Thus, the eighteenth-century thermometer was *not* the basis of a revolution in practice: rather, it was assimilated into the brewer's array of gestural knowledge. The lack of evidence surrounding the thermometer's arrival may in its own right serve as evidence for an uncontroversial transition of this kind.[212]

We should address, finally, what appears to be *absent* from the story of brewing thermometry's introduction. Recent work has considered what Latour would term the *black-boxing* of the thermometer and Fahrenheit scale within the natural-philosophical community: their transition from objects of contention and investigation in their own right to trusted 'givens,' used straightforwardly (in this case, as tools for measurement) and interchangeably by all parties.[213] As Golinski and Hasok Chang note in separate works, Fahrenheit's scale was not associated with a public, replicable means of calibration until the late 1730s (through the work of the Scots physician George Martine, mentioned by Combrune); and that the trustworthiness of the various materials and modes of calibration used were the subject of dispute well into the nineteenth century.[214] Yet there is no trace of such controversy in the literature of the brewery.

It may appear that, through Combrune's work, both instrument and scale sprang fully-formed into the brewery consciousness as reliable indicators of heat: but, since we have observed the limited impact of Combrune's philosophical assertions on his fellow brewers, we cannot accept this conclusion. The true explanation for the absence of controversy, I believe, lies not in orthodoxy but in heterodoxy. Since *every* thermometric brewer (or, given the possibility for shared tacit understandings

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[212] Mathias 1959: 67 presents this account.

[213] For the concept of the black box, see Latour 1987: 2-17, 67-8, 130-1

[214] Golinski 2000: 195, and cf Combrune 1758: 57, 62-3; Chang 2001

communicated gesturally on a shared site, every thermometrically-run brewery) applied the instrument according to individual, locally-determined rules, there were no factions for controversy. This situation was secured by the absence of brewers attempting to exert proprietary control over thermometers or scales, a point discussed in the following section.

2.5.3 Tacit quantification: the absence of thermometric directions

The assumption that brewers in general formed their own practices is strengthened by the conspicuous lack, in almost all brewery accounts which discuss the thermometer, of even the most general directions for its use. This stands in marked contrast to the slightly later innovation of the saccharometer, to be discussed in the next chapter, which from its first introduction was routinely supplied with a booklet of rules explaining its operation.[215] It cannot be claimed that the correct operation of a thermometer was simple, uncontroversial or self-evident. Combrune himself is circumspect over the validity of the readings in the malt-drying experiment, and shows awareness that the thermometer would give different values at different spots within the heap; the practice he adopted to achieve systematic results was criticised by Accum as rendering all his results "fallacious."[216]

The definite mashing heat values in the *Theory and Practice*, however, are accompanied by no definite information on where to place the thermometer, or how long to hold it there, in order to test whether those values have been reached; the author of *Every Man His Own Brewer* who borrowed from Combrune, likewise, gives no particular instructions, only commenting that it is "in every body's power to experiment."[217] Forsyth, writing around 1823, considers the instrument "of so much importance to the maltster, the distiller, and the brewer [all among his audience], that a practical description of it here cannot well be dispensed with"; yet his selected extracts, all from Combrune, give no advice on application.[218] Even those writing for a domestic audience expected to be unfamiliar with the device, such as Chadwick and

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[215] See Section 3.3.1

[216] Combrune 1758: 173-4; Accum 1821: 31-2

[217] *Every Man His Own Brewer* 1768: 36

[218] Forsyth [1823?]: 73

the evangelical Cobbett, give no details.[219] The whole construction of a thermometric practice, then, was left to the brewer and localised at that individual brewer's level.

It might be imagined that the absent directions simply could not have existed. Sibum highlights the difficulties of conveying the brewers' traditional stock of knowledge by textual means: Wigney, his principal exemplar, was well aware that his writings could not directly improve the brewer's experience.[220] We might question whether there *was* any textual formulation which could have aided the intending thermometric brewer, beyond an account of the principles behind the device. Our answer, however, must be *yes*, on the basis of a single, decidedly untypical, and yet overwhelmingly convincing source. Levesque's *Art of Brewing and Fermenting*, first published in 1836, gives the following procedure for regulating a mashing heat:

> Take [the thermometer], and, at arms' [*sic*] length, sink the bulb into the middle of the depth of the goods, the heat of which should not exceed 148°, nor be less than 143°… [Alternatively,] turn all the liquor intended for the first mash, boiling, into the mash-tun, and cool down to the required heat, and then add the malt; but for this method, the heat must be taken… 8° lower… Attention and judgment, united with caution and practice, will render this method… more perfect than any hitherto practised: for, at the time of turning on for the making up the mash, [*sic*] with the man at the copper-cock, the machine, or the oars, working at the same time, and the brewer, with the thermometer in the mash, directing his eye to the index, to ascertain the degree of heat, has only to say the word *stop!* to the man at the cock. The method here pointed out is applicable to every kind of malt… [Yet t]he heaviest and palest malt will absorb the greatest quantity of liquor… The colour and dryness, or slackness, will also cause a variation in the liquor and heat… light-coloured or pale, being much heavier than brown malt, will absorb more liquor in proportion; or, if more liquor is not put to the heavier malt, the heat must be added accordingly.[221]

The overall account is far more operational than that given by Combrune or any of the intervening writers: it deals not only with the physical positioning of the thermometer and the means of allowing for the contingencies of the malt, but with the most time-efficient planning of cleaning and other necessary operations, with the division of tasks between foreman-brewer and servant (a figure conventionally excluded from most accounts), and with diagnostics based on the appearance of the worts.[222] This is largely explained by the fact that Levesque was himself the supplier of a thermometer: it was

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[219] Chadwick 1835: 25; Cobbett 1916: 31

[220] Sibum 1998b: 26

[221] Levesque 1847: 36-7

[222] Levesque 1847: 33-41, [117]

in terms of his specific instrument that the above instructions are framed. The *Art of Brewing and Fermenting*, then, served partly as a means of marketing his device.

In the account of the saccharometer in Chapter 3, we will learn that its original promoter, John Richardson, pursued much the same strategy: because the saccharometer was *initially* a proprietary device, directions for its use (by Richardson and his rivals) proliferated through the literature of the brewery.[223] The thermometer, by contrast, was presented as a well-established philosophical instrument, whose trustworthiness lay in prior work outside the brewery: Combrune and his successors did not trouble to provide minute directions, of the kind that might engender trust in a *specific* thermometer, because they had no agenda for proprietary control.

We have seen, then, that in the brewing thermometry of the eighteenth and early nineteenth centuries, the centralising standardisation and "instruments of precision" outlined by Sibum played no noticeable part.[224] Even the most 'scientific' brewers in this period did not develop superfine accuracy of the kind characterised by Sibum in the Joule case — not because they were incompetent to do so, but because such accuracy was not relevant to their project. Yet the localised, tacit development of brewery thermometry was not a necessary consequence of the nature of the thermometer: it was a contingency proceeding largely from the manner in which the supply of instruments — the interface between the natural-philosophical and brewing communities — was opened up. As the culture of the brewery changed increasingly to accommodate chemical analysis, then, and with the growth of Excise laboratory work from the 1840s, it was possible for notions of thermometric value to alter, leading ultimately to the situation discussed in Sibum's work: thermometric measures superseded the sensory judgment of the individual, and "gestures of accuracy" involving tools such as the thermometer became an accepted feature of the brewery identity.

2.5.4 Adaptations of the thermometer

Combrune had imported the thermometer directly as a philosophical instrument: we know nothing about the individual devices he used, but they were presumably made to established designs, intended for application in medicine or philosophical experiment.

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[223] See Section 3.3.1

[224] Sibum 1998b: 31

As the market for brewery thermometry developed, however, specialisation ensued: there was considerable scope for this, given the range of operations and working scales involved. David Booth in 1829 describes "tun-thermometers" particularly adapted to the primary fermentation, when a huge cloudy head covered the wort: the instrument was at least three feet long, so that, with the bulb immersed in the liquid, "all that is necessary of the scale overtops the froth of the head." Booth outlines the possibility of a specific thermometer for the copper, with a distinctive marker which would show the temperature clearly through the a considerable fog of condensing steam: it seems that at least one maker, William Loftus, subsequently took him up on the proposal.[225] William Chadwick, a few years later, suggests even the private brewer should acquire "a second thermometer, with a tin guard, to use in the boiler."[226]

Of particular interest is the 'blind' or 'private' thermometer. Alexander Morrice, who recommends the firm of Atkins as a supplier in 1802, describes it as "useful in many Respects, particularly when it is desirable to keep your Heats a Secret." The device featured a detachable scale, the body of the thermometer bearing only a travelling index marker. In the example discussed by Morrice, this marker would be set to a particular value, such as a mashing heat, with the scale in place; once the scale was removed, the thermometer could be applied to set this heat without the privileged value being discernible by anyone — *including* the brewery servant actually performing the operation, an important consideration in competitive markets with a high turnover of staff, where not only "impertinent pryings" but serious industrial espionage was a real possibility.[227] The use of this safeguard seems to have been a standard practice for decades. In the 1850s and 60s, Loftus advertised a fourteen-inch "Blind Scale" thermometer at sixteen shillings, two shillings dearer than his similar fixed-scale device,[228] while Oswald Pearce Serocold, of the large London firm of Reid's, described from personal experience the brewery culture of the 1880s as follows:

> Brewing operations were veiled in secrecy, so much so that the thermometers used for determining the heat were not marked in degrees but by letters, and a loose scale marking true degrees had to be applied to obtain a correct result.

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[225] [Booth] 1829: 11. Loftus 1863: [143] advertises "Steam or Boiler Thermometers (to order)."

[226] Chadwick 1835: 6

[227] Morrice 1802, appendix; Morrice 1827: 154-5; Tuck 1822: 32, 60

[228] Loftus 1863: [143]

> Even entries in brewing books were partly faked so as deliberately to deceive the casual reader![229]

The blind thermometer serves as useful evidence of a technological innovation independent of natural-philosophical or scientific considerations. Although thermoscopes without scales predate the scaled thermometer, the *detachable* scale was an adaptation of the later device, constructed to solve a specific brewery problem.

Such an innovation contrasts with the professed virtues of openness, scrutability and numerical accounting often associated with gentlemanly natural-philosophical culture (though absent, notably, from Shaw's commercial chemistry), and so the temptation may arise to consider it as the rather hidebound product of an only semi-successful 'scientisation.' We should instead view it as a neat early exercise in information management. Adaptations which were 'philosophically' trivial yet practically invaluable were not uncommon in the period. The instrument-maker Atkins, for instance, probably around 1800, adapted the four weights of his hydrometer to be different shapes ("round, square, triangular, and pentagonal") so that Excisemen would not mistakenly affix the wrong weight, and doubtless also so that distillers could not accuse them of doing so: William Nicholson, showing a clear sense of distinction between the needs of "philosophical men" and of others, approved highly of the "sagacity with regard to the practical requisites of an instrument offered for general use" shown by this adaptation.[230]

2.6 Conclusion

The thermometer, then, was *not* simply a straightforwardly-imported natural-philosophical device, whether considered with regard to its underlying theoretical justification, the mode of its application, or even its physical form; yet its initial applications were, from a brewery outlook, conservative. Localisation allowed its use to be subjugated to the brewer's sensory judgment: if a given thermometric operation did not give the desired effect, the value used could be altered (and, in the case of a brewery servant using a blind thermometer with an index pointer, the operator would not even detect the change.) These alterations occasionally became codified in print, as in the case of Combrune's correction factors: they serve as numerical echoes of the pre-thermometric writers' appeal to the authority of the traditional brewer. Without

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[229] Quoted in Janes 1963: 140. My thanks to Martyn Cornell for this reference.

[230] N[icholson] 1802: 50-1

this safeguard, the thermometer would not have been accepted by those who did not share Combrune's natural-philosophical priorities.

This situation was not to persist, however: the proliferation of the thermometer in its own right had effects which ultimately helped to redefine its status. Most obviously, its ubiquity extended the association between brewers and instrument-makers, who were naturally keen to find a market for other technologies. Among these we may class brewery manuals themselves: a reciprocal relationship between texts and instruments existed, with the manuals advocating purchase of the instruments and the instruments trade's established supply networks commonly providing an outlet for books in provincial locations.

Another important technology to become established in this way was attemperation equipment, which arose hand-in-hand with the spread of thermometry. In establishing their individual modes of management, brewers would have discovered — via the tacit operations we cannot recapture in any detail — the intense spatial and temporal localisation of thermometric values, a factor which *did* challenge sensory understandings. Whereas the brewer's traditional experience told only that a mashing, or gyle, or fermentation vessel, was (or was not) in a 'right' heat condition, the thermometer could give a vastly more complex interpretation, showing heat gradients across large vessels and minute, unpredictable variations in fermenting temperature, due not only to atmospheric conditions but to occult factors, apparently relating to the nature of fermentation itself, left unaddressed by the most 'scientific' brewers before 1830.

The response, especially at larger scales of operation, was to attemperate: to introduce heating and cooling equipment which would *impose thermometric constancy*. Richard Shannon, who had become acutely concerned with thermometric issues through a reading of John Richardson's works, suggested in 1805 that the cooling worm, similar to a distiller's condenser, was already in widespread use: he marketed his own "refrigeratory" on this principle, along with a "cooling attemperator," a fanning device claimed to allow slower and more controllable cooling, as might be required during the sensitive cleansing phase. Stabilisation achieved using the thermometer, rather than straightforward cooling, was stressed in Shannon's account.[231] The proprietary thermometrist Levesque, too, stresses the ability to "affix" certain temperatures,

[231] Shannon 1805: 67-9, 77-8, 85-9, 90-4,

indicating that the nineteenth-century thermometer was used less for diagnosis than for the verification of intended results.[232] The position is well summarised by W L Tizard, who marketed a mashing attemperator with pipes in the hollow shaft and rakes carrying hot water or steam:

> [T]he use of the thermometer, as a standard of temperature, must be strikingly obvious; but when we consider it as an implement of science and not of art, as a theoretical test and not as a problematical means, as an indicator of heat and not the cause of it, we have attributed to it all that belongs to it: but the brewer wants more; he wants, in fact, to attemper his heat to his subject, and he wants a thermometer to prove that it is properly attempered.[233]

The very largest concerns, such as Whitbread's London porter brewery as described in the 1810s, made extraordinarily systematic use of this mode of thermometry in order to regulate bulks of liquid which would otherwise have been highly unpredictable: thermometers were dispersed through the plant's network of piping, and, depending on the readings, cocks could be switched to send the cold supply from the brewery's main well through a cooling jacket over the fermenting-squares' supply pipe.[234] Such innovations gradually reduced and eventually abolished the summer period traditionally held to be too unpredictable for brewing operations to be carried on, allowing all the cost advantages of a continuous supply.

Finally, we should note the thermometric influence on the quantification of a property of more direct material significance: the strength of beer. This was one of Combrune's goals from the outset, as we have seen in his suggestion that strength might be quantified thermometrically, via the boiling points of its constituent parts. The author of *Every Man His Own Brewer* took up this theme: since "none will presume, that beer shall be of the same strength from the like quantity of malt and hops of every kind of growth, and drying, tho' extracted, and worked by the same rule," some means of establishing a standard measure of strength based on analysis of the wort alone would be useful. The author elegantly summarises the principle as follows: "The rule is said to be, that worts are hotter than water in the like state, in ebullition, which is a fixt point, and what difference there is between them, is the value of the strength of the

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[232] Levesque 1847: 48, 56

[233] Tizard 1845: 16-7

[234] Rees 1819, s v "Porter"

wort."[235] It is carefully pointed out, however, that proceeding on the basis of optimising strength is a matter for the commercial brewer only: the private gentleman, who has no need to "force the mash for profit", should stick to his established methods.[236]

This scheme was not realised, but has conceptual features in common with — and may indeed have influenced — the project of *gravimetric* strength quantification, publicised in treatises of the 1780s. The makers who supplied the brewery with thermometers also marketed gravimetric equipment, mostly in the form of hydrometers which had a pre-established distillery application; it is through this route that 'scientific' brewers first became aware of them. Moreover, the thermometer was a prerequisite for the gravimetric project: density, the attribute measured, is temperature-dependent, and thus can only be satisfactorily applied in the presence of a fairly sophisticated thermometric regime, including attemperation or appropriate sampling techniques to ensure a representative reading in bulk fluids, and the construction of conversion factors in situations where bringing a sample's temperature up or down to a nominated standard is impossible. In my next chapter, I assess the nature and consequences of this new 'scientific' project.

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[235] *Every Man His Own Brewer* 1768: 185-6

[236] *Every Man His Own Brewer* 1768: 186-7

Chapter 3: Strength, hydrometry and saccharometry

3.1 Introduction

The introduction of thermometry into brewing practice is echoed by that of saccharometry, the quantitative endeavour to determine strength, which came to prominence a couple of decades later. Most accounts of early brewing technology note a degree of symmetry between the two processes. The instruments involved were somewhat alike, being small, portable and in the form of a glass or metal tube: each had origins in the philosophical instruments trade, and the arrival of each in the consciousness of brewers is associated with a specific author and a specific work. For the thermometer, as previously discussed, this was Michael Combrune and the 1758 *Essay on Brewing*. The relevant figure in saccharometry is John Richardson of Hull, and the text, entitled *Statical Estimates of the Materials for Brewing, or a treatise on the application and use of the saccharometer*, was first published in 1784.[237]

We should be careful not to carry the analogy too far, however. The thermometer's inculcation into brewery culture left very little trace, and Combrune's enshrined status as progenitor may to some extent be an artefact of historical enquiry; the saccharometer, by contrast, was clearly associated with Richardson from the outset, and was the subject of much discussion and debate. Mathias suggests that the saccharometer caused a major upheaval in brewing practice, whereas the thermometer "did not violate any traditional process, merely allowing regularity of treatment to successive guiles of beer."[238] The account I presented in Chapter 2 does not give unqualified support to this reading: whereas most brewers did subsume the thermometric measure under their local and traditional practices rather than following Combrune's scheme, its introduction also led to attemperation and the abolition of seasonal brewing, with far-reaching consequences.

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[237] The parallel between Combrune and Richardson is very clearly evoked in Richardson's *DNB* entry. It seems to be widely-distributed, and appears especially in more general accounts presenting developments in brewing technology in brief overview, eg Yeats 1871. Mathias 1959 and Corran 1975 both exploit the parallel indirectly in framing their accounts.

[238] Mathias 1959: 67

The distinction, I would contend, is due rather to two interrelated circumstances unique to the saccharometric case. The first is the involvement of a body external both to the brewing and natural-philosophical communities: the Excise. The temperatures applied to beer had no direct relevance to its taxable value; strength, however, was a matter of paramount fiscal importance. As government policy swung towards indirect taxation, the Commissioners of Excise showed an increasing concern not only with geometrical gauging standards but with accurate means of alcoholic strength determination. This initially affected spirits most of all: disputes between distillers and the Excise were common, and by the 1780s hydrometry — as the general project of strength determination was known — had attracted a degree of notoriety and controversy not seen in the thermometric case. This state of affairs probably influenced the second important circumstance: Richardson's creation of an independent and brewery-specific instrument and measure, divorced from their hydrometric roots.

Combrune's heat-management project, as we have seen, involved the importation of a thermometer already 'black-boxed' on the basis of theory and practices drawn directly from contemporary natural-philosophical authorities. A similar approach *was* followed in the case of strength by one of Richardson's contemporaries, James Baverstock — albeit, as we shall see, with far less success. Richardson's approach, by contrast, was deeply proprietorial. His saccharometer was firmly distinguished from the hydrometers then in Excise use, and the quantity it was nominated to indicate was similarly distinct. Combrune had worked always in "degrees of Fahrenheit's thermometer", a measure which, though still trailing its former status as embodied in a specific instrument, was by then becoming a transferable standard among natural philosophers; Richardson's quantity, the 'pounds-per-barrel extract' or 'brewer's pound,' was unique to his sponsored device. The main purpose of this chapter, then, is to comprehend the project in which Richardson was engaged, but Combrune and Baverstock were not: *the construction of a new quantitative standard*.

In Section 3.2, I consider in detail the circumstances which moved Richardson to set out his project. In view of the significance attached in this analysis to pre-quantificatory criteria, subsections are devoted to the way in which 'strength' was interpreted in the brewery before quantification; the rise of an Excise-dominated programme of hydrometric determination in the distillery around the mid-eighteenth century; and the means by which this came to the attention of brewers and thus inspired the contrasting programmes of Baverstock and Richardson. Having established the motivation for the latter's separatist conceptual focus, I move in the

concluding subsection (3.2.4) to an analysis of what an act of quantification must entail in order to succeed. Recent work in the history and philosophy of science shows 'objective' quantities to be rather contingent entities, constructed, preserved and modified by their users. Richardson's saccharometric quantity therefore presents an interesting case study: since it is defined only in a highly specialised, commercial context, it may strike the general reader as quite obviously constructed and contingent; yet Richardson's work shows him striving to establish it as the fundamental component in an overarching theory of brewing as ambitious as Combrune's.

Section 3.3, then, charts the strategies adopted by Richardson. Of particular importance is the role of the *instrument*: the quantifier who, like Richardson, himself constructs a property to be measured, also requires new instrumentation and procedures by which to measure it. Richardson's saccharometer had a distinct role in defining, publicising and reifying the quantity which, ostensibly, was conceptually prior to it and determined its construction. The first subsection focuses on the instrument, and the second, in parallel, on its associated quantity, and to the traditional notion of 'value' to which it was tied. The accommodation of traditional understandings was, I aim to demonstrate, essential to the acceptance of Richardson's scheme among the brewers, but carried with it the danger of inconsistency: in the final subsection I address how Richardson's saccharometric redefinition of 'strength' in beer threatened to bring concepts of value which had co-existed in the prequantitative period into conflict, and the steps Richardson took to avert the problem.

Lastly, in Section 3.4, I look at the mixed fortunes of Richardson's project: while his proprietary instrument itself did not achieve lasting success, the quantitative endeavour which had been designed to legitimate it survived well into the twentieth century: it informed governmental policy on the taxable value of beer for over a hundred years, and in some respects forms the basis of brewers' interpretations to the present day.

3.2 Background to the emergence of saccharometry

3.2.1 Notions of beer strength prior to quantification

Before the second half of the eighteenth century, the strength of beer was not considered to be a quantity. That is not to say that differences in strength were not intended or appreciated: on the contrary, beer's dual function as an intoxicant and a

source of relatively unpolluted water meant that brewing to different strengths had been commonplace for hundreds of years. This was facilitated, and maintained, by the traditional method of extracting as much fermentable matter from the malt as possible: after mashing a load of malt, the brewer would draw the wort off, run fresh liquor onto the malt and mash it again, producing a second, weaker wort. This procedure might be repeated, giving worts of widely differing quality.[239] If these were then fermented separately (the 'parti-gyle' system), rather than mixed, the products would range from strong, intoxicating ale to weak and neutral brews suitable for drinking throughout the day.[240]

This traditional notion of *divergences* in beer strength informed the Excise policy on beer taxation. Although stronger beers, using more malt, indirectly attracted higher overall taxation through a separate malt tax, the main levy — that on the finished beer itself — employed two (or, for some years from 1782, three) very broad strength categories, each attracting a flat duty per barrel. The intention was that Excise officials would categorise samples on the basis either of the volume of malt used, or of the price at which the brewer sold the beer: the traditional demarcation between 'strong' and 'small' beer was a retail price of six shillings per barrel exclusive of duty.[241] In practice, however, the system both represented and relied on the traditional assumption that the distinction between 'strong' and 'small' was qualitatively obvious. Both in the public understanding and in law, beer strength in this period was not a continuum, but a system of distinct zones representing different styles and purposes.

This understanding, however, was a fragile one. The Excise had decreed a nationwide standard, whereas popular expectations about beer strength were strongly localised: before the development of canal and rail freight, the low mercantile value of beer relative to its weight made it uneconomical to transport, so patterns of trust and expectation between brewers and customers maintained a wide variety of strength values confined to small geographical areas.[242] Moreover, since retail prices for beer were generally fixed, the brewers claimed the right to adjust the strength of their product as their only defence against rises in taxation or the cost of materials. Thus,

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[239] [Whitaker] 1700, for example, proposes three worts.

[240] Worthington 1812: 67

[241] Mathias 1959: 110, 369

[242] Mathias 1959: xxii; Gourvish & Wilson 1994: 41

inevitably, borderline cases occurred. These were generally resolved by an Exciseman tasting the beer and pronouncing on the basis of his individual sensory judgment — an approach which, in line with Theodore Porter's characterisation of prequantitative regimes,[243] understandably led to collusion, disputes, hostility and suspicion.

The significance of this problem had increased dramatically during the wars of 1689-97 and 1701-14: unprecedented duties were loaded onto beer, widening the gap between the 'strong' and 'small' rates and making accurate demarcation a crucial matter. The profession's distinct consciousness of, and sense of injustice against, these tax increases is represented in the 'Obadiah Poundage' polemic, which first appeared in 1760 and was so widely reproduced in subsequent brewery literature as to form the basis of most nineteenth- and early twentieth-century accounts.[244] Deception proliferated: the brewers found they could take advantage of the taxation system by brewing exceptionally strong beer, paying duty at the uniform 'strong' rate, and then diluting to a more usual strength with small beer on which a far lower rate had been paid. This practice, although prohibited, was undetectable unless actually witnessed by attentive Excisemen, and thus widely suspected to be endemic.[245]

In 1782, an intermediate rate for 'table beer' was introduced specifically to lessen the attractions of this deception, but it did not address the root cause.[246] One possible solution, perennially discussed among the legislature and the Excise, was to tax the brewers solely on the malt they used. The volume of malt added to the mash-tun could be quantified rigorously by the mathematically sophisticated gaugers; but then, it was well-understood that this quantity did not correlate particularly well with the 'strength', as assessed by taste or intoxication, of the resulting brew. The value of malt in this respect was known to be influenced by all kinds of factors throughout the production process: these included the type of barley used, the weather conditions during the growing period, the duration and temperature of the malting process, the method of drying employed, and the various times and temperatures for mashing, boiling and fermentation. None of these effects, however, could be predicted in anything more than the vaguest qualitative terms: Michael Combrune, as we have seen, attempted an

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[243] See Section 1.4

[244] The account will be discussed in detail in Section 4.3.

[245] Mathias 1959: 346; Corran 1975: 175-6

[246] Glendinning 1900: 359

absolute quantification of material value based on the thermometer, but this was not legitimated by mainstream philosophical acceptance.

3.2.2 The distillery and Excise origins of strength quantification

A contrasting situation existed in the distilling industry. The economic feasibility of transporting spirits naturally caused much comparison of different manufacturer's wares, and spirits, unlike beer, were generally produced for the purpose of intoxication alone; the notion of the 'value' of a sample of spirit was therefore much more keenly defined and observed. Distillery practices also contributed to the emergence of an interpretive framework very different from that established in the brewery. The process of extraction and purification naturally suggested the concept of an absolute, a most 'highly rectified' form of spirit which could not be purified any further: this 'pure spirit' was identified with the principle of intoxication, since the effect of drinking a given volume increased with the degree of purification.[247] Consequently, eighteenth-century distillers interpreted the value of spirits in terms of a continuum representing the relative proportions of 'pure' alcohol and water (which chemical analysis, derived from distillation practice, showed to account for almost all of any spirit's volume).

As Mathias suggests, this interpretation was only taken up by the Customs and Excise authorities after it had been articulated by the distillers themselves;[248] however, its acceptance by these bodies established it beyond contention. Like the levy on beer, spirit duty had hitherto been charged in wide, uniform bands, with qualitative methods were often used in demarcation. As the Excise became the government's key revenue-raising tool after 1713, and following a moral panic over the incidence of spirits drunkenness resulting from the rising price of beer, spirit duties too were subjected to a hefty increase.[249] Just as in the brewery case, accurate demarcation now became a matter of great economic significance: however, the pre-existing notion of a continuum meant that the broad duty bands were increasingly undercut by attempts to define strength in precise numerical terms. Building on the existing arbitrary reference standard of 'proof', the Excise established a numerical scaling, whereby samples were

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[247] Wilson 1993: 142-5

[248] Mathias 1959: 68

[249] For the move away from reliance on the formerly-dominant Land Tax, and increased use of the Excise and other means of indirect taxation, see Beckett 1985; O'Brien 1988; Brewer 1989: 95-101.

rated as so many degrees 'above' or 'below proof'. Distillers thereafter had no choice but to consider the strength of their product in terms of its position on the proof scale.[250]

The most precise methods of assessing proof involved fractional distillation followed by weighing using extremely accurate balances. Yet the Excise officials, who travelled between distilleries making regular assessments on the premises, needed a means of assessing spirit content which was not only reliable but rapid and, above all, portable.[251] The device which best seemed to meet these needs was the spirit hydrometer, first developed in the 1720s by John Clarke, a London "Turner and Engine Maker" linked to the natural-philosophical community through the patronage of the influential experimental philosopher, Jean Théophile Desaguliers.[252] This instrument exploited the fact that pure alcohol is considerably less dense than water: to use the contemporary natural-philosophical expression — retained to this day in the language of brewing — it has a much lower *gravity*. Assuming the test sample to consist of spirit and water alone, the gravity, as measured by the hydrometer, could therefore be taken as representative of the proportion of spirit present.

The principle of flotation hydrometry was known in antiquity, and apparently 'reinvented' in the late seventeenth century, engaging the attention of Desaguliers and other natural philosophers including Robert Hook, Robert Boyle and Daniel Gabriel Fahrenheit.[253] The hydrometer consisted of a long hollow stem made to float upright by a weighted bob at its base, to which additional weights might be attached. A sample of liquid was placed in a trial vessel, and the weighting on the hydrometer adjusted until it would just float in the liquid, with part of its stem above the surface and part below. The total weighting required rose in proportion to the gravity, and a conversion factor could be determined by calibration from direct mass and volume measurements. With most models, the density could be found more precisely from the depth to which the hydrometer sank: the mass of the stem was usually designed to

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[250] For the history of spirits taxation, see Tate 1930: ix-xviii.

[251] For the structure and day-to-day operations of the Excise, see Brewer 1989: 101-14; but see also Ashworth 2001 on hostility towards the institution and the specific problems (discussed here below) faced in the spirits assessment case.

[252] Tate 1930: xiv, xv

[253] For the hydrometer in natural-philosophical context, see Bensaude-Vincent 2000 and the sources listed in Mathias 1959: 67 n 5.

coincide with the smallest weight difference available, and the determination made by reading off a scale (again established by precalibration) etched into the stem at the point where it cut the surface of the liquid.[254]

Bernadette Bensaude-Vincent's recent work on the spread of hydrometry, focusing chiefly on French natural philosophy, suggests that only from the late eighteenth century was the device generally accepted as a black-boxed representative of density (as distinct from a philosophical curiosity exhibiting Archimedes' principle.)[255] Among the English and Scots Excise authorities, the process was effectively completed in the time of Clarke, who worked closely with them to develop a hydrometer specifically tailored to the needs of a mobile spirits assessor. In the Excise project to establish a single, trustworthy standard which would minimise conflict with the distillers, it is easy to find an application of Theodore Porter's "trust in numbers" — a corporate body, in this case the Excise, applying a rule-bound, quantificatory system to establish control, and appealing to the "objectivity" of the values produced as a means of banishing disputes.

However, recent work by Will Ashworth, who is informed by Porter's interpretation,[256] has demonstrated that this measure was only ever partially successful. There was doubt over the reliability of gravity measurements as a guide to spirit content: if a sample contained, besides spirit and water, sugars or other matter in solution — as all, in practice, did — this would raise the gravity and make the spirit content appear lower than it really was. From the Excise perspective, it was thus possible for distillers to defraud the assessors by adulteration; the distillers responded that a certain proportion of sugary matter was naturally present in the unadulterated product, and contributed to the flavour and quality as perceived by the public. The ongoing controversy over this point culminated, in 1781, in what became a test case: under charge of adulteration, the brandy merchants Steele and Co mounted a strong challenge to the authority of the device which, although the verdict went against them, served to highlight the instrument's vulnerability. The situation had been greatly complicated by rival instrument-makers who, following Clarke's death in 1746, were conspicuous in proffering alternative devices, weakening the reputation of the Clarke device and,

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[254] For the history of the hydrometer's construction, and different approaches adopted by different makers, see Garnett 1910: 162-5.

[255] Bensaude-Vincent 2000: 154

[256] Ashworth 2001: 30 n6

therefore, the projected consensus. In 1787, as a provisional measure while a more reliable device was sought, the established model was enshrined in law as providing definitive readings.[257]

For the first time, then, an instrument had been given official sanction not as an indicator but as a direct *arbiter* of strength. Spirits hydrometers were now standardised with respect only to another spirits hydrometer: the device was being divorced from its philosophical roots. Yet this had occurred without the establishment of the expected accompanying consensus; the quantificatory agenda now operated to meet the needs of the legislature, not of the relevant professional community itself. The activities of John Richardson, discussed below and in the next section, suggest that this state of affairs did not go entirely unnoticed among the brewers.

3.2.3 The hydrometer enters the brewery

The first known account of an attempt to apply gravimetric principles in the brewery appears in the posthumous work of William Reddington, whose pre-thermometric technique of heat management was discussed in Chapter 2. Reddington's *Practical Treatise*, first published in 1760, describes a device nominated the "sensible Float," which the author claims to have devised himself. It was fashioned from a wooden stick up to two feet long, stuck through interspersed corks and pieces of lead, which were to be adjusted so that its flotation range would include plain water at one extreme and the brewer's strongest beer at the other. "As many Shillings as you value your Beer at," he advised the reader, so many scale divisions should be interpolated between the levels of these two extremes: "By this method, you may estimate what proportion the value of any Beer bears to the price of the strongest."[258]

This proposal, however, was not integral to Reddington's work, and was not taken up by his fellow brewers: although the *Practical Treatise* ran to a third edition in 1776, his name was lost to succeeding generations. The first influential claim for the application of hydrometry to beer came, not from a brewer with a home-made device, but from Benjamin Martin, an established instrument-maker. Martin was seldom slow in spotting a new market or opportunity: he was at various times a philosophical lecturer,

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[257] Ashworth 2001: 36-41; Mathias 1959: 69

[258] Reddington 1760: 1-3

microscopist, philologist, magazine editor and spectacle-maker.[259] He had been one of the most vociferous of the rival hydrometrists mentioned above, making a concerted play for the 'official' hydrometry market in 1762 by dedicating to the Customs and Excise a work entitled *Theory of the Genuine Hydrometer*, in which Clarke's instrument was compared unfavourably to his own.[260] In 1768, however, having failed to gain Excise support, and doubtless seeking sales outside the relatively small market of the distillery, Martin advertised, in very general terms, his instrument's usefulness "in discovering the strength of beer, ale, wine and worts."[261]

The growing natural-philosophical awareness of the brewing community is illustrated by the fact that this claim came to the attention of at least two brewers, John Richardson of Hull and James Baverstock of Alton, who were sufficiently enthused to commission hydrometers from Martin, make experiments of their own, and communicate with him on the subject. Both brewers found, curiously enough, that Martin himself had since abandoned the project: in Baverstock's words, "having made his experiments on different sorts of *beers* instead of on unfermented worts, [Martin] found himself so bewildered and in such a labyrinth that he had abandoned the pursuit."[262] The problem which caused controversy in the distillery case was apparently of fatal proportions here. Beer, since it does not pass through a distillation process, contains a very large proportion of dissolved, unfermented matter, which contributes its 'body,' colour and flavour. In all practical cases this more than counteracts the gravity reduction due to spirit content, so that the gravity of beer is *higher* than that of water. By itself, the final gravity of a beer tells us nothing about its alcoholic component, and this, if we believe Baverstock, is what Martin failed to grasp.[263] The same problem would have applied to Reddington's scheme, as outlined in his 1760 work, and may be one factor in its lack of success.

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[259] For Martin's life, and the topography and culture of the Fleet Street instrument trade to which he belonged, see Millburn 1976.

[260] Ashworth 2001: 35-6

[261] quoted in Baverstock 1824: xiii-xiv

[262] Baverstock 1824: xiv; Richardson 1788: 116-7. Richardson deliberately omits Benjamin Martin's name from his account; that his "late celebrated philosopher" is indeed Martin is, however, clear from Baverstock's son's account of the episode [J H Baverstock in Baverstock 1824: 256].

[263] Baverstock 1824: 6-7

A possible solution, however, was successfully explored by both Baverstock and Richardson. Unfermented wort is sweet-tasting, and has a gravity much higher than that of finished beer; it was widely assumed that, in the fermentation process, most of the sugary materials dissolved in the wort were somehow converted into alcohol, with a corresponding falling-off in gravity — the thinning-out or 'attenuation' of the beer. If it were further assumed (and the assumption was not necessarily an obvious one) that the gravity fell proportionately as the alcoholic concentration rose, then the *difference* between the original and final gravities would give a value which indicated the alcoholic content of the beer. While we can never know how obvious or feasible the implementation of this principle might have appeared to contemporary brewers, it should be noted that the project occurred to Baverstock and Richardson independently, and that Richardson's professed conclusion from a period of initial failure was not that the theory was impracticable, but that Martin's spirit device was ill-adapted to the purpose and in need of refinement.[264]

The route by which practices based on this hydrometric insight became standard among common brewers in the last years of the eighteenth century is difficult to recapture. Conceivably, it was promoted by the common context between brewing and distilling: the Bankside Distillery records of the 1760s and 70s, mentioned earlier in connection with thermometry, sometimes include average figures for "The Strength of the Worts in the Back," or original gravity, generally falling around 1080° on the degree scale which takes water at 1000°. However, no *final* gravities are given, and no clear application to the brewery case is made, the writer noting only that "[a]fter all, the quantity of Liquor & Hops, used for Brewing must be regulated by the goodness of the Malt & Hops, and the strength & bitter, the Beer is wished to be."[265]

Among the brewers, James Baverstock was undoubtedly the first to promulgate the principle privately: in 1770, besides communicating a long essay full of practical results and theoretical justifications to Martin, he attempted to interest major London porter brewers in the device. Samuel Whitbread, whose plant was the largest in England, and whom we might assume to have been an ideal candidate for such a standardising tool, was distinctly uninterested. So too were most others, the only

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[264] Richardson 1788: 117-8

[265] British Library: Additional Manuscripts 39683

significant exception being Henry Thrale.[266] Thus most brewers remained indifferent to or ignorant of the hydrometer until, as Baverstock saw matters, "about the year 1780 — (through the activity of another maker who had got the hint, and went among the brewers in London to sell them,) hydrometers became nearly as generally used as the thermometers…"[267] The identity of this 'other maker' (not Martin) is unknown, although he was almost certainly an established rival supplier of spirit hydrometers.

In fact, the device was perhaps not adopted so quickly as Baverstock suggests: his account tellingly excludes the significance of the first published text on hydrometric brewing, Richardson's *Statical Estimates of the Materials for Brewing*, which did not appear until 1784. Richardson is perhaps the archetype of the 'scientific' brewer. As a member of the Hull Literary and Philosophical Society, a retailer by proxy of scientific instruments, and a user of the London coffee-house network, he exploited most of the "boundary objects" identified by Sungook Hong as facilitating interaction between scientific and technical communities.[268] Richardson advertised himself not only as a practising commercial brewer, but as a consultant advising others on efficient methods. His writing style is distinctively acerbic, especially in his contrasts between his own approach and the apparently hidebound attitudes of the 'traditional,' unphilosophical brewer, and influenced later writers who considered themselves equally progressive.[269]

Richardson was not a Hull native, but moved to the city from Liverpool to enter a brewing partnership around 1783. At this time, most public houses in Yorkshire still brewed on a small scale for their own use; the North Brewery, under Richardson's management, was the first in Hull to build up a pub estate systematically, and by 1800 was almost certainly the city's largest.[270] Local historians have suggested that

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[266] Thrale's ambitious and technocratic bent is often remarked upon, usually with reference to the *Autobiography* and correspondence, published under the title *Thraliana*, of his wife Hester [later Hester Piozzi], which would repay systematic study. His experiments with the hydrometer seem to have worked to his advantage, but, as is noted in Section 5.3.1, his desire to take on new innovations, such as proprietary malt and hop substitutes, nearly led to his downfall. See Mathias 1959: 70-1, 206-7, 228, 265-71, 417-8.

[267] Baverstock 1824: 191

[268] Hong 1999

[269] For this kind of rhetoric in Richardson's work, see for example Richardson 1788: 83-5. Among later writers, see in particular Hayman 1819 and Wigney 1838.

[270] Aldabella and Barnard 1997: 9, 80-1. The North Brewery's estate was apparently imitated by other Hull brewers, with the result that the port became noticeably

Richardson served his apprenticeship in one of the major London breweries: this is likely in view of Richardson's estate-building activities,[271] and of his obvious familiarity with London practices — certainly, his directions on porter grists assert a familiarity with the London market[272] — and it seems probable that in London he developed contacts among the scientific instrument-makers.[273] The *Statical Estimates* was accompanied by the unveiling of the saccharometer, designed according to Richardson's own specifications and manufactured solely by one such maker, John Troughton of Fleet Street: the project was in many ways a joint venture between the two.

The *Statical Estimates* discussed, in terms which implied innovation, many principles which Baverstock had elaborated independently in the early 1770s, and which most of the brewers to whom he had communicated them privately had ignored. Obviously feeling the need to assert his priority, Baverstock himself published in 1785 a text, *Hydrometrical Observations and Experiments in the Brewery*, which (according to his son's testimony) was substantially equivalent in content to the sheaf of observations Baverstock had sent Martin back in 1770.[274] It is Richardson, however, whom brewers principally remember as the driving force behind the importation of hydrometric practices. In the years following the *Statical Estimates'* publication, most brewing manuals which mention gravimetric strength determination identify Richardson as its pioneer (Baverstock's being an obvious exception).[275] William Black, writing half a century after the *Statical Estimates*, has this to say:

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anomalous within Yorkshire, where individual on-site brewing remained the norm well into the nineteenth century. In the 1850s and 60s around 80% of excised malt in Hull was brewed by large common breweries, as against 58% in York, 19% in Sheffield and 12% in Leeds. [Clark 1983: 265-7; *VCH York, East Riding*, vol 1 (1969) 266 n 84]

[271] Common brewers dominated London, the south-east and East Anglia.

[272] [Booth] 1829: 46

[273] Aldabella and Barnard mention an advertisement for one of Richardson's early works, published in 1777, which gives as contact address a coffee-house in Fleet Street. There was thus a period for which Richardson was based, or at least had regular business, in close proximity to the hub of London's philosophical instrument trade. John Troughton's business was located nearby at this time, though he did not take up premises in Fleet Street itself until 1782.

[274] Baverstock 1824: xx

[275] [Booth] 1829: 11. Booth reproduces Richardson's illustrations and occasionally quotes him verbatim [12-15]; Shannon 1805 is particularly noteworthy for reproducing several chapters from the *Statical Estimates* consecutively and verbatim [156-233].

> The late Mr. Richardson of Hull, had the honour and merit of first causing the art of brewing to be regarded as a science in this country, by the invention of the saccharometer, and no means could possibly carry his researches farther than he did, as to the most scientific mode of making the extracts…[276]

Black considered Richardson's work so thorough on certain points that he "need say little on that subject, presuming that few brewers are without a copy of it."[277] Later brewers, too, considered Richardson's contribution as pre-eminent; the view became widely-dispersed in the secondary literature and can also be found in technical accounts not specific to the brewery.[278]

Why were brewers more receptive to Richardson's entreaties in the 1780s than to Baverstock's in the 1770s? Economic factors have at least some relevance. Mathias draws attention to the steady rise in the price of raw materials over the intervening period: since retail prices were effectively fixed, brewers were forced to seek economies, which saccharometric management could provide.[279] However, it is my contention that the differences between the two writers' approaches weighed more heavily. Baverstock's hydrometric project, like Combrune's in the thermometric case, took an instrument with an existing philosophical pedigree and transferred it straightforwardly into the brewery environment, retaining its established physical construction, associated quantity and theoretical interpretation. We have seen that the brewers embraced the thermometer only gradually (over perhaps two decades) — and the project of hydrometry had a disadvantage which thermometry did not, in the welter of doubt, controversy and confusion which had come to surround the hydrometer in its distillery application. Richardson was almost certainly conscious of this state of affairs, and pursued a radically different conceptual approach which, I believe, explains the almost immediate effect of his ideas.

3.2.4 The conceptual requisites of quantification

Richardson's quantitative approach was thoroughly separatist: he cut the principle of gravimetric determination off from its Excise and distillery associations, developed an independent justification of its reliability, and spelt out ways in which it might be used

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[276] Black 1835: 98

[277] Black 1835: 37

[278] See for example Glendinning 1900: 358; Yeats 1871: 234.

[279] Mathias 1959: 71-2

specifically to the brewers' advantage. The centrepiece of this wider strategy was the construction of the brewer's pound, a quantity of special brewery relevance. The next section discusses how all of this was achieved; it will be advisable, firstly, to give a general account of what must be in place in order for such a quantitative endeavour to succeed.

One important influence in characterising quantification has been Harry Collins' work in the sociology of science, which challenges the assumption that quantities can be taken for granted as 'naturally occurring' or 'intuitively obvious'. Quantities pass into use, change in meaning, and are ultimately discarded: that we perceive them as self-evident, Collins argues, results from their "entrenchment" within our society's overall pattern of assigned properties. They are like "ships in bottles": their chief virtue is that they seem always to have existed in their present configuration, yet they must in reality have been brought into being at some time and by some agency.[280] The pioneer of a quantitative project, then, must work to secure its adoption in several ways.

Most immediately, the very act of picking a quantity out has to be justified. The quantity must be represented as a *coherent conceptual entity*: this inevitably requires some theoretical innovation, but is most easily achieved by building on some pre-existing idea of a distinct property, already entrenched in practitioners' minds. The quantity must also be represented as *reliable*. As Graeme Gooday has pointed out, quantities are not intrinsically 'well-behaved': some positive demonstration must be given that the figures produced are constant over repeated trials, and consistent with expectations derived from pre-quantification understandings.[281] Finally, the quantity must be shown to be *useful*. Again, it must be tied to some pre-existing notion of usefulness in order to be accepted; at the same time, however, it must provide new benefits to justify the work involved in its imposition. Quantifiers, therefore, must present themselves as both radical and conservative, promoting a new programme of understanding — usually justified by an increase in 'precision' or 'certainty' — but at the same time carefully embracing established shared expectations.

An existing account which illustrates these principles is Simon Schaffer's interpretation of the emergence of eudiometry in the 1770s. The 'goodness' of air, as measured by Joseph Priestley's nitrous-air apparatus, was not quite equivalent to any

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[280] Collins 1985: 5-18

[281] Gooday 1997: 409-413

established property: Priestley justified it, however, with reference to the readily-understood concept of the air's fitness for breathing, at the same time stressing the new certainty and precision imposed by his scheme.[282] There are definite parallels here with Richardson's conceptualisation of the saccharometric 'extract', which emerged around the same time. Common to both cases is the presence of a wider agenda driving the project of quantification. Priestley developed the nitrous-air test in support of his underlying theory of an aerial economy of 'virtue', grounded in his theological concerns. Richardson's agenda focused on an economy of another kind: he sought the adoption of a system tying beer strength, taxation and the cost of raw materials to a single numerical standard. The extract was planned as the centrepiece of a universal scheme of value determination, which would safeguard the brewer's profits in a hitherto uncertain climate.

The instrument, and the act of measurement, are also crucial tools in the establishment of a quantity. My account is informed by Gooday's challenge to the view that mensuration requires a prior "clear conception" of the quantity to exist: using the example of teaching practices in nineteenth-century electrical physics, he suggests that students were required to undertake measurement work as a way of naturalising unfamiliar and 'ontologically problematic' concepts in their minds. A first-principles explanation might leave the sceptical apprentice unconvinced that, say, electrical resistance actually *existed* in any worthwhile sense; after a couple of years of painstaking laboratory work with resistance boxes, however, it would be as real to him as his right arm[283] — the ship, as Harry Collins has it, would be in the bottle. In much the same way, Richardson was to exploit the saccharometer in an attempt to entrench the status of his quantity among fellow professionals.

In so doing, he ran up against certain problems concerning the very definition of a notion of 'strength'. Just as the arrival of thermometric 'temperature' necessitated a review of the theory underpinning the old, sensorially-rooted concept of 'heats', so Richardson's definition of strength, based on the saccharometrically-determined concentration of malt sugars in wort, seemed to conflict with the idea of strength as the principle to intoxicate. In the sensory, qualitative understandings of brewery tradition, both kinds of understanding had co-existed without any apparent conflict: Richardson

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[282] Schaffer 1990: 287-8, 290

[283] Gooday 2004: 49, 265-6

was clearly unwilling to discard either, and hence showed alarm at the conceptual incoherence threatened by his scheme. The steps he took in modifying his theory to avoid this problem, I believe, tell us a lot about the relationship between quantifiers and the pre-quantificatory mindset.

Richardson's project to construct a new quantity, then, was far more complex than Combrune's strategy of importation and legitimation. It required the quantity, the act of measurement and the instrument itself to be defined, rendered trustworthy by empirical evidence palatable to the brewers, and presented convincingly as useful in practical brewery situations. The considerable time Richardson took to publish may well be attributable to the work needed to establish results in support of this wider project, to which I now turn.

3.3 John Richardson's construction of the saccharometric project

3.3.1 The definition of the saccharometer

As we shall see, Richardson aimed to create a monopoly over hydrometric determination in the brewing world, establishing his own instrument, methods and interpretations as the sole authority. Yet in 1784, the hydrometer was already a firmly-established device: if it was not necessarily known among traditional brewers, it was certainly familiar to natural philosophers, Excisemen and distillers — including the Bankside distiller, who wrote for a brewery audience — as an instrument with a considerable historical pedigree. Furthermore, in 1780, the Liverpool maker Dicas had become the first individual for some decades to obtain a patent on a hydrometer.[284] Richardson plainly could not represent the hydrometer to the brewers without acknowledging this history, and so, crucially, could not make the case for sloughing off the interpretations, practices and controversies which had surrounded it. He therefore performed a neat terminological sidestep: the device Richardson presented to the world was described not as a hydrometer but as a *saccharometer*.

Did this coinage truly describe an instrument distinct from the hydrometers of Martin and Clarke? The new device measured gravity by its weighting and depth of fall according to the principles discussed earlier, and, to judge from the *Statical Estimates*'

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[284] Corran 1975: 123-4

frontispiece illustration, looked very much like the hydrometers in use at the time. Yet Richardson was adamant that his device was conceptually separate from what had gone before, and quite specifically characterised his application of hydrostatic principles to beer-brewing as a new development. His justification was that no gravimetric project before his own had satisfactorily met the needs of *the brewers in particular*, for want of adequate specialisation.[285] This assertion was backed up by several features of the instrument itself and of the account Richardson gave of it.

The neologism itself, first of all, helped to engineer the distinction. We should note that other specialised hydrometers were similarly christened by other innovators — 'acetometers' for vinegar, Dicas' 'lactometer' for milk, and so on;[286] Richardson's choice of term perhaps requires a little more explanation than these. In making his device a 'sugar-measure', he emphasised the divide between the brewers' and the distillers' use of gravimetric methods: whereas the distillery (and the Excise) were chiefly concerned with the finished product and its state of rarefaction relative to pure water,[287] the brewers made their most important measurements before the fermentation process had even begun, and hence were concerned not with alcohol itself but with the sugary solubles which went to produce it. As we will see later, Richardson made the quantification of these solubles central to his whole philosophy of brewing.

At a more practical level, the distinction was supported by the saccharometer's effective range. The brewing and distilling industries both began their processes with the extraction and fermentation of sugary substances, so the upper limits of gravity measurement might be similar in both cases. Only distillers, however, would need a measure for those values *below* the gravity of water: the lowest gravity value a brewer should encounter in normal practice would be that of water, and he would be more concerned to have trustworthy readings for his original (pre-fermentation) gravities. In fact, any hydrometer could be made to give readings in a particular gravity region, given the appropriate set of weights; the question was how reliable the device would be in that region. This was determined by how much attention had been paid to the

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[285] Richardson 1788: 116

[286] Morrison-Low 1998: 312; Burnett 1993: 242-254; and cf Bensaude-Vincent 2000: 156-9 on the distinctness of the French *aréomètre.*

[287] No term other than 'hydrometer' was ever in common use to describe the British distillery instrument. In France a device constructed by Gay-Lussac, which gave direct percentage readings of alcohol by volume, was dubbed the 'alcoholometer' [Garnett 1910: 164].

instrument's calibration within that region *at the time of its construction*: as Bensaude-Vincent points out, the non-linear effects of fluid density and temperature on flotation properties, and the unpredictable effects of stem irregularity, meant that the accurate graduation of any hydrometer could *only* be established empirically.[288]

A device purpose-built by someone with an understanding of the brewer's needs might therefore be expected to function more reliably in a brewery setting. Richardson accordingly devoted some space in the *Statical Estimates* to describing his earliest experiments in calibrating the device. He began by establishing a zero for it in distilled water, then applied it to a sample of his wort, adding weight until the zero was regained. He then weighed half-barrels of the water and the wort, presumably with a large beam balance, and established the difference between them: confirmation that this difference rose linearly with the weight required to sink the saccharometer was obtained from tests on other worts.[289]

This account has a puzzling feature: the device under discussion is seemingly the finalised saccharometer itself, made to Richardson's own instructions; yet he also presents himself as discovering the instrument's properties for the first time in this calibration process. Perhaps the narrative is in truth based partly on his earliest experiences with the Martin hydrometer: Richardson would naturally have sought to downplay the significance of the precursor instrument. The intention was to drive home the point that his device was a brewer's innovation through and through — rather than, as we might alternatively consider it, an adaptation of a well-known distillery and Excise tool. An anonymous "friend" who performed more precise experiments on Richardson's behalf — detailed in an appendix — tells us quite explicitly that he planned at one point to investigate the gravity region particular to the spirits trade, but did not consider "the necessary toil of wading through liquors, comprehending such a variety of density" to establish temperature-dependence relations worthwhile, given the limited market for instruments presented by the distillery.[290]

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[288] Bensaude-Vincent 2000: 166

[289] Richardson 1788: 95-102

[290] Quoted in Richardson 1788: 324. The identity of this "friend", who wrote from London and whose initials were given as "W. D.", seems to be lost: Glendinning remarked on the mystery in 1900. The content of "W. D."'s letter suggests him to have been a non-brewer, well versed in hydrostatic theory and skilled in the

We might also consider Richardson's choice of instrument-maker. The firm of John Troughton (later J & E Troughton) was one of the most renowned in the London trade, with a particular reputation for engineering accurately-divided scales, chiefly for astronomical instruments. John's brother Edward Troughton, who ran the business alone following his brother's death in 1807, was generally acknowledged to be London's foremost instrument-maker after 1800.[291] The prestige of the Troughton name would certainly have been helpful to Richardson's purpose, and does not go unmentioned in his account of the instrument;[292] but we might speculate as to the possible relevance of another factor. The name of Troughton had not, unlike those of several other leading makers, been conspicuous in the fraught and sometimes unseemly scrambling for position associated with the spirits hydrometer:[293] Richardson's partnering with the Troughtons arguably gave him additional insurance against negative comparisons, while they for their part gained early access to a largely unexplored market for gravimetric devices.

The Richardson/Troughton device also possessed one undeniable novelty, the 'regulator'. This was a sliding attachment designed to correct mechanically for local variations in the gravity of the water used for brewing, so that dissolved mineral salts were not counted as part of the extract. Before first using the saccharometer, the brewer would float it in a sample of the water he planned to use, and manually adjust the regulator until the water-line corresponded to a zero mark. The instrument was now appropriately localised as the "equipoise or representative" of the water.[294] The regulator evidently served the useful purpose of demonstrating that the saccharometer was not *just* a hydrometer, and, specifically, signalling to potential buyers that its inventor was informed of the particular needs of the brewery.

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manipulation of instruments. We might reasonably speculate that he was himself an instrument-maker: if the initials are genuine, however, they do not correspond to any obvious suspects.

[291] For the Troughtons, and their place in the London instrument trade, see Skempton and Brown 1972-3; McConnell 1992; McConnell 1994. [Skempton and Brown dismiss the claim in earlier literature that John Troughton died in 1784, the year of the *Statical Estimates*' publication.]

[292] Richardson 1805: 457

[293] The Troughtons did, however, later submit an instrument (without success) in response to an 1802 call for a new device to serve as the official Excise spirit hydrometer. [Tate 1930: 8]

[294] Richardson 1788: 97

Richardson's monopolistic scheme made him not only the creator of the hydrometer and, via Troughton, its sole supplier; he also sought, by means of the *Statical Estimates*, to become its sole *interpreter*. Unlike many technological innovators, Richardson was manifestly unconcerned with presenting simplicity as a point in the instrument's favour. The claim that the new-style, saccharometric brewer must be literate and "scientific" accommodated the construction of a highly complex set of rules for the best operation of the device. The *Statical Estimates* prescribed when and where in the brewing process it should be used, how the readings should be corrected, and how initial results could be used to determine — via laborious arithmetical digestion — the best practice for the remaining part of the brewing operation. Copious use was to be made of Richardson's numerous tables which corrected for temperature, the effects of evaporation and so forth.

The tables were supplied in a book with the saccharometer, as were "Directions for using the instrument":[295] even with these in his possession, however, the inexperienced brewer would have found the operation of the instrument a rather opaque business without the *Statical Estimates*' detailed procedural explanations. Equally, the relevant passages of *Statical Estimates* were written with exclusive reference to the Troughton saccharometer's construction and scale, and so each effectively required the other: indeed, the book might well be viewed as an extended advertisement for the saccharometer. A description of the device, with the price quoted as three guineas, appears at the close of the book, with Troughton's address and a note that "Country brewers may be supplied by means of their booksellers, who have correspondents in London."[296] This method of distribution — not uncommon in the period in question — was essential for the propagation of Richardson's device among provincial brewers.

On a variety of fronts, then, Richardson worked hard to define the saccharometer as both distinct from the distillery hydrometer, and solely under his authority. In doing so, he furthered the acceptance of the quantity measured by his saccharometer as a distinct conceptual entity, forestalling the kind of controversy which had arisen in the spirits case by establishing a single device as the universal standard — not primarily at the Excise level, but among the brewers themselves. This was, at the time, a far more important matter than asserting the gravimetric accuracy of the device (which was

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[295] Richardson 1788: 345. The "Directions" were ultimately incorporated into the final (1805) edition of the *Statical Estimates*.

[296] Richardson 1788: 345

considered at length in the anonymous appendix, but barely addressed in Richardson's own text): once the saccharometer was suitably entrenched as an authority in its own right, it need not be justified by appeal to the hydrostatic principles which had spawned it.

The contingency of Richardson's approach can profitably be illustrated by comparison with Baverstock's equally evangelical efforts in the same field. No doubt as a result of the disgruntlement over priority mentioned earlier, Baverstock defined a conceptual agenda just as strong as that of Richardson himself, first expressed in an appendix to his 1785 text. Carefully unpicking Richardson's project to establish the separateness of the saccharometer, Baverstock first criticised the regulator — "the only novelty of it as a hydrostatical contrivance" — as prone to slippage, wear and tear from the effects of friction, and possibly leakage, all of which would affect the reading. A more serious problem, Baverstock contended, was Richardson's method for achieving the desired strength of worts on the basis of saccharometric readings. This potentially required long evaporations to provide the required concentrations, and was determined by a laborious calculation process. Baverstock, who recommended a rather simpler scheme involving the mixing of worts of different strengths, considered the evaporation method impractical, unreliable and superfluous, and cast the calculation procedure which directed it in the same light. In doing so, he worked to divorce the saccharometer from the *Statical Estimates*, breaking down Richardson's monopolistic dependence relation.[297]

Its regulator aside, Baverstock raised no objections against the saccharometer as a measuring device. In fact, it well suited his purpose not to, but rather to profess his impartiality as to the claims of different instrument-makers, and thereby to place the saccharometer on a level with any other hydrometer.[298] The *Hydrometrical Observations* contained a section on the question of variation between hydrometers, in which Baverstock argued that the only true distinction was in the scale used. Even this was "a matter of the most perfect insignificance": Baverstock claimed to have tested five hydrometers then on the market, and to have developed "to great or fully sufficient exactness" simple arithmetical conversions between their readings.[299] Possibly by this

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[297] Baverstock 1824: 86-7, 96. This policy was emphasised by his tendency sometimes to characterise the saccharometer as Troughton's, rather than Richardson's product.

[298] Baverstock 1824: 96

[299] Baverstock 1824: 61-4

stage he had seen, or was in possession of, hydrometers with multiple scales to cover the units of makers other than their own. An 1802 account of Atkins' hydrometer shows it to have been supplied with a rule giving measures on the scales of both Dicas and the Excise-sanctioned hydrometrist, Clark.[300]

We may question the degree of Baverstock's success in conforming the different devices to each other, but it is clear that he believed the future of measurement in brewing lay in this project of conformation, rather than in the privileging of a single device. An "Advertisement" added to the text later in 1785, prompted in part by some remarks (not extant) of Richardson's concerning the appendix, proclaimed: "*All* the hydrometers now made, those intended merely for spirits excepted, *speak a language* expressive of the superiority or inferiority of worts to each other; and that, besides shewing the difference in water, is all that a brewer has to require of the instrument."[301] The issue of differing degrees of accuracy in different gravity regions was not discussed: Baverstock, who, as has previously been noted, had been a keen early thermometrist in his youth,[302] followed Combrune in advocating the overall principle of measurement without becoming involved in the specifics of instrumentation.

3.3.2 The saccharometric extract

The same contrast can be found with regard to the quantities employed. Benjamin Martin's hydrometer, the inspiration for both Richardson and Baverstock, was scaled in units which were meaningful only within the distillery. Baverstock, who used the Martin device exclusively in his early work, retained these units and did not seek a more brewery-specific scaling.[303] Just as with Combrune's adoption of the Fahrenheit scale, the fact of quantification alone was important: the units employed were arbitrary, and might reasonably have held no material significance at all. Richardson took an opposite course in his formulation of the scale of 'pounds per barrel' or 'brewer's

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[300] Fletcher 1802: 280

[301] Baverstock 1824: 101. Italics original.

[302] See Section 2.5.2

[303] Baverstock 1824: 256-7

pounds.' This quantity had a major effect on British brewing, remaining in use until around 1980.[304]

The abovementioned operational description of the instrument's calibration in the *Statical Estimates* indicates how the scale came about. By direct weighing, Richardson established that a barrel of the first wort sampled was 39 pounds heavier than a barrel of distilled water. He therefore proclaimed that the weighting needed to sink the saccharometer in a sample of that wort was the "representative" of this increase of 39 pounds per barrel.[305] Further experiments demonstrated to Richardson's satisfaction that the gravity of wort increased linearly with the load needed to sink the saccharometer, and so he expressed all gravity values on the pounds-per-barrel scale. The actual physical mass of the weights loaded onto the saccharometer was, at least as far as the brewer was concerned, immaterial; again, here, we see the instrument, and the values it produced, being established as independent from its hydrostatic roots.

Note that Richardson's system focused the user's attention on the additional density found in worts: that is, on the *extent of the positive contribution* made by the mashing process. Habituating the brewer to the pounds-per-barrel scale facilitated a conceptual focus on the *extract*, the sugary material extracted from the malt during mashing. This bears comparison with Gooday's resistance boxes: Richardson's overall goal was to establish, in the brewers' minds, the readings from his saccharometer as a quantification of the 'value' contained in a wort. He achieved this by defining value exclusively in terms of the extract, an apparently uncontroversial but hugely significant step. Extract, crucially, was something tangible: it was possible — though not a common analytical practice — to evaporate off the water from a sample of wort, leaving the extract behind as a dry, sweet-tasting mass. The weight of this dry extract and the brewers'-pounds measure of liquid weight increase were not, in fact,

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[304] The pound per barrel was dropping out of use for recording the gravity of beer samples by the early twentieth century, to be replaced by the Excise-approved specific gravity degree scale. It survived, however — generally in the form of its multiple, the brewer's pound per quarter — as the standard unit for expressing laboratory-defined extracts of malt, and was used by brewers in calculating extract yields. This usage was phased out with industry acceptance of the litre degree per kilogram after 1977. [Ray Anderson, personal communication, 8 January 2002]

[305] Richardson 1788: 98-9

equivalent quantities;[306] they were, however, linearly proportional, and this was sufficient for Richardson's purposes.

In a sense, the pre-existing concept of the extract performed the same role for saccharometry as had the 'breathability of air' in the eudiometry case described by Schaffer: it was an entrenched idea, familiar to all the interested parties, with reference to which the benefits of a quantitative treatment could be spelt out in practical terms. Yet Richardson's quantification scheme entailed a subtle shift in priority. The pre-saccharometric notion of extract was needed to justify the pounds-per-barrel measurement; once the proportionality was established, however, the precedence was reversed. The directly-quantified extract itself — the mass of dry material — never appeared in Richardson's operational procedures; 'extract' could now be determined by, and hence was exclusively defined by, the instrument's reading. Richardson's intentions for the brewer's pound, then, were as ambitious as Combrune's for the degree Fahrenheit.[307]

Perhaps the most important conceptual principle in the *Statical Estimates* is Richardson's building-up of the extract as a replacement for the only pre-existing quantity available to the brewer in determining the strength of his beer: the volume of malt used in the mash. As previously mentioned, brewers were aware of the limitations of this measure; in the absence of any other, however, they seem to have considered it a tolerable guide to the strength produced — Richardson at one point discusses the apparently familiar case of a brewer attempting to emulate the beers of another region on the basis of malt volume data.[308] Richardson sought to sweep away not only this practice, but the whole notion of a 'guide' to strength. The saccharometrically-determined extract was not merely a 'better' means of assessment: *strength*, under the definitions Richardson imposed, *is precisely that quantity recorded by the saccharometer*. To borrow Schaffer's term, strength was 'elided' into extract,

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[306] Richardson elaborated upon the distinction with some care, but, according to Glendinning 1900: 363, it gave confusion to "brewery pupils" as much as a century later. [Booth] 1829: 16-7 assumes Richardson was entirely unaware of the distinction.

[307] As discussed in Combrune 1758: 69 (see Section 2.4.1.)

[308] Richardson 1788: 289-90

just as the extract had been elided into the quantity defined by saccharometric measurement.[309]

We are fortunate in having a colourful account from Richardson of exactly the kind of brewing mentality he sought to overturn. He gave the example of two samples of "the same kind of barley, under the management of two different maltsters." Saccharometry revealed a difference in extract per bushel of nine per cent:

> and yet these two parcels of malt would have passed, among common consumers, with this [*sic*] simple observation that *this sample is freer than that*; the difference in sale, would not, perhaps, have exceeded a shilling per quarter; and the brewer would have thrown them indiscriminately into the mash tun, drawing his usual length from each, to the positive loss of 9 per cent. either in the quality of his liquor from the latter parcel, or in the obtainable profits of his trade from the former; which ever might happen to tally with the general quality of the malt he used.[310]

Critically, there was in this analysis the notion of a pre-existing *standard*: each brewer aimed to brew his beer to a specific strength to be sold for a specific price. This standard of strength would certainly be more closely-determined than the Excise category in which it fell, but it would still be rather broadly defined. The variation in the quality of malt inevitably caused the strength to fluctuate: if it rose too high, the brewer would realise he was making an undue expenditure on malt, and if it fell too low, the customers would object; but, with only the evidence of taste as judge, there would be a broad band in the middle within which both parties were satisfied.

With the introduction of the saccharometer, however, 'strength' was redefined as a rigorous and replicable quantity. Richardson's technology imposed a sharply-defined *optimum* of strength: if the value could be precisely controlled — which, said Richardson, it could — this would naturally correspond to the lower edge of the former 'acceptable strength' band, and the brewer would thus achieve a considerable saving. *Any* deviation from this value worked to the brewer's disadvantage, entailing either the certainty of customer dissatisfaction or a determinable waste of materials. Once established, the saccharometric standard had to be maintained.

Whereas, in the spirit case, the proof scale embodied by the Clarke hydrometer became an inevitable part of practitioners' lives through brute force of legislation, with all the

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[309] Schaffer 1990: 288: "Respirability elided into dephlogistication, dephlogistication into health, health into virtue."

[310] Richardson 1788: 164-5

potential for resistance that implied, the inevitability Richardson projected in the brewery rested on an appeal to the brewers' own interests. This, then, is a reversal of the model of quantification offered by Theodore Porter: here the practitioners were driven to seek greater precision than the legislature had imposed. If, as I have assumed, Richardson was aware of the serious difficulties which had transpired in the distillery, he must thereby have been led to seek support for his scheme within the brewing community first of all.

Richardson's next step, indeed, further extended the appeal of his scheme to the brewers. By analysis of extract values, he submitted the abovementioned variation in malt quality to a quantitative determination. Brewers and maltsters were already in the habit of grading malt qualitatively on the basis of its physical appearance, its response to the bite, and its ability to float in water.[311] Richardson proclaimed that there were much greater "invisible" differences in extractive potential, undetectable before saccharometry: he advanced results suggesting that some apparently "indifferent" barley was more extractible than "well-made" samples produced in different years or locations. Brewers could now abandon judgment by appearance, "relative to no standard of comparison":[312] Richardson claimed to be able to "estimate the intrinsic worth of every kind of malt, to the very great precision of the one-thousandth part of the fermentable matter extracted from every quarter employed." This revealed "a great variety in malts, which, but for these discoveries, would scarcely have been deemed of different value."[313] In downgrading the evidence of the brewer's own eyes, Richardson aimed to install the saccharometer as the chief arbiter of quality, and extractability as the chief criterion for selection; at the same time, by tying the extract to the concept of economic value, he strengthened the prospect of its adoption.

Richardson was very explicit on how the value of malt might be standardised. Presumably proceeding from his own more general experience, he nominated a standard reference value, "82 pounds [per barrel] produce" to represent "what is now termed *good malt*", and calculated the values of the several malts included in his survey relative to this figure. He also nominated the term *par* to express malt values, by direct analogy with the concept of 'proof' in spirits, a sample of malt being

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[311] Most literature discussing these characteristics is based on [Ellis] 1736: 17-8.

[312] Richardson 1788: 171

[313] Richardson 1788: 158-9

described as so far above or below par.[314] He even sketched out a plan for a possible "apparatus for ascertaining the value of malt to the purchaser or maker, independent of the consumer; in order that the buyer and seller of that article may adopt a clear and explicit language, conveying definite ideas which by common usage may become as familiar to each other, and as well understood, as the terms used by the importers and dealers in spirits."[315] Richardson never constructed, or at least never marketed, such an instrument, although a note in the third and final edition of his collected work, published in 1805, suggests the proposition attracted several enquiries.[316]

Richardson's message was one of empowerment for the brewer, who was no longer reliant on maltsters' claims regarding the efficacy of their practices; the judgment of the saccharometer could be applied in deciding the merits not only of individual samples of malt, but of entire customs of malt-making. Richardson noted with interest the consistently low extracts from malts made by the procedure characteristic of Ware in Hertfordshire. Ware brown malt was produced mainly for the London market and was the principal choice of the major porter brewers, commanding the highest prices: "credibility would be staggered" at the idea that this premium product could be so inferior, wrote Richardson, "were it not mathematically demonstrable."[317] This was the nub of Richardson's argument: 'mathematical demonstrability' would, he boldly stated, be sufficient to turn the popular prejudice on its head, and price would become a function of extractability.

Having painstakingly constructed his own system of assessment, Richardson allowed himself a few remarks, in the *Statical Estimates*' introduction, on that operated by the Excise authorities. We should not be surprised to find Richardson roundly derisive of the "darkness" in legislative thought represented by the uniform duty bands, the reliance on the Exciseman's sensory powers, and the "ridiculous restrictions" preventing the mixing of beers. Richardson's saccharometric extract measurements, in contrast, could be taken to express both strength and commercial value; they permitted — indeed, were defined by — a convenient and authoritative means of determination, and gave precise quantitative figures to which taxation might be proportionated.

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[314] Richardson 1788: 172, 174. Italics original

[315] Richardson 1788: 170-1

[316] Richardson 1805: 253 n

[317] Richardson 1788: 161

"Were the duties shaped according to the gravity of the wort," Richardson wrote, "these altercations would immediately vanish, the revenue would be increased, the brewer would be at liberty to make, alter, or compound his liquor into as many and as various sorts, as he has palates to please, without subjecting himself to the interference of the officer, or the lash of the law."[318] So neatly is the argument woven, it is hard to escape the conclusion that this final extension had been in Richardson's mind throughout the project's development.

Of course, it was not in Richardson's power to proclaim a change in the Excise legislation. Yet he provided plentiful inducements: as he described it, the saccharometer would not only put a stop to costly legal disputes and facilitate the tailoring of strength to customer demand. It would also ensure revenue was drawn from the brewer in direct proportion to the known value of his raw materials, since all the relevant quantities were rated directly to the saccharometric standard. It was unquestionably Richardson's hope that his saccharometer would ultimately receive the legislative endorsement accorded to the Clarke hydrometer.

The following key features, then, lie behind the success of Richardson's project: it is addressed solely to brewers; it aims to legitimate quantitative innovation by rendering tangible a matter of economic concern; and it in no way acknowledges antecedent or parallel work in the distillery. It might therefore be asked why William Reddington's even more separatist approach of 1760, discussed above,[319] failed: Reddington's "float" was intended to give a reading directly expressing monetary value, and, as a home-made brewery instrument, excluded the hydrometrists altogether. This absence of a connection to philosophical instrument-makers, however, in fact goes some way to explaining the failure, as does the posthumous nature of Reddington's work. To the established criteria for the success of a quantitative endeavour (coherence, reliability, utility) must be added *publicity*. Richardson was a zealous proponent of his principles and instrument, exploiting the networks of the bookselling trade and coffee-house, and writing speculatively to solicit the custom of individual brewers; the benefits of the saccharometer were also expounded not only by the Troughtons but, as we will see later, by other London makers who put forward their own instruments to gain a slice of the new market. Moreover, Reddington's scheme was intensely localised, with each

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[318] Richardson 1788: 87-9

[319] See Section 3.2.2

brewer to construct an independent instrument. Whereas the thermometric quantity, though applied in a localised fashion, had been legitimated (in line with Gooday's account) by extensive application prior to its entry to the brewery scheme, Reddington offered no *standard* or means of resolving disputes.

Richardson's project, by contrast, would — at least on his own account — have obviated most of the legislative, economic and technical unknowns and irregularities associated with the brewing business, through the abovementioned system of standardisation based squarely on the equation of strength and value with the extract, as defined by the saccharometer. For all his focus on the extract, however, Richardson recognised the presence of an alternative criterion, pre-existing in the minds of brewers, by which the reliability of his system had to be affirmed if it was to gain acceptance. His attempts to secure this point are dealt with in the final part of this section.

3.3.3 Competing definitions of strength: Richardson and spirituosity

The pre-saccharometric concept of the 'strength' of beer contained what we may view, in retrospect, as two principal notions. On the one hand, there was the 'richness' of the wort employed to make it: this was the principle Richardson had appealed to in privileging the saccharometrically-determined extract. On the other, brewers in general accepted that a beer containing more alcoholic spirit was stronger, in that it would cause greater intoxication. As previously noted, this second principle was more clearly evident in the distillery case, where it underpinned the Excise project of hydrometric determination: but it was also an established feature of brewing culture. As far as the sensory criteria of the traditional brewer were concerned, there was not necessarily any distinction between the 'extract' and 'spirituosity' understandings of strength: under Richardson's quantificatory scheme, however, they threatened internal contradiction.

The problem was that, as noted earlier, the spirit content of beer was proportional to the fall in gravity, or attenuation, during fermentation — the difference between the original and final gravities. Richardson's extract, however, corresponded to the original gravity *alone*: since the gravity never fell finally to zero,[320] the two quantities

[320] Richardson's scale took the specific gravity of water as zero, rather than unity.

were not equivalent. This itself would have been unproblematic had Richardson been able to demonstrate — as seemed plausible — that the attenuation was *proportional* to the original gravity: alcohol content could then have been straightforwardly 'elided,' like so much else, into the extract. But when Richardson began the relevant saccharometric experiments, employing beer samples of different kinds and apparent strengths, he found only disproportion and disorder, echoing Benjamin Martin's initial incomprehension. "[T]he amount of the attenuation," Richardson wrote in terms of surprise, "did by no means correspond with the original gravity."[321]

Most shockingly, Richardson's readings indicated that a "strong," highly-valued Burton ale, having an original gravity (on the pounds-per-barrel scale) twice that of an everyday porter, might display so high a final gravity as to indicate exactly the same attenuation as for the cheaper drink, meaning that the alcohol content, too, would be equivalent. It seemed that Richardson's hard-won quantification of strength would turn long-established understandings on their heads; he considered the possibility that his entire approach might be "erroneous; especially when I considered that two liquors equally attenuated, tho' originally of very different gravities, had apparent strength, or inebriating effects more nearly proportioned to their gravities, than to the amount of the attenuation."[322] "Apparent" here indicates not the evidence of saccharometry, but the firmly-entrenched, sensorially-based understanding amongst brewers and customers.

Something had to give, but Richardson's options were limited. Like any quantificatory innovator, he could not move too far from his community's pre-quantificatory understandings: abandoning the conceptual equation of strength and intoxicating potency would have destroyed his credibility among the brewers. Nor could he attack the proportionality between spirituosity and the attenuation as determined by the saccharometer: this followed from the basic physical postulates he had already invoked to give credence to his quantitative approach.[323] The only remaining option was to

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[321] Richardson 1788: 241

[322] Richardson 1788: 241

[323] The principle that alcohol was produced directly from malt sugar, on which the proportionality rested, was widely but not unanimously accepted at the time: some still held to the once-prevalent view that 'spirituous parts' pre-existed in the wort and were somehow 'set at liberty' to some degree during fermentation, an interpretation we have met (Section 2.4.1) in the work of Combrune. Richardson argued strenuously against this, both in the *Statical Estimates* and in its forerunner, a 1777 work entitled

break down the interposing proportionality between intoxication and spirituosity. This could not be denied in the spirits case; but, Richardson announced, the situation with regard to beer was somewhat more complex. His experiments were to be taken as conclusively *demonstrating* that, as he put it, "*the apparent STRENGTH of malt-liquors, or that INEBRIATING EFFECT which they produce upon the animal frame, does not entirely consist of SPIRIT*."[324]

Richardson therefore needed another "principle" in which to locate the additional potency of high-gravity beers, one which, according to the results of his experiments, should have an effect roughly equal to that of the spirit. Cutting himself loose from established philosophical doctrine, and stressing that he was now dealing only with "probable conjecture", Richardson nominated as the agent responsible the gas — fixed air, as it was then understood — present in the beer. This manoeuvre, of course, made good use of the principal qualitative factor distinguishing beer from the intrinsically non-gassy spirits. It was evident that the fermentation process evolved fixed air as well as spirit — some early chemical accounts of fermentation had held them to be the same substance[325] — but, at the same time, it was obvious to all brewers that some of the fixed air escaped during fermentation. Richardson proclaimed that the final proportions of spirit and fixed air were not "always equal in quantity or effect": this introduced a variable which was absent in the spirits case and which, crucially, was dependent on the particular brewing procedure used.

This position had a lot of explanatory power. The difference between the methods employed in producing the ale and the porter, Richardson said, was one of 'forcefulness'. Porter was brewed with a great deal of "auxiliary force", which had driven off most of the fixed air; the ale had been treated less forcefully and so retained more fixed air, but at the same time the lack of force meant the conversion to spirit was less complete. The art of the skilful brewer, therefore, lay in trading off the competing requirements for fixed air and spirit. (In contrast, fermentation in the distillery

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Theoretical Hints on an improved Practice of Brewing Malt-Liquors, which paved the way for the saccharometric project. Richardson's words suggest a sound basis for quantification: "the fermentable matter… becomes more or less attenuated, and in lieu of every particle thus attenuated, a spirituous particle, of less density than water, is thus produced." [Richardson 1788: xx, 56-9, 118, 120]. Corran 1975: 139 goes so far as to describe this principle as "Richardson's Law", though it clearly predated him.

[324] Richardson 1788: 246. Italics and capitalisation original.

[325] Corran 1975: 259

represented the case of maximal 'force', pushing the fermentation to its limit but leaving no fixed air at all). Richardson couched this claim in the language of a strict inverse proportionality: clearly the trade-off must have an optimum point, and Richardson's quantitative method would reveal it.[326]

Unfortunately, this was an aim Richardson had to put to one side: he could not measure fixed air in the same sure, quantitative terms he applied to extract, and admitted he had no better guide than "the vague discrimination of the senses". He did elaborate a rough example showing how a quantificatory scheme might work, but this proceeded by a series of *ad hoc* assumptions and was obviously not realised to Richardson's own satisfaction.[327] He held out the hope that "some further chemical analysis shall lay a foundation capable of supporting a system established in mathematical certainty."[328] Such a development did, indeed, come to pass; but not in a way which safeguarded the equation of strength and extract, as we shall see when we consider the ultimate consequences of Richardson's work.

3.4 Saccharometry after Richardson

3.4.1 The survival of the saccharometric quantity

Richardson's project met with mixed success. He was, as we have seen, rapidly enshrined as the pioneer of saccharometry; yet he did not achieve his aim of establishing sole control over the saccharometer. One drawback to his reliance on a neologism was his inability to control it: the term 'saccharometer' was rapidly applied, by the many established hydrometrists, to numerous instruments with a greater or lesser degree of brewery specialisation. Lacking even the limited protection afforded to Clarke by the official sanction of the Excise, Richardson was powerless to prevent other makers cutting in on a market he was chiefly responsible for opening up.

This can be seen in the writings of later brewery writers, who probably formed their own exclusive deals with various makers. Quin received the support of Hayman, one of the most enthusiastic nineteenth-century saccharometric brewers,[329] while at least

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[326] Richardson 1788: 255. Italics original.

[327] Richardson 1788: 251-3

[328] Richardson 1788: 259-60

[329] Hayman 1819: 34-5

two writers favoured Dicas;[330] yet the reputation for the most accurate saccharometers settled ultimately on Dring and Fage, now a powerful force in hydrometry having become the official manufacturers of the Excise-approved Clarke device.[331] Alexander Morrice, in 1802, professed himself a user of the Richardson saccharometer whilst noting that other brewers praised both Quin's instruments and Dring and Fage's; by 1827, when the seventh edition of his brewery manual appeared, Dring and Fage were among those retailing it, and the text had been revised to advocate their device above all others.[332] Perhaps because the Troughtons' interests lay primarily in other directions, meanwhile, the original saccharometer gradually faded from view after Richardson's death.[333]

Yet James Baverstock's alternative contention, that all gravimetric devices are interchangeable, was not accepted either. The interpretation which developed among later brewers — that the saccharometer represents a special case of the hydrometer, adapted to the brewer's purpose[334] — lies somewhere between the two positions, and demonstrates that Richardson's rhetoric concerning the *idea* of a dedicated brewery appliance did lodge itself in the brewing community's mindset. Those accounts favouring other makers, whilst downplaying the contemporary value of Richardson's own nominated instrument, typically praise his theoretical contribution; Richardson, not Baverstock (and certainly not Reddington or Martin) is generally cited as the principal innovator in the measurement of beer strength.[335]

This is due principally to the fact that Richardson's quantificatory agenda, unlike his proprietary project, gained lasting success. When Troughton's rivals came to offer saccharometers to the brewery, they mostly adopted the pounds-per-barrel scale:[336] it became the standard quantity expressing gravity values within the profession. Even David Booth, who in 1829 considers Richardson's mensuration unhelpful from a

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[330] Shore 1809: iv; Worthington 1812: 68-9

[331] Accum 1821: 105

[332] Morrice 1802: 43-5; Morrice 1827, *passim*.

[333] Although [Booth] 1829: 11-12 states that the refinements of other makers are not of practical significance, while John Levesque allowed his judgment of Richardson's as "the best Saccharometer" to remain in his work into the 1840s. [Levesque 1847: 79]

[334] [Booth] 1829: 11; Loftus 1863: 116

[335] See for example Accum 1821: 104-23

[336] Accum 1821: 106-7

scientific standpoint because the saccharometric pound-per-barrel is not equivalent to a pound's weight of real fermentable matter — believing incorrectly that Richardson was unaware of this point — states that, to its intended users, the brewer's pound is more useful than a more conceptually rigorous measure.[337] It went almost unchallenged in the brewery until the 1880s, when it began slowly to be superseded by the specific gravity scale of the Excise and distillery, though it was apparently "still widely used" as late as 1940.[338]

The dominance of the saccharometric quantity, I contend, was achieved thanks to the brewers' eager assimilation of Richardson's programme of brewery management. By tying all relevant values to the extract, and establishing the saccharometric quantity as the direct representative of extract, a manoeuvre facilitated by the obvious physical intelligibility of "pounds per barrel," Richardson was able to make sure that his saccharometric scale (though not the Troughton saccharometer itself) was generally adopted. Simple quantification was not enough: Baverstock in the 1770s had offered the brewers a measure, but he had not offered them the extended system of precise value determination, created from a brewery perspective and tailored to protect and serve their interests, which Richardson offered. The new powers of valuation and standardisation which this gave to the brewers hold the key to the saccharometric project's success in this respect.

In particular, the saccharometer provided the first quantitative interpretation of the difference in extractability between brown and pale malts. Traditional understandings indicated that the higher-dried brown malts, however well-managed, always yielded somewhat less malt-sugar, and tended consequently to be somewhat cheaper.[339] Richardson, following up the lead given by his observations on Ware malt, submitted the matter to saccharometric analysis: he confirmed the traditional view in principle, but found that the extractible value of brown malts was in fact far lower than the price differential assumed.[340] Invoking this discovery in support of the value of saccharometry, Richardson collected new extract results for each year's malts, and

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[337] [Booth] 1829: 16-7

[338] Ray Anderson, personal communication, 8 January 2002. The reference, which I have not had the opportunity of consulting, is to Herbert Lloyd Hind (1940), *Brewing Science and Practice*, London: Chapman and Hall, ii, 239.

[339] [Sedgwick] 1727: 30; [Ellis] 1736: 19

[340] Mathias 1959: 414-6; Richardson 1788: 163-4

published them cumulatively in succeeding editions of his work to 1805.[341] Curiously, the results of this work are not overwhelmingly convincing: Mathias perhaps overstates the case when he refers to Richardson's "proving conclusively" the superiority of pale malt over the years.[342] The figures presented in the 1784 edition, and those added for 1787-8, do give clear support, but after this date there is often little difference between Richardson's values for "pale" and for "brown and pale mixed."[343]

The utility of the saccharometer in resolving the matter, however, was soon generally accepted, and other brewers appear to have made the comparison for themselves.[344] Furthermore, although saccharometry was not established as a principle for beer taxation, it was soon incorporated into Excise practice alongside spirits hydrometry. In 1805 and 1806 the Scots chemist Thomas Thomson, later Professor of Chemistry at the University of Glasgow, was commissioned by the Boards of Excise of Scotland and England to determine extracts from barley and the strengths of ale and porter samples: he devised a new model of saccharometer (christened "Allan's saccharometer" after its maker, Alexander Allan), which was used unofficially by the Scottish Excise until its official sanction in 1806.[345] Thomson's conclusions were far more clear-cut than Richardson's: brown malt was "perhaps… on an average but one fifth" as extractible as pale, though costing at that time seven-eighths as much.[346] The low extractability of brown malt was increasingly evident, and brewers nationwide took note: the period around the turn of the century saw a falling-off in demand for brown malt, and increasing use of the lower-dried pale and amber.[347] The price differential grew and became to some extent a function of extractability, just as Richardson had intended.[348]

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[341] Richardson 1805: 249-52

[342] Mathias 1959: 415. The later figures produced in support of the same point by Accum, also mentioned by Mathias, are similarly ambiguous. [Accum 1821: 34]

[343] Richardson's accompanying text in the 1805 edition [as cited above] problematises the figures somewhat, but his claim for the superiority of pale malt is unamended.

[344] See, for instance, Worthington 1812: 21-2.

[345] Morrell 1969: 247-8

[346] Quoted in Donovan 1830: 198

[347] Mathias 1959: 72-3; see also Baverstock Jr's comments [in Baverstock 1824: 189-190].

[348] Mathias' representative price figures for brown and pale malts between 1784 and 1830, taken from Truman's rest books, clearly show this effect at work [Mathias 1959: 548.]

3.4.2 Saccharometry and strength

Richardson's attempt to reconcile the two possible definitions of 'strength' fared less well. No mention of his project of determining the intoxication due to fixed air is found in subsequent brewery literature; neither Richardson nor any subsequent writer built up the "conjecture" into a quantitative scheme which could be made to accord with pre-saccharometric expectations. This left the potential contradiction between the 'extract' and 'spirituosity' definitions unresolved. Even as the reconceptualisation of malt values prompted by Richardson's focus on the extract was becoming general, most other brewing theorists (including Baverstock) tended to the distillery view that alcoholic spirit alone represented the sole principle of intoxication, and therefore that extract values were *not* a sure guide to strength.

Professional chemists, such as William Thomas Brande, were careful to point out that the brewers' instrument was "not quite correctly called a *saccharometer*, since it is influenced by all the contents of the wort," given as "*saccharine matter*, *starch*, *mucilage*, and a small quantity of *gluten*."[349] Over the remaining course of the nineteenth century, brewing chemists further deconstructed Richardson's monolithic notion of 'extract', identifying separate constituents which would ferment at different rates, some being directly converted to alcohol, others providing such features as 'body' and flavour.[350]

These features had held no place in Richardson's analysis, starkly focused as it was on what could be measured by the saccharometer: the same was true of colour, and (the source of one of Baverstock's complaints) the long, potentially deleterious boiling times Richardson ordered in order to bring worts to the correct gravity. A certain reductive simplicity was probably necessary in order that the project could be readily grasped and applied: the ability with certainty to ignore certain parameters focuses investigation, blocking out the distraction of factors which would render the situation too complex to analyse.[351] This same simplicity, however, made it inevitable that the

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[349] Brande 1819: 397-8. Italics original. Cf Donovan 1830: 188, and also Chadwick 1835: 27-8, which addresses the same point to private brewers.

[350] For an account of these developments see Hooper (1885), especially 128-167.

[351] This passage is informed by an interpretation introduced by Collins, proceeding from his views on the entrenchment of ideas. Any system of understanding imposes on its user a perceptual framework in which certain properties *do not exist* in any consequential sense: hence, for instance, to the majority of electrical workers (but not

project would be modified or limited as later brewing theorists turned their attention to matters it had left unaddressed.

The Excise and legislative response to the gauntlet Richardson had laid down was a convoluted one. In 1830, amid the substantial reforms which made up the Duke of Wellington's Beerhouse Act, the crude taxation bands *were* replaced by a quantitative assessment modelled on a direct proportionation — but not, however, to the saccharometric extract. The existing duty on malt usage, assessed volumetrically, was expanded to become the principal beer tax, invoking the very quantification Richardson had sought to discredit.[352] The government had accepted the utility of introducing proportional duty, in order to allay the disputes associated with the fixed rates; but, apparently, it did not share the brewers' agenda sufficiently to accept the saccharometric measure, now used as habitually as the thermometer in most of the larger breweries. Probably a desire to keep the farming lobby satisfied was at work: since the measure ignored the invisible 'quality' of malt revealed by the saccharometer it certainly worked in favour of farmers and maltsters, and to the detriment of brewers.

Then, after half a century of volumetric assessment, and almost a century after the *Statical Estimates*' publication, Richardson's recommendations were suddenly enacted wholesale. Gladstone's "Free Mash-Tun" Act of 1880 abolished the malt tax and introduced direct taxation in proportion to the pounds-per-barrel extract contained in worts, as determined by "an approved saccharometer and tables".[353] What is interesting is the legislators' view that the value of beer subsisted unequivocally in the gravity of its wort, rather than in the intoxicating effect it would produce.[354] Although the disparity between extract and spirituosity was now established, chemically understood and very precisely quantifiable, the legislators chose to accept a measure

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to those working in electronics) wires 'do not possess' length. [Collins 1985: 70-1, 73.]

[352] Clarke 1998: 66-7. Mathias 1959: 73 states that after 1830 beers were "still classified fiscally into strong, small and intermediate": in fact the only tax bands remaining in 1830 were 'strong' and 'table', and both were abolished in that year.

[353] Nettleton 1881: 7; and cf Clarke 1998: 65-6

[354] Assessment on the basis of original gravity persisted with various minor modifications until 1993, when it was replaced by the alcohol-by-volume scale traditionally associated with the distillery. This final legislative abolition of the saccharometric scheme perhaps reflects the increasing marginalisation, in Great Britain, of the brewery culture Richardson stood for. I hope at some point to submit this matter to further study.

based directly on Richardson's extract-centred edifice of economic meaning. This definition remained in place until 1993, when, in the course of European harmonisation, an alternative levy based on alcohol by volume (ABV) — recapturing the spirituosity definition — replaced it. While some contemporary news reports take for granted a straightforward connection between ABV and 'strength' or 'weakness,'[355] brewers themselves continue to think of the extract as a more meaningful defining feature, and still specify original gravities for internal quality control purposes.[356]

3.5 Conclusion

To understand the outcome of the saccharometric endeavour, we appreciate that, by addressing his innovations to the brewing community directly, Richardson had created a culture capable of surviving both the vagaries of the legislative process and the loss of its own conceptual underpinning. The brewers of the later nineteenth century did not see extract as the sole representative of strength, as Richardson had intended; they continued to use the measure, however, on account of its deep entrenchment in brewery culture. The constant handling of saccharometers (universally calibrated in pounds per barrel) helped to reify the quantity: it was simply a given, indicative of a brewery property fundamental in its own right. Since the authority of the extract was not (unlike that of the distillery proof scale) rooted in the legislature, it could, perhaps, have survived for far longer without legislative sanction; as it turned out, the legislature moved ultimately to embrace its established universality.

Richardson's personal ambitions, however, were not fulfilled. He had clearly sought to establish the Troughton saccharometer as the sole authority and legal standard in determining strength in the brewery, just as Clarke's hydrometer had been made the distillery standard: this would doubtless have generated for him an enormous profit through whatever commission arrangement he had reached with Troughton, while the *Statical Estimates* would have become an indispensable brewery reference. The controversies associated with the spirit case, however, showed that paper authority, such as that vested in Clarke, was of no lasting use unless accompanied by a firm

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[355] John Shepherd, "Big brewers cut strength of top beers," *Independent*, 7 June 1993, 24; Philip Rawstorne, "Brewers criticised for weakening beers," *Financial Times*, 8 June 1993, 6; John Shepherd, "Bitter taste of the brewers' duty," *Independent on Sunday Business*, 13 June 1993, 6-7

[356] Ray Anderson, personal communication, 8 January 2002

acceptance among the relevant professional community. Richardson therefore pursued a long-term strategy, seeking first of all to inculcate saccharometry among his fellow brewers.

The presentation of saccharometry as specifically tailored to the brewery's needs should not, however, be read simply as a ploy. Richardson was sincere in his desire to improve the brewers' lot, by banishing the uncertainties in their dealings with maltsters, Excise officials and customers. As we have seen, Richardson's pronouncements on these matters were enthusiastically taken up, the result being the rapid establishment of the extract-focused saccharometric system which underlay them. Yet the brewers were evidently sophisticated in distinguishing the parts of Richardson's scheme designed to assist them, from those intended for his own benefit. Thus, Richardson's theoretical system took hold (and he retains the lasting goodwill of the brewery on this account), but the Troughton instrument itself did not: the situation does highlight, in parallel fashion to Ashworth's discussion of the Clarke case,[357] the difficulty in maintaining control over an innovation, however carefully-fashioned the proprietorial tie. The ultimate consequences of quantitative developments are determined neither by individual apostles such as Richardson, nor by the legislature, but by the community of practitioners engaged in performing and assessing the processes subject to quantification.

Our analysis of the concept of 'strength', finally, warns us of the dangers of taking the object of our investigation for granted: we have here the interesting case of quantification provoking a conflict between two modes of definition which had previously been held as more or less interchangeable. Richardson's handling of the matter clearly confirms the view, expressed elsewhere in the present thesis, that any act of quantification must to some extent embrace the established, qualitative criteria which precede it. Thus Richardson, in many ways the arch-representative of the 'scientific' approach, was willing to discard such arguably significant properties as colour, taste and maturation behaviour from his analysis, but was not prepared to put his name to an account which made intoxicating potential irrelevant to an understanding of 'strength'. His whole brewery-specific scheme relied on an appeal, not only to the brewers' fiscal sensibilities, but to their established way of life. So, for instance, while much of his work was geared towards the problem of accurate gravity

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[357] See Section 3.2.2

determination, he did not *prescribe* (even in privately-communicated directions) the best gravities at which particular beers should be brewed: that, he affirmed, was for the individual brewer to decide.[358]

That is not to suggest, however, that there were never occasions when the brewers' customary practice seemed to conflict with their financial best interest, and when the radical in Richardson outstripped the conservative. The superiority of pale versus brown malts, alluded to above, is the most notable example: the brewers were persuaded in a direction which took them away from the established conventions of porter brewing, and hence from the expectations of their customers (another factor not susceptible to saccharometric analysis). The steps taken to reconcile the public with this shift, and the fundamental changes in beer-brewing which resulted, will be dealt with in Chapter 4.

[358] Richardson 1788: 176. Richardson's private directions as reprinted in [Booth] 1829: 40-49 give explicit Fahrenheit temperature values for mashing and other parts of the process, but no saccharometric determinants of the lengths to be taken.

Chapter 4: Colour and the identity of porter

4.1 Introduction

Peter Mathias, in 1959, stated explicitly that brewing in the middle years of the eighteenth century underwent a revolution. By this he meant "a fundamental change in its structure — a complete shift in its centre of economic gravity — which breaks open the horizons of entrepreneurs by its effect on the scale of production and alters *qualitatively* all their assumptions and problems."[359] This drastic change in scale was, he said, reliant upon the changing technicalities of the brewing process. It depended above all on the origination of a quintessential eighteenth-century product: porter, the brown beer of London.

Porter is now little-known, and barely produced beyond some revivalist styles, marketed to beer aficionados by a handful of independent breweries. The product, and the name, largely dropped out of British consciousness around the time of the First World War (surviving in Ireland beyond the Second); it is most often placed in context as a forerunner to stout, the name of which — abbreviated from 'brown stout' or 'stout porter' — once referred to a strong variety which ultimately eclipsed its parent style. Throughout the period of the present thesis, however, prior to the rise of pale ale after 1830, porter was the staple malt liquor of most of urban Britain: wherever 'beer' is specified, porter is more often than not intended. Mathias describes the significance of its introduction as follows:

> Porter, in brief, seems to have been the first beer technically suited for mass-production at contemporary standards of control, unlike ale which needed 'attemperated fermentation' for stability in large-scale brewing. The appearance of the new beer should be seen, therefore, as an event of the first importance, or as an invention exactly equivalent in its own industry to coke-smelted iron, mule-spun muslin in textiles or 'pressed-ware' in pottery.[360]

Mathias notes how the growth of London's populace, and consequent expansion of the market reachable by brewer's dray, had allowed a small set of well-capitalised brewers to expand production from the late seventeenth century onward, absorbing most of the trade formerly in the hands of brewing victuallers or smaller common brewers. Yet

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[359] Mathias 1959: 11. Italics original

[360] Mathias 1959: 13

they only achieved true dominance, he claims, following the introduction of the new beer some time in the 1720s. Porter was more stable than paler drinks: it presented a relatively uniform appearance, resisted infection and was tolerant of fluctuations in temperature, allowing long-term storage. It was thus particularly suited to large-scale production: a gulf in scale was the result, culminating in the perceived divide between the eleven (sometimes twelve) 'great' porter breweries of London, and the smaller and rural common brewers and victuallers who generally brewed the more traditional (and paler) ale.

Mathias' economic account explains the acceptance, but not the actual invention of porter: this appears to be entirely fortuitous, appearing as a revolutionary discontinuity. In the literature of technological change, a distinction is often drawn between *invention* itself and the subsequent act of *innovation*, or application and development of inventions in contingent circumstances to achieve practical ends.[361] To an economic historian, acts of invention may be considered to strike at random, being irreducible 'flashes of inspiration,' but the innovations which they underlie are seen to be governed by fiscal and structural factors.[362] The dichotomy, however, carries the danger of establishing 'invention' as a ring-fenced arena in which asocial and ahistorical creation accounts may survive.

The archetype of this approach is the naïve reading of the patent system, which reifies 'inventions' into seductively tidy packets, each bearing a single date. Christine MacLeod's *Inventing the Industrial Revolution* has probably done most to establish that early patents cannot be read as a chronicle of discrete developments arranged for the benefit of future historians, but rather reflect a tangle of monopolistic agendas, personal power-struggles and incommensurable definitions. It is, therefore, worth noting MacLeod's own account of porter: this proceeds directly from Mathias', and so describes a distinct and very localised act of invention, which is followed by a variety of innovations. This process occurred, however, "outside the cognizance of the patent system," largely because the brewers' trade was sufficiently closed to outsiders to make patents for brewing processes themselves an unnecessary precaution.[363]

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[361] For example Hughes 1987: 57-8; Inkster 1991: 8-9. For the origins of the divergence, see Beales 1958: 13.

[362] Berg 1994: 171-2

[363] Although brewery equipment was patented, particularly from the late 1780s. [MacLeod 1988: 108-9]

The aim of the present chapter is to deconstruct the image of porter as a revolutionary invention. Following the interpretation of George Basalla outlined in Section 1.5, I argue that the product evolved from pre-established practices over a period of decades, and that the very identification of its independent nature was a contingent development. Mathias' economic factors, on this view, serve as selection criteria: manufacturers shifted the character of porter in order to accommodate the risks and opportunities of large-scale trade and production, ultimately making it the characteristically 'large-scale' beer it has been presumed to have been from the outset. Consequently, I present in Section 4.2 my own account of the origins and early development of porter, stressing the evolutionary nature of its rise to prominence; I then show how changes in its production created an aura of secrecy which fed the need for an origin story.

The concept of invention as discontinuous 'breakthrough' technology may, of course, be useful where the subject is an artefact or process dissimilar, in some palpable way, to what was familiar before it, and where some obvious *proprietor* (individual or organisation) can plausibly claim the breakthrough as localised to its own or its dependents' activities. In the case of the early porter, an almost totally unrecapturable consumable which gradually assumed an identity from various trends in the actions of various London brewers, this is not the case. There is simply no tenable historical evidence on which to draw a dividing-line between the prolonged period of technical development and some sudden genesis point at its root. Nonetheless, a casual survey of modern histories of brewing, nineteenth-century reference sources, and the promotional literature of some specialist breweries now producing their own porters would reveal an enormous degree of consensus over a highly specific origin story which characterises porter as a discontinuous invention: it was from this that Mathias took his cue in formulating his original interpretation.

This story, which I deconstruct in Section 4.3, runs briefly as follows. Porter, we are told, was invented around 1722 by one Ralph Harwood, a common brewer of Shoreditch, East London, in the interests of convenience. Around that time, most customers drank mixtures of the various styles of beer then available. This was a labour-intensive arrangement, as each pot of beer had to be drawn from two or, in the case of a popular drink known as 'three-threads,' three different casks. Harwood's achievement was to develop a single ('entire') brown beer style with the desired combined characteristics: this proved immensely popular and gained the name 'porter,' it is usually claimed, from the porters around Shoreditch who formed its original

customer base. The story is now discredited, research by a variety of authors over the past fifty years (beginning with Mathias himself) having demonstrated the parts played by happenstance, cut-and-paste journalism and a dearth of independent source material in entrenching it in popular lore. Here, I chart the development of the legend from 1760, over a period of about a century, as a procession of new features were added; my chief aim is to highlight the reasons for the story's construction, in terms of the unassailable prominence of porter in the minds of drinkers, and ultimately of the merely curious.

In Section 4.4 I address a key feature in the identity of porter: colour. Beside the economic factors mentioned above, there were other selection criteria in place, most notably the growing importation of natural-philosophical values and interpretations into brewing, as typified by the activities of Combrune and Richardson so far discussed. Richardson's saccharometric project, as noted in Chapter 3, set up a significant tension in prompting 'scientific,' efficiency-driven brewers to use the most extractible, paler malts, when high-dried malt provided the quintessential characteristics of traditional London porter. Under this new 'selection pressure,' porter continued to change, with colouring added to supply the place of brown malts: as a result, porter came to be *defined* in terms of its colour, which could now be minutely adjusted or darkened to levels never seen before. By 1830, towards the end of its period of unrivalled popularity, the typical mode of porter production was utterly different from that followed in the early eighteenth century. I conclude by assessing the significance of this development for the identity of porter-brewing, and its consequences in terms of the perceptions of the drinking public.

4.2 The evolution and identity of London porter

4.2.1 The origins of porter

The name 'porter,' primary sources strongly suggest, was not coined for a new product: it came into use as a colloquialism for the brown beer which was the established staple product of the London brewery, and perhaps specifically for 'butt-beer,' or beer matured in the three-barrel casks known as butts.[364] The earliest instance of the usage found by the *Oxford English Dictionary*'s etymologists appears in a Whig

[364] For the nature of the butt, see [Ellis] 1736: 36.

weekly half-sheet, the *Terræ-filius*: in May 1721 the anonymous author, Nicholas Amhurst, characterised the Whig's pragmatic ability to choose the lesser of two evils by stating that "we had rather dine at a cook's shop upon *beef*, *cabbage* and *porter*, than tug at an *oar*, or rot in a dark stinking *dungeon*."[365] Other early sources mention "Porter's ale" or "Porter's Beer,"[366] and it seems obvious that this was the original form, fitting the standard derivation. Amhurst's use of the contraction to 'porter' without elaboration, then, suggests that it was already well-established in certain areas by 1721. Certainly, it predates any revolution in practice which might, as the standard account suggests, have occurred the following year.

The first part of the *London and Country Brewer*, originally published around 1734, does not describe any of the London beers as 'porter,' but the term has appeared in the later parts by 1738.[367] Instances such as a recipe for "Brewing Butt-Beer, called Porter,"[368] show that William Ellis treats it as merely a synonym for the earlier term, which he seems to prefer. In the index to the 1750 edition of the work, the entry for 'Porter' directs the reader to pages where mention of brown butt-beer appears, but the word 'porter' itself does not. Similarly, a Yorkshire brewer of the 1740s refers to "the very best sort of brown Strong Beer, commonly called London Porter,"[369] while a 1768 manual describes "London Brown Beer, under the Name of Porter."[370]

The characteristic constituents of this drink were the high-dried brown or blown malts, a speciality of the Hertfordshire maltsters who supplied the London trade, which gave it a brown colour and a peculiar flavour, often called smoky or 'empyreumatic'; and an especially high quotient of hops. Oliver Macdonagh suggests that hop rates rose significantly in the early eighteenth century: this helped to preserve the product, facilitating the long storage in butt which should be taken as another identifying feature.[371] Age softened the harshness of both the hops and the high-dried malt, and gave the beer a full body and a taste described as 'stale' (generally represented as

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[365] [Amhurst] 1726: 202. Italics original. My thanks to Maggie Scott of the *OED* for assistance on this point.

[366] *OED* s v "porter," noun, sense 3

[367] Mathias 1959: 14

[368] [Ellis] 1750a: 221

[369] *Leeds Mercury*, 15 May 1744, quoted in Cornell 2003: 92

[370] *Every Man His Own Brewer* 1768: 39

[371] Macdonagh 1964: 533

agreeably acidic and quite distinct from undesirable sourness.)[372] Even the particularly smoky wood-dried malt which, Ellis says, was valued primarily for its cheapness (and which had, apparently, in any case fallen out of use by the 1730s) lost its "ill Taste… in nine or twelve Months, by the Age of the Beer, and the strength of the great Quantity of Hops."[373]

Staling soon became a considerable business: a butt of porter could be a sound investment, since the staled product was worth significantly more than in its 'mild' or new condition. John Tuck, writing around 1820 of the former custom, notes that "not only did the respectable publican have his own cellar well filled, but every vault and cellar that could be appropriated, was hired for the purpose, for which was paid one shilling per butt per annum." Having been brought in barrels to the publican's cellar in the normal fashion, the beer was 'started' into butts in the cellar under the supervision of the brewer's abroad cooper, and might be matured for a year.[374]

Brown butt-beer, then, was a robust product: from the outset it lent itself to large-scale production, which gave the brewer "less charge and trouble by means of his more convenient Utensils."[375] Being well-hopped, it was also greatly superior to the small brewers' product, kept in small casks, which was "loaded with the pernicious Particles of great Quantities of Yeast." The resulting acidity might bring on "a sudden hardness and staleness of the Ale, which to preserve in its mild Aley Taste, will not admit of any great Quantity of Hops," meaning that the small brewers could not brew in the warmer months, when the porter brewers dominated.[376] As an additional benefit to the brewer, sour, flat beer returned by publicans as unsaleable could be re-used by mixing back into new working beer.

Owing to these advantages, records the *London and Country Brewer*, "the common Butt-beer [ie, the product of the common brewers] is at this time in greater Reputation than ever in *London*, and the Home-brew'd Drinks out of Credit; because the first is

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[372] Boyle [1800]: 17 advises publicans to "keep your tap-tubs clean, otherwise your stale beer will become sour."

[373] [Ellis] 1736: 22-3

[374] Tuck 1822: 6-7

[375] [Ellis] 1736: 43

[376] [Ellis] 1736: 36-7; cf Smith 1729: 12

better cured in its Brewing, in its Quantity, in its Cask, and in its Age…"[377] Victuallers brewing for their own houses, then, were excluded from porter production by the nature of the product, and their trade was passing steadily to the large common brewers. To Ellis, in 1736, this superiority of the mass product might have been a passing phase; before long, at least in London and the south-east, it became accepted as the only possible state of affairs. Macdonagh, echoing Mathias' claims, does not exaggerate in stating that the porter method "laid the foundation for mass production in the industry."[378]

4.2.2 Secrets and scale

By 1760, 'porter' was established as the dominant term for London's brown beer; a divide was perceptible between those who brewed porter and those who brewed ale, the former trade tending to become the preserve of a small number of breweries operating at larger and larger scales. The product, too, was changing: one source, which we will later discuss in some detail, mentions the introduction of "more age, better malt, better hops, and the use of Isinglass" (this last for fining), each contributing to the stability and standard appearance of the beer.[379] The author of 1768's *Every Man His Own Brewer* suggests that porter has reached technical perfection: the undeniable existence of some bad product he ascribes to "avarice" leading the most unscrupulous brewers into "schemes to spoil their own commodity,"[380] foreshadowing the storms over adulteration which will be discussed in Chapter 5.

The large working scales and lengthy maturation times of London porter had by this point made it the first beer in Britain whose production varied significantly from the traditional principles of ale-brewing, which many householders and victuallers (especially outside southeast England) still practised. As the commercial brewery, still a relatively closed world, developed porter along divergent lines, its characteristic flavour and appearance gained a mystique, coming to be seen as an "impenetrable secret" and ripe for speculation: "nothing," in the words of George Watkins, another

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[377] [Ellis] 1736: 36

[378] Macdonagh 1964: 534

[379] Poundage 1760: 436

[380] *Every Man His Own Brewer* 1768: 39

brewery writer of the 1760s, "has occasioned more dispute or diversity of opinions" than the true nature of London porter.[381] The question was significant on account of the potential profits to be had in producing beer "after the manner of that made in London" at other urban centres, undercutting the metropolitan brewers.[382]

One of the most obvious and striking features of London production was the scale of activity: the metropolitan brewers' tuns are recorded as "extraordinary large" prior to 1700.[383] As a result, it was widely believed that a large scale was in its own right essential: that is, that the great brewers' size did not merely give them the advantages of economy, concentration and standardisation, but positively contributed to the unique taste, through some action particular to bulk storage. The *London and Country Brewer* certainly suggests as much in commenting that "the greater the Body, the more is its united Power in receiving and discharging."[384] Watkins, despite aiming to instruct the private brewer in porter-brewing, and suggesting that the chief determinant is the type of malt used ("sold ready-made," by this stage, "under the name of Porter-malt"),[385] nevertheless adds that the produce of his recipe

> tho' real porter, is [not] entirely equal to the finest that is made at public brew-houses… which is principally owing to the great quantity brewed together, and in a great measure also to the conveniences of those brew-houses.[386]

This opinion was probably stoked to some extent by the major brewers themselves: it served as a useful protective against both the credibility of smaller entrants to the porter market, and the alternative insinuation that the 'secret' of porter lay in dangerous drugs.[387] Thus it was, in the late eighteenth century, that vat size — not total storage capacity, but the volumes of *individual vessels* — became the chief source of pride and one-upmanship among the London brewers, overshadowing more ostensibly relevant indicators such as total output. The 'Great Tun of Heidelberg' (a purely ceremonial vessel, never used for beer) was invoked as a vanquished foreign

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[381] Tuck 1822: 124; Watkins 1767: 122

[382] *Edinburgh Advertiser*, 30 July 1765, 67. My thanks to John Millburn for this reference.

[383] Lightbody [1698?]: 5

[384] [Ellis] 1736: 43

[385] Watkins 1767: 126

[386] Watkins 1767: 122-3

[387] Watkins 1767: 124; Hayman 1819: 39, and cf Bickerdyke 1886: 369

competitor;[388] most popular histories of brewing tell of rival brewers vying to construct the largest and most impressive tuns, culminating in the erection by Richard Meux, in 1795, of a 20 000-barrel vessel (5.8 million pints, over 3000 cubic metres.)[389]

Correspondingly, a culture of the porter brewery as technological marvel grew up, aided by the introduction of rotary-powered plant driven by steam engines. The very largest breweries figure prominently among the 'curiosities' picked out by the topographic surveys of the time: to Thomas Pennant, in 1790, the very sight of them displayed "a magnificence unspeakable,"[390] while the *Picture of London* for 1802 remarks on the astonishing scale of Whitbread's, then the greatest brewery in London, and on its pipework, Archimedean screw and other technical advances: "Whether the great size, or ingenuity of contrivance, is considered, this brewery is one of the greatest curiosities that is to be seen any where…"[391] This brewery's plant, picked out in idealised elevation, was the subject of a plate (figure 4.1), first published around 1816:[392] this was reproduced in Rees' *Cyclopaedia* of 1819, and later in Andrew Ure's *Dictionary of Arts*.[393] An accompanying description of Whitbread's plant ("the first that had a steam-engine, and the most complete in its arrangement of the utensils")[394] served as the basis for Rees' long entry on "Porter": running over seven pages of quarto, as Corran points out, the entry dwarfs those for "Beer" and "Brewing."[395]

George Dodd, in 1843's *Days at the Factories*, told of Barclay Perkins' huge reservoirs, conveyor belts, pipework, suspension bridge, gigantic maturation vats and a brewhouse "nearly equalling Westminster Hall in magnitude"; an enclosed churchyard is at one point glimpsed, hemmed in on all sides by the brewery's rapid growth through the Southwark streets. Spectacle, as a rule, is emphasised in Dodd's work, but there is no denying the truly vast and, to the uninitiated, wondrous nature of the operation, which (barring the addition of ale-brewing facilities alongside those for porter) would

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[388] Mathias 1959: 61 n 3; Dodd 1846: 31

[389] Most such accounts probably have a common source in Bickerdyke 1886: 372.

[390] Pennant 1790: 279

[391] [Feltham] 1802: 250

[392] Wellcome Photographic Collection, London, image V0019360.

[393] Ure 1839: 109-113

[394] Rees 1819 [unpaginated], s v "Porter." In fact, Goodwyn's brewery acquired its Watt engine marginally ahead of Whitbread [Mathias 1959: 83-5.]

[395] Corran 1975: 162

Figure 4.1: Engraving of Whitbread's Porter Brewery, circa 1816.

have been conducted in a similar fashion and on a similar scale earlier in the century. Citing the "clean, regular, and orderly" appearance of the tun-room, Dodd considers that "the large extent of the operations is the very circumstance which leads to cleanly and orderly arrangement, from the absolute necessity of economising room and time."[396]

Such magnificence relied on a degree of capitalisation which further reinforced the separateness and impenetrability of the porter trade, as Mathias' work amply demonstrates. The setting-up of a small common brewhouse of the kind found in provincial towns, which might supply a dozen houses or so, was not beyond the reach of a single investor: successful brewing victuallers, by taking on the supply of neighbouring pubs, often rose to this position.[397] By 1760, however, porter (or, as popularly perceived, 'true' porter) could only be produced in a major brewery, such as could not be established without vast financial commitments from the partners. The Anchor brewery in Southwark, perennially among the half-dozen greatest producers, was bought by Ralph Thrale (father of Henry) at the end of the 1720s for a reputed £30 000; fifty years later, notwithstanding the desperation of Henry Thrale's executors to be rid of the property, it was sold to Barclay and Perkins for £135 000.[398] It was, legendarily, in relation to the potential profits to be enjoyed by the buyer of Thrale's that Samuel Johnson coined the expression "rich beyond the dreams of avarice."

This enormous capital barrier meant that, from the late eighteenth century, the London porter breweries were effectively unrivalled: occasionally, the entry of a major investor (such as Robert Barclay) would result in an established brewery's being bought and sold, and inheritance and family disagreements caused the names and occasionally the number of concerns in operation to vary, but as a rule there was no possibility of an outsider building up a new porter operation on the London brewers' territory. The manoeuvre was too risky for individual investors, whereas a joint-stock flotation allowing small shareholdings would have required parliamentary approval in the form of a Private Act, and this was highly unlikely given contemporary concerns about the possibility of bubble speculation, and the influence of the several brewers who sat in

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[396] Dodd 1843: 17-38 [quoted at 24, 29-30]

[397] Mathias 1959: 253-4

[398] Mathias 1959: 259-260, 273

Figure 4.2: Porter vats at Barclay Perkins.

the Commons.[399] According to John Tuck (a "little brewer" himself) around 1820, the large breweries were increasingly in the hands of capitalists cut off from the business of brewing:

> The price of casks, horses, labour, corn, taxes, and every necessary appurtenance to a brewery, having of late years so much increased, there is no longer a chance of success to the laborious and industrious little brewer. All is swallowed up in capital. There are Brewers who never see the brewhouse, contenting themselves with receiving ten per cent. upon their capital.[400]

The only serious attempt to breach the barrier came in 1804, when the 'Golden Lane Genuine Beer Brewery' was set up to capitalise on public perceptions of price-fixing combination, and probable adulteration, in the established trade. The principal projectors raised capital by a new and untested approach, creating what was in law a vast partnership, with several hundred subscribers (effectively shareholders) as 'co-partners.' They acquired the Golden Lane site formerly occupied by Gideon Combrune,[401] expanded the capacity of its engine to the unprecedented (in brewing) level of 36 horsepower,[402] and commenced retail in 1805. The business was at first riotously successful, becoming the third-greatest producer (behind Barclay Perkins and Meux Reid) in 1807; thereupon, however, it was involved in a complex series of Excise trials turning on the status of the partners and the admissibility of the brewery's isinglass substitute. Rising material costs, and the problems of debt management in such a judicially complex entity, provoked a liquidity crisis, and production collapsed. This effectively ended the concern's competitive potential, owing to the chronic diseconomies of a large plant operating well below capacity: a long decline terminated with the sale of the plant in 1826.[403]

4.2.3 The identity of London porter crystallised

The Golden Lane episode reaffirmed the absolute dominance of the great brewers until the rise of provincial competition in the 1830s. Despite the advent of porter and stout

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[399] Mathias 1959: 245

[400] Tuck 1822: 7

[401] Given the rarity of the surname, it is entirely plausible that Gideon was a relative of Michael Combrune, who brewed at Hampstead. I have not had the opportunity of tracing any such relationship.

[402] Mathias 1959: 85

[403] Mathias 1959: 243-251

production in several urban centres (notably Dublin), the public perception that 'true' porter could be brewed only on a vast scale, and perhaps only in London, persisted at least until roughly that period.[404] Porter — the name threatened, at times, to supersede 'beer' as the generic — was the distinctive product of a few technically and spatially prodigious production plants, whose operations might almost have been regarded as utterly distinct from the craft of the traditional ale-brewer.

It is worth remembering that, on the limited but adequate evidence of the *London and Country Brewer*, this state of affairs did *not* pertain at the time the coinage 'porter' was introduced (some time before 1721.) The urban brown butt-beer methods described by Ellis may have been beyond the capacity of private brewers and victuallers, but the common brewers who applied them were not gargantuan. They certainly included the largest breweries in Britain, but these were no bigger than many of the ale breweries which applied 'traditional' methods in subsequent decades, and were not veiled behind a capital barrier too great to contemplate. Capital and competitive success fuelled their growth, and their growth promoted the development of a product increasingly suited to large-scale production; but these changes in production influenced London drinkers' notions of the standard product's nature and the right basis for porter-brewing, which reciprocally lifted more of the trade into the large-scale brewers' hands. This interpretation chimes with Ian Inkster's conclusion from historical case studies made in the 1960s: a large jump in production scale may be due to many changes (technological and otherwise) working in concert, as opposed to any one "major invention."[405]

A major invention, however, was the form of explanation most easily assimilated by curious minds. The separateness and the mystique of London porter began to be established around 1760; and it is from that date that a public curiosity over the origins of the drink begins to make its presence felt in contemporary literature. As the breweries grew, and the mystique intensified, so the search for an account of the drink, and the application of new information (sometimes on an almost haphazard basis) to supply the want, increased. It is to this process that I now turn.

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[404] Black 1835: 91

[405] Inkster 1991: 5

4.3 The porter creation myth

4.3.1 The porter creation myth unravelled

As previously noted, the established account of the origins of porter — invoking a brewer named Ralph Harwood, a site in Shoreditch, the date 1722, and the project of replicating a mixture named 'three-threads' in a single cask — is both peculiarly detailed and supported by a huge range of sources. The problematic nature of the evidential consensus was not publicised until 1959, in Peter Mathias' account of the significance of porter alluded to in the introduction to this chapter. Alerting the reader to "[t]he unanalytical, antiquarian character of most literature upon the history of brewing" and, in consequence, "the remarkable degree of plagiarism present in all accounts of the introduction of porter brewing," Mathias traces the route by which one specific version of events — originating, ostensibly, in an anonymous article in the *Gentleman's Magazine* around 1760[406] — was taken up and reproduced in an incredible variety of subsequent sources. The representative sample cited includes Friedrich Accum's brewery manual of 1821, two topographic works, the entry "Porter" in Rees' *Cyclopaedia* of 1819 and Yeats' work of technical history from the late nineteenth century, with a note that "[a]fter 1850 [the account] is repeated by most writers on brewing without significant additions."

By the later nineteenth century, writers assessing the evidence were liable to interpret the accounts as a consensus of independent sources, thereby perpetuating the trend.[407] Thus a single, inevitably partial history worked its way through to Archibald and Nan Clow's *The Chemical Revolution* of 1952, one of the first studies in the history of science to accord any serious place to the brewing industry.[408] The Clows' treatment was the basis for Mathias' own account of technological developments in the period under review; but, in investigating the porter origin story in more detail, he uncovered for the first time the chain of interdependent accounts. Mathias' work informed H S Corran's 1975 *History of Brewing*, a semi-popular work: Corran also draws attention to the chain, with the result that, today, even those accounts aimed squarely at a

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[406] *Gentleman's Magazine* (1760) **30** 527-8

[407] Mathias 1959: 13, n 2. [The account in Feltham's *Picture of London*, traced by Mathias to 1805, first appeared in 1802 as discussed below; the Rees *Cyclopaedia* entry is in volume 28 rather than 38.]

[408] Clow and Clow 1952: 539, proceeding from Accum 1821.

popular audience tend at least to be rather circumspect about the legend: the culmination of this trend is Martyn Cornell's recent treatment, a vehement debunking exercise.[409] The occasional ingenuous reading, however, still appears.[410]

4.3.2 The evidence of the Obadiah Poundage letter

It was Corran, in 1975, who provided the first account of the narrative's ultimate origins. In his capacity as archivist to Guinness Dublin in the 1970s, Corran happened fortuitously upon a manuscript copy of one version of the story, which he was able to trace back to its source: a letter to the editor of the *London Chronicle* newspaper, published in November 1760.[411] The letter's author, who signs himself in the name of "Obadiah Poundage,"[412] claims to be an 86-year-old clerk, still serving a major London brewery; he writes with the aim of justifying recent moves by the brewers towards a rise in the retail price of beer, which at that time was protected by force of law. One month before the letter's publication, the *Chronicle* had reported a meeting of the Brewers' Company at which the rise was agreed: the paper's editorial position was

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[409] Foster 1992: 5-7; Wheeler 1997: 120-1; Cornell 2003, as cited below.

[410] Haydon 2001: 110-1; Brown 2003: 80

[411] *London Chronicle*, Saturday 1 November 1760 [hereafter 'Poundage 1760.'] There is an outstanding mystery over the letter, which exists in two forms: one is that partially reproduced in Corran's text; the second is that cited here, which was extracted verbatim for the *Gentleman's* account. Beside many cosmetic differences between the two, the second is more tightly written, and lacks several digressions and references personal to the author; each contains material which the other does not. At the time of writing, the first version is lost. Dr Corran recalls that his transcript was prepared, in the 1970s, from a copy held in what was then the British Museum's newspaper collection [H S Corran, personal communication, 30 December 2002]; exhaustive searches of both the current British Library Newspaper Library at Colindale, and of relevant holdings in the British Library's main St Pancras facility, have however produced only copies of the second form [Claudine Davie, Early Printed Books, British Library, personal communications, 12 and 13 March 2002.] The *London Chronicle*, like many newspapers of the time, was prone to variant editions, but an extensive survey, P[hillips] 1934, reveals no variations on this scale (my thanks to Jon Topham for this reference.) A survey of copies held at the Bodleian Library, Oxford, Cambridge University Library, Durham University Library, the University of London Library, London Guildhall Library and St Bride Printing Library has not brought a copy of the first form to light. It is possible that Corran's transcript — which has the appearance of a draft — instead corresponds to the manuscript found in the 1970s, which might just conceivably be the work of the author; at the time of writing, however, this item has not been traced by the present Guinness archivist.

[412] A name which has latterly been adopted for the diary column of *What's Brewing*, the journal of the Campaign for Real Ale.

made clear in a bracketed addendum listing the ancient and draconian statutory penalties applying to such an action (including, for the third offence, a fine of £40 or "the pillory, loss of an ear, and to become infamous.") The Treasury then instructed its solicitor to prosecute any brewers engaged in combination to raise prices, and a further Brewers' meeting laid the plan aside.[413]

The November letter is intended as plea for the justice of the brewers' cause: to this end, it includes a historical section, largely addressing the steep rises in Excise levy from 1689. This fits with Corran's unelaborated statement that the letter is pseudonymous:[414] we might puzzle over 'Obadiah' (literally 'servant of the Lord,' and thus perhaps appropriate for a brewery clerk);[415] we are on sure ground, however, with 'poundage,' meaning a tax or levy, specifically one imposed at a certain rate per pound's value of goods. In fact, none of the relevant duties were poundage rates in the strict sense, but the reference was clearly to the rising taxes on raw materials which threatened the livelihoods of the brewers. We might go further, and question whether any of the author's biographical details were genuine: there are certainly grounds for scepticism over the venerable Obadiah's 86 years. For a clerk still to be serving at that age was by no means impossible; in the circumstances, however, it was undeniably convenient. In a second letter, it is stated that he entered the trade aged 14, in the year 1688.[416] This helpfully puts him in a position to comment from almost the exact moment when the French wars, and the loading in earnest of indirect taxation, began.[417]

The Poundage chronology, then, was a chronicle of a life lived in the shadow of the Exciseman. The account of the development of porter is almost incidental to the overall argument: the beer is addressed as a product which arose, around 1722, as the

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[413] *London Chronicle*, Saturday 4 October 1760 [334]; Saturday 11 October [358]; Friday 17 October [377]

[414] Corran 1975: 112

[415] None of the several biblical Obadiahs is conspicuous for any conceivably relevant actions. 'Obadiah' was at one time a slang term indicating a Quaker, but the considerable involvement of prominent Quaker families in brewing [Mathias 1959: 287-299] was generally post-1760.

[416] *London Chronicle*, Monday 15 December 1760 [603-4]

[417] Brewer 1989: 96-7 [figure 4.2, "Sources of net tax revenues, 1692-1788"] gives a striking visual indication of the rising Excise duty over the period of Poundage's professed career.

brewers' impoverishment caused a search for new materials, and which subsequently created overheads in its own right, principally through the long storage required. Yet the effect of the account was radically altered when the *Gentleman's Magazine* used it a few weeks later as the basis of the article cited by Mathias. Of the original 2400-word letter, the *Gentleman's* reproduced (verbatim and unattributed) a continuous section, amounting to roughly one-third of the whole, dealing specifically with changes in beer consumption and production: the brief account of the origins of porter, now falling at the end of the piece, appeared to be the conclusion to which the narrative leads. This act of scissors-and-paste journalism removed all trace of the author's identity, fashioning from the original polemic what could easily be mistaken for an objective history.

The story recounted in the 'Poundage' letter can, to at least some degree, be conformed with those few prior sources which survive. The project of interpretation was probably carried as far as the evidence allows in Oliver Macdonagh's 1964 piece on "The Origins of Porter,"[418] which proceeds from the *Gentleman's Magazine* article (not then traced back to 'Poundage') and the *London and Country Brewer*. In the late seventeenth century, it seems, the metropolitan market was supplied chiefly with brown ale or beer. Duty rises during the wars of 1689-97 and 1701-13 placed both malt, and the coals or coke used for the more delicate drying processes, at a premium. The brewers turned increasingly to malts prepared over wood or straw, which were more crudely-dried, higher in colour, less dense and less extractible than formerly, and imparted a characteristic taste[419] (Ellis refers to the "smoaky tang" of the cheapest, wood-dried product in particular.)[420] The volume of malt used per brewing was cut back, and since its extract was poorer in any case, the alcoholic content of the ale declined: this, coupled with the by-products of the smoky drying process, would have made it highly perishable, and unsuitable for long-term storage. This explains the rise in hop rates emphasised by Macdonagh: hops were lightly taxed in comparison, and the brewers gained a brown beer relatively easy to preserve. This beer, however, was apparently too bitter[421] to suit the public's palate immediately, and gave a lower profit

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[418] Macdonagh 1964: 531-4

[419] For the nature and effects of drying fuels, see [Ellis] 1736: 12-14

[420] [Ellis] 1736: 22; cf Poole 1783: 32

[421] Macdonagh's suggestion of "too acid" [1964: 532] is liable to confuse: hop bitterness would not then have been understood as due to an acid principle.

margin than the unstable ale: consequently, both products survived and were often drunk as 'half and half.'

These were the established drinks of working people in London; the rural gentry, having customarily had their own brewhouses, and not being subject to commercial pressures, greatly preferred the traditional, refined pale ales. As fashions changed and the gentry began to settle in London, pale ales, probably produced by a different set of brewers, drifted into the urban market. "This little opposition," as Poundage has it, led the established brown beer producers to attempt a more refined and controlled product, chiefly by further raising the hop rates and requiring much longer storage to allow the product to mature, usually in the publican's cellars. Under this new custom demand for cellar-space outstripped supply, so that a "set of moneyed people" took to buying beer from the brewers, maturing it for a time, and selling it to publicans at an inflated price. Drinkers now consumed this 'staled' beer alone, or mixed with the 'mild' (non-matured) form; sometimes, it seems, pale ale was included to create a drink called 'three-threads.'

"[A]bout the year 1722," however, the account suggests that the custom among the brewers changed. As Poundage has it:

> [T]he Brewers conceived there was a mean to be found preferable to any of these extremes; which was, That [*sic*] Beer well brewed, from being kept its proper time becoming mellow, that is neither new or stale, would recommend itself to the Public… Though at first it was slow in making its way; yet as it certainly was right, in the end the experiment succeeded beyond expectation: The labouring people, porters, &c. found its utility; from whence came its appellation of *Porter*, or *Entire Butt*.[422]

Thus, apparently, rather than staling some beer for long periods and mixing it with mild, the brewers kept beer for an intermediate period and dispensed it unmixed: this change, if we believe Poundage, constitutes the invention of porter. This passage alone is the kernel of belief in a revolution in practice around 1722.

Macdonagh, following Mathias' lead, appears to accept the discontinuity; yet other evidence renders it doubtful. Quite possibly the maturation time of 'stale' brown beer did fall at that time, but beer identified as porter can be found supplied in separate 'mild' and 'stale' forms, mixed at the point of supply, right through until the early nineteenth century (though staling by that time was generally undertaken in vats at the brewery.) Peter Boyle, writing for a publican audience around 1800, states that this

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[422] Poundage 1760: 436

dual source was an important tool to ensure a uniform product, smoothing out fluctuations in degree of staling:

> The Publican receives from the brewhouse, we will suppose three, six, nine, or twelve butts at one time; if the quantity received be three butts, there are two mild and one stale; but if the beer is old, or brewed early in the season, one butt of stale will do to draw off five or six mild. Now suppose the store beer comes from different cellars [in the brewery], which is of different brewings, what they call the waste cellar, it is not one time in ten that two butts are or will draw alike… either in flavor [*sic*] or colour, how can the Publican keep the beer to one palate for his customers; therefore I would always, if possible, recommend a store cellar of [the publican's] own… and the Publican then can with safety say, my beer is all of one palate…[423]

Rees' *Cyclopaedia* describes ingenious beer-engines in use by the 1810s, allowing mild and stale drawn from separate casks to be dispensed through a single spout: thus the publican could adapt the product "to the palates of his several customers"[424] — for which reason the "Obliging Barmaid" in a lithograph around 1825 is seen to ask: "Do you like it mild, sir?"[425] In fact, the *Cyclopaedia* author treats the process as a deception, if a benign one, suggesting the drinkers really believe they are getting an unmixed drink; the chemist Michael Donovan, probably working from the *Cyclopaedia* account, treats the matter as fraud.[426] This view, however, is not found elsewhere, and may itself indicate a degree of confusion in non-brewing minds. Moreover, even assuming the existence of two separate products, one mixed and one supplied whole, the term 'porter' would have been applied to both by the drinking public (and to neither, at least at first, in the records of major breweries, which discuss only 'mild beer' and 'stale beer.')[427]

The problematic notion of a discontinuity around 1722 is one minor element of the Poundage account, incidental to the author's original purpose. Yet it was *specifically* this notion which survived most prominently when the story came to be retold. The technical complexities of large-scale production, understood for the most part only by the brewers themselves, do not suit the requirements of a classic creation myth. What is required is a place, a time, an inspiration and, as we will now see, an individual.

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[423] Boyle [1800]: 14

[424] Rees 1819, s v "Porter"

[425] Wellcome Photographic Collection, image V0019578

[426] Donovan 1830: 200-1

[427] Mathias 1959: 14

4.3.4 Porter gains a father: the legend of Ralph Harwood

The Poundage account states that "the Brewers" collectively produced the innovation of 1722; the installation of Ralph Harwood as the heroic inventor of porter came much later, and may (though the evidence, as ever, is inconclusive) reasonably be interpreted as the result of pure coincidence, albeit coincidence channelled by the positive and widespread desire to enshrine a creator.[428]

As Cornell's new research makes clear, a brewer named Ralph Harwood certainly did reside in Shoreditch, from 1703 or earlier; "HORWOOD's Drink" [*sic*][429] is mentioned in the *Guide for Malt-Worms* of around 1720, and a trade directory of 1736 shows Ralph in partnership with a relative, James Harwood. The Shoreditch brewery's lack of success — a source of great puzzlement to proponents of the heroic account — led to bankruptcy for the Harwoods in 1747; although operations seem to have resumed, Ralph then died in 1749. James continued for a short time alone, but had sold or lost the brewery by 1752, and himself died in 1762. A brief newspaper obituary of this date (as yet unsourced), preserved in the London Borough of Hackney's Archives Collection, describes James as "an eminent brewer in Shoreditch, and the first that brought porter to perfection."[430]

It was perhaps this or a similar obituary note — and quite possibly this alone — which moved the obscure Shoreditch poet and shorthand instructor Thomas Gutteridge (*floreat* 1740-1762?) to pen a memorable set of lines. Gutteridge's extant works in the British Library are all elegies, mostly on recently-deceased clergymen; around 1745 he produced the curious *Universal Elegy, or a poem on Bunhill Burial Ground*, attempting to commemorate all those interred at the site, many of whom he could not have known. Gutteridge's piece on a departed Harwood does not survive in its original form, and is of unknown date, making it impossible to say whether Ralph or James was the subject; given the obituary, we may suspect the latter. The extant lines run as follows:

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[428] My conclusion on this point is essentially equivalent to that in Macdonagh 1964, though certain gaps in Macdonagh's chronology make the story worth re-telling.

[429] It is probably coincidence that the variant *Horwood* is found in three widely-dispersed sources: *Guide for Malt-Worms* [1720?]: 10; John Timbs' *Curiosities of London*, published between 1855 and 1885; Yeats 1871: 235

[430] Cornell 2003: 92-3; *Guide for Malt-Worms* [1720?]: 10; Martyn Cornell, personal communication, 6 January 2004

Harwood, my townsman, he invented first
Porter, to rival wine, and quench the thirst;
Porter, which spreads its fame half the world o'er,
Whose reputation rises more and more,
As long as porter shall preserve its fame,
Let all with gratitude our parish name.

The first known surviving publication of this text is in "A short Description of Shoreditch Parish, in the County of Middlesex… by a Parishioner," a topographic survey, pointing out various curiosities, published in the *Gentleman's Magazine* for 1788. "On the East side of the High-street," notes the author, "is Proctor's brewhouse, formerly Ralph Harwood's, who, it is said, was the first brewer of porter-beer, which he made there, as sung poet Gutteridge," and the above lines are quoted.[431] The index to this volume — a valuable resource for the scissors-and-paste journalist — contains the line "*Harwood*, Ralph, the first Porter-brewer in London," and we may assume that it was from here that the Harwood story took root; the poem reappears, during a digressive discussion on inn signs, in the *Gentleman's* for 1819.[432]

Note how the sense of what is being claimed twists through this pattern of partial dissemination. The 1762 article does not suggest that James Harwood invented porter, but that he was first to perfect it — and then, perhaps, only so far as Shoreditch was concerned. Gutteridge's poem does clearly place Harwood's eminence on a global stage, but the text is ambiguous: it may be read as suggesting that Harwood made the first porter worthy of such eminence, rather than the first porter outright. The latter reading is chosen by the Shoreditch native of 1788, by which time the birth of the term 'porter' had already vanished into the mist. This writer also nominates Ralph as Gutteridge's unspecified 'Harwood.' This may, of course, have been on the basis of certain knowledge; yet it is equally possible that James was the intended subject and that the writer, in ignorance of this, misapplied a name known, or disinterred from parish records, to improve the specificity of the tale. From this point forward, where any forename is attached to a porter-brewing Harwood, it is always Ralph.[433]

What firmly cemented Harwood's role as inventor was an account which appeared in the *Monthly Magazine* for February of 1802 and, probably a few months later,

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[431] *Gentleman's Magazine*, November 1788, 958

[432] *Gentleman's Magazine*, May 1819, 394

[433] So far as I am aware, Cornell is the first secondary writer to make any mention of James Harwood.

verbatim in the *Picture of London*, a guide to the "curiosities, amusements, and remarkable objects" of the city compiled anonymously by the travel writer John Feltham. Guide and periodical shared the same publisher:[434] presumably, the piece was deemed a useful space-filler for the *Monthly*, having been gathered for the book then in preparation. It runs as follows:

> The wholesome and excellent beverage of porter obtained its name about the year 1730, from the following circumstances, which not having yet been printed, we think them proper to record in this work. Prior to the above-mentioned period, the malt-liquors in general use were *ale*, *beer*, and *twopenny*, and it was customary for the drinkers of malt-liquor to call for a pint or tankard of *half-and-half*, i.e. a half of ale and half of beer, a half of ale and half of twopenny, or a half of beer and half of twopenny. In course of time it also became the practice to call for a pint or tankard of *three threads*, meaning a third of ale, beer, and twopenny; and thus the publican had the trouble to go to three casks, and turn three cocks for a pint of liquor. To avoid this trouble and waste, a brewer, of the name of HARWOOD, conceived the idea of making a liquor which should partake of the united flavours of *ale*, *beer*, and *twopenny*. He did so and succeeded, calling it *entire* or *entire butt*, meaning that it was drawn entirely from one cask or butt; and as it was a very hearty nourishing liquor, it was very suitable for *porters* and other working people. Hence it obtained its name of *porter*.[435]

I consider (as Mathias assumes) that the 1802 text is based — possibly via an intermediary — on the root Poundage account, although it certainly introduces some new material, and appears to be the work of a brewery outsider. The narrative structure is virtually identical: London drinkers consume a variety of mixed drinks; this is inconvenient to the brewers (or single "heroic" brewer), who invent a new product simulating an established mixture; this experiment is successful; porters and other labouring people take to it and the drink is thus named 'porter.'

Comparison with the 1760 original suggests the intervention of a hack-writer: the piece has been rewritten to improve comprehensibility to the general audience, but apparently on the basis of limited and confused brewery knowledge. The 1760 statement that "The labouring people, porters, &c. found its utility; from whence came its appellation of *Porter*, or *Entire Butt*" is a little garbled, 'Entire' seeming to require a wholly different explanation, which the 1802 text seeks to provide. 'Three-threads,' unglossed in the Poundage account, is explained here too — although the explanation casts doubt on the whole account. "Ale, beer and twopenny" is a doubtful recipe for

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[434] Richard Phillips.

[435] [Feltham] 1802: 248-9. Italics original. Cf *Monthly Magazine and British Register* **13** 42 (1 February 1802.)

1730: 'twopenny,' a pale drink, was understood as a variety of ale, and the suggestion that mild and stale forms of beer were blended has been lost.

Moreover, the 1802 account of the three casks, leading to an etymology for 'entire butt beer,' is highly problematic. The *London and Country Brewer* and other sources indicate heavily that 'entire' derives from the process of mixing all the mashes for one fermentation, rather than brewing strong and small beers from the same grist (the 'parti-gyle' system): the porter or brown butt-beer process, which was dominant in London by the 1760s, did indeed characteristically involve brewing entire.[436] The writer's claim, then, looks like a confused interpretation, or a fanciful construction, by one not familiar with brewery methods, and the lack of certain evidence that the beer was blended in the pot, rather than in the cask, tends to support this. Cornell points out that any presumed connection between 'three-threads' and the 'threading' of taps screwed into the cask must be spurious, since the spigot was conventionally hammered into place; 'threads' more probably derives from 'thirds.' In addition, the *Vade Mecum for Malt-Worms* mentions "full casks of Threads call'd Three," which may suggest the blend came ready-mixed from the brewer.[437] The indication that the publican had a tiresome and readily-understood manual task to overcome, however, helps to reinforce Harwood's heroic status as an ingenious innovator.

Across the nineteenth century, numerous accounts drew directly from either the 1760 *Gentleman's Magazine* excerpt from the Poundage letter, or the 1802 *Picture of London*/*Monthly Magazine* account;[438] Cornell notes that one author was borrowing portions of the 1802 text verbatim as late as 1909.[439] Friedrich Accum, interestingly, quotes the *Picture of London*, but alters the date of the change from 1730 to 1722, indicating that he was also familiar with the Poundage account. Curiosity over the

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[436] Ellis' recipes, based on his London brewery experience, do show small beer being made after "common brown Starting Butt-Beer," or what we may assume was increasingly termed porter; his slightly later recipe for "Butt-Beer, called Porter," however, was certainly brewed entire: see [Ellis] 1736: 40; 1750a: 221-2. More generally Ellis was an opponent of parti-gyling, recommending small beer (and hence strong beer) to be brewed entire: [Ellis] 1736: preface (unpaginated), 50.

[437] Cornell 2003: 96

[438] Accounts proceeding from the 1760 source are Morrice 1802: 9-14; Hughson 1806: 293-4; Tizard 1857: 419-20. Those based on the 1802 source alone include Rees 1819, s v "Porter"; Paris 1830: 212 and, in paraphrase, Dodd 1843: 37; Loftus 1863: 45; Yeats 1871: 235.

[439] Cornell 2003: 95

origins of porter led many nineteenth-century writers to examine multiple sources; but the pattern of borrowing was now so endemic as to be mistaken for a consensus of independent authorities.[440] The tale mutates, occasionally, in the interests of remaining comprehensible to a contemporary audience. Although the 'porters' for whom the drink is named were, as Cornell points out, the licensed fetchers and loaders of London's streets and waterfront, more recent versions specify market porters or even, in what we might imagine an obvious anachronism, railway porters.[441]

Probably the most thorough version of the legend was that presented in the *Curiosities of Ale and Beer* of 1886, a cavalcade of songs, poems and anecdotes produced by 'John Bickerdyke,' the journalistic pseudonym of a respectable lawyer of the Inner Temple.[442] This treatment incorporates elements from both the 1760 and 1802 accounts, as well as Gutteridge's poem: it is padded, to humorous effect, with the aid of a certain amount of licence: the drinkers of 'three-threads,' for instance, are nominated "the real connoisseurs" of malt liquors. Increasing specificity (as already witnessed in the addition of the forename 'Ralph') was a feature of the legend's mutation: some intermediate versions of the 1802 account add that Harwood's brewhouse was named the Bell, or that the new beer "was first retailed at the Blue Last, Curtain-road":[443] this latter, we may surmise from the account of 'Bickerdyke,' entered the legend on the authority of nothing more than a sign-board outside the pub in question.[444]

The proliferation of sometimes spurious details, I contend, fed a public desire for more information about the invention of porter proceeding from the assumption that that 'invention' must have been a highly significant act. This is unsurprising given that, as we will now see, the porter of the nineteenth century was a vastly changed and highly distinctive drink.

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[440] Dowell 1888: 62

[441] Cornell 2003: 102-3, 286

[442] Bickerdyke 1886: 366-8

[443] Brande 2003: 16; Haydn 1857, s v "Porter"

[444] Bickerdyke 1886: 365

4.4 The privileging of colour

4.4.1 Changing porter grists around 1800

It has often been assumed that the 'perfected' porter of the early to mid-eighteenth century employed only high-dried brown malt: the evidence is not clear-cut.[445] William Ellis' London recipes appear to be all-brown, but he states that he does not personally care for the "extream" of such a grist: he recommends either the use of amber malt, or pale and brown mixed, and somewhat later, in his short work of 1761, distinctly states that such a mixture is commonly used in porter.[446] What is certain is that, following Richardson's saccharometric revelations as discussed in Chapter 3, and as a new series of wars provoked once more the familiar Excise rises, the porter brewers turned increasingly to paler malts.

Recipes of the early nineteenth century vary: Thomas Thomson, the chemist who worked as an Excise saccharometrist,[447] states that the "best genuine porter" requires three parts of pale to two of brown; George Adolphus Wigney considers that proportions should not be prescribed, but adapted to the customers' palates and the variable qualities of the malt.[448] The commonest proposal presented, however, was to employ pale, amber and brown malts in equal measure. This was asserted, in a loose and qualitative manner, as a reasonable compromise giving both a respectable extract and something of the traditional porter flavour, and was the formula proposed by Richardson himself in his privately-communicated directions.[449] Recipes proposing yet higher degrees of pale nonetheless proliferated.[450]

It was widely stated, even by the brewers themselves, that this development had robbed porter of its "real flavour"; that "ALL the porter now brewed [was] not what porter was formerly."[451] Some detected malicious agencies at work. George Blake,

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[445] Tuck 1822: 124-5 supports this; but contrast Brande 2003: 56

[446] [Ellis] 1736: 38-40, 20, 23; Ellis 1761: 220

[447] See Section 3.4.1

[448] Thomson, quoted in Donovan 1830: 198; Wigney 1835: 234-5

[449] Richardson in [Booth] 1829: 46; Shannon 1805: 235; Tuck 1822: 125; Blake 1817: 44-5

[450] Brande 1830: 255, for instance, proposes seven quarters of pale to six amber to three brown.

[451] Tuck 1822: 124; Accum 1820a: 172

claiming in 1817 nearly fifty years' study of brewing, states that porter production "has been within the last thirty years enveloped in the grossest error": brewers "in different parts of the kingdom," showing the ignorance of the porter method alluded to above, assume the secret must lie in ingredients other than malt, hops and water.[452] In the parlous period in question, mashes became paler not only because the malts were lower-dried, but because they were used in lower quantities: the use of additives, systematically supplied and sometimes dangerous, intended to mask this weakness was indeed widespread. The majority of these additives will be discussed in Chapter 5. Here, I tackle the particular matter of 'artificial' colouring: this was, by virtue of its complex legislative status, something of a special case, and is of primary importance in understanding the changing definition of porter.

4.4.2 The introduction of beer-colouring

Colour, on the account given above, was not initially the most obvious defining characteristic: the name 'porter,' as we have seen, was coined to describe a type of brown butt-beer in a London principally supplied with brown beers and ales. The growing interface between town and country brewing customs, however — perhaps due in part to the growth of urban gentry, as suggested by the Poundage account, and perhaps also through the broad geographical scope of the *London and Country Brewer* — established in the minds of drinkers an opposition between the brown product ('porter,' 'entire,' sometimes simply 'beer') and the pale (increasingly, just 'ale'.) Accounts of porter by 1800 are as likely to draw attention to its darkness as to its "smoky" or "empyreumatic" signature taste. The possibility naturally arose of adding to a pale or understrength wort small quantities of some cheap and highly-coloured substance: Hayman, in 1819, claims that colouring "began to be used about forty years since, and has increased in use from that time" as pale malt has come to dominate the grist.[453]

In reality, the principle of beer colouring was old-established, considerably predating the particular colorific needs of the porter market. An Act of Parliament of 1701 prohibits the use in beer of "a late invented Liquor or Syrup made from Malt and Water, boiled up to the consistency of Melasses, [*sic*] and very much resembling the

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[452] Blake 1817: 43-4; cf Baverstock 1824: 117-8, making similar claims for the ignorance of home-brewers.

[453] Hayman 1819: 102

same, and commonly called *Essentia Bine*."[454] Molasses itself had been banned in the interests of protecting the barley-growers, and later the malt duty, but the objection to the malt-based substance (usually *essentia bina* or *binæ*) probably arose from the potential for deception. Other possibilities occasionally appeared: the *London and Country Brewer* mentions that "a Pottle [four pints' volume] of dried ground Horse-Beans" to each quarter of pale malt would raise its colour, and includes recipes for certain "excellent Balls" employing red saunders wood.[455] Elderberries, too, are mentioned in several sources,[456] though the most common proposition was always burnt or concentrated sugar or wort.

This early use of colour, however, seems to have been predominantly for adjustments, most often to present a standard appearance: the porter still contained a quotient of brown malt. It was only around the turn of the nineteenth century that colour ceased *primarily* to reflect the materials used, and became instead a function of the customers' expectations. Nineteenth-century accounts tend to indicate that porter would be pale but for the customer's expectation of darkness and the familiar acidic, empyreumatic tang.[457] The revelations of thermometric and saccharometric management, which had created the 'rational' tendency to pale malts, had also greatly facilitated pale-malt brewing at the porter scale (and would, before long, help to make pale ale the dominant product.) From being a primary necessity of bulk operation which had to be imposed on the drinker, darkness was becoming almost a superficial marketing consideration. To use the language of a distinctly later period, early nineteenth-century porter was *reverse-engineered* in emulation of the observable characteristics of the traditional product.

This opens up problems in the view that coloration was 'fraud' or 'concealment.' The colouring was not, after all, toxic: it might easily be viewed, especially on the view of the 'scientific' writers, as simply a means of accommodating the drinkers' expectations as well as possible in changing economic and technical circumstances — just as the first brown butt-beer, the 'true' or 'traditional' porter it replaced, had been, but now with the benefits of quantitative control. This was the view Richard Shannon, whose

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[454] 13 William III (1701), cap 5

[455] [Ellis] 1750: 285, 292

[456] Jackson 1760: 40; Watkins 1767: 124; Tuck 1822: 241

[457] Shannon 1805: 7; Accum 1820b: 27; Chadwick 1835: 13-14.

work drew heavily on Richardson's saccharometry, sought to inculcate in 1805. The loss of the "genuine flavour" of porter, he wrote, would "appear less exceptionable to the reader" viewed in the following light: the traditional brown malts had the "bad qualities" of being burnt, blown and extractively inefficient: this had been acceptable in an age of low prices and an ignorant brewing culture, but the disappearance of both promoted the "beneficial change" to paler malts. These, "although absolutely stronger… would appear weaker to the eye, and less like porter to the palate," hence the rational case for additives.[458] Shannon shifted the definition of what was 'genuine,' ultimately nominating essentia bina as "the genuine colouring substance and flavouring ingredient for Porter."[459]

The flux of perceptions of the matter is reflected in a complex legislative response. Notwithstanding intermittent preventions, it seems that colouring based on cane sugar was widely interpreted as legitimate until 1802, when, in a climate of mounting public concern over adulteration in general, all substances besides malt, hops and water were explicitly banned in commercial beer.[460] Immediately, the druggist Matthew Wood secured a patent for the production of a concentrated wort-based colouring, which, in contrast to the position in 1701, could now be deemed legitimate. The point in law, however, seems to have been a tricky one: Mathias points out that Wood's legitimacy was secured by his influence with Nicholas Vansittart, then Secretary to the Treasury.[461] The wording of the patent presents only a brief operational description of the process which had been carried out since the early eighteenth century: this was patent as monopoly, no doubt imposed partly to simplify Excise control of the situation, and represents no detectable technological development.[462]

In 1811, owing partly to pressure from the West Indian sugar-producing interests, there came a temporary "Act for allowing the Manufacture and Use of a Liquor prepared from Sugar for colouring Porter and for indemnifying Persons who have manufactured or used such Colouring."[463] The question of legitimacy was plainly contingent so far

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[458] Shannon 1805: 6-7

[459] Shannon 1805: 242

[460] 42 George III (1802), cap 38

[461] Mathias 1959: 420

[462] Patent 2625, of 21 June 1802.

[463] 51 George III (1811), cap 87; Mathias 1959: 421

as the legislature was concerned, as evidenced by the rationale provided within the Act: "it is expedient." Only the porter breweries were permitted to make use of the colouring: in ale, its use would still have been seen as fraudulent. The permission was extended by further Acts, finally expiring in July 1817.[464] By that point, however, another patent arrangement, curiously similar to Wood's, had arrived to take its place.

4.4.3 Wheeler's patent malt

Another London chemist and druggist, Daniel Wheeler, had in March of that year been granted the patent in "A New or Improved Method of Drying and Preparing Malt": this involved "the heating of malt to four hundred degrees and upwards of Fahrenheit's thermometer" in conditions which made it "very highly coloured" without charring or burning.[465] The principle was difficult to argue against, since the product was clearly not a 'substitute' but a form of malt itself, even to the extent of being (slightly) extractible; yet it could be applied to an otherwise all-pale grist in the same way as the newly-banned colourings. Indications of the proportion required varied from one part in thirty to one in eighty; Wheeler himself, in 1818, suggested the figure should be one part of the new malt to 48 of pale.[466] Certainly, it was understood that a tiny proportion would have the desired effect. The relentless tabulator, John Levesque, aims to show how much patent is malt needed, to emulate colorifically the "old" pale-brown-amber grist, for a variety of quantities of beer: so small are the volumes of patent malt that they are measured in pints (one barrel of beer, for instance, requiring just over five pints.)[467]

Wheeler's contribution is sometimes interpreted as a scientifically-minded 'technical fix' satisfactory to all parties, on the widespread assumption that what Wheeler actually patented was a rotary cylinder, similar to a coffee-roaster, which kept the malt grains in constant motion in order to prevent charring. However, while Wheeler unquestionably commissioned and applied such devices, his patent states quite

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[464] By 56 George III (1816), cap 58.

[465] Patent 4112, of 28 March 1817

[466] Tuck 1822: 48; Thomson, quoted in Donovan 1830: 197-8 and [unacknowledged] Brande 2003: 56-8; evidence of Wheeler, *Parliamentary Papers* 1819, v5, 82. Mathias' suggestion that the new malt would be needed in the same proportions as the old brown product [Mathias 1959: 423] appears to result from a misreading of the sources.

[467] Levesque 1847: 96 [Table VIII]

specifically that "[t]he process may also be performed on kilns made nearly of the ordinary construction… it being sufficient to specify the nature of the operation by which the object of the Patent is obtained, without mentioning every possible manner of doing it." All malt slow-roasted to a blackness thus came under the terms of patent — hence the name *patent malt*, which, alongside *black malt*, was commonly applied to it: Wheeler's patent, like Wood's, facilitated the kind of monopoly which suited the collectors of Excise. Subject to a heavy duty, and under regulations to be carried on separately from normal maltings, the trade in patent malt fell to a conveniently small number of licensed firms.[468]

The advent of patent malt spurred the disappearance of browns and ambers: the reductive project of relying on pale malt alone for extract, and on patent malt for colour, became increasingly acceptable. What had started out as an attempt at replication led to a new product, one with the colour of traditional porter but little of the characteristic taste. This led some brewing writers, notwithstanding their acceptance of the saccharometric project, to question the validity of the new malt. Accum claimed that "repeated experiments" showed that its use rendered the beer "more liable to become spoiled" (Wheeler claimed the same for the old brown malt)[469] and that its use could provide no economies if good porter was truly required. "Brewers of eminence" in London, he claimed, informed him that the new colour was "wholly unnecessary; and that porter of the requisite colour may be brewed better without it; hence this kind of malt is not used in their establishments."[470] John Tuck claimed the new malt could produce "a fiery unpleasant flavour," and objected to it as "mere colour" with no extractive merit: in contrast to Accum he believed, in 1822, that it was nonetheless "generally used by the London Porter houses."[471]

Tuck's view is probably nearer the truth: Mathias records that Whitbread recorded stocks of patent malt in the year of its introduction, with Truman and Barclay Perkins (and doubtless the other large brewers) following suit over the course of the 1820s.[472] Gradually, the interpretation proposed by Shannon — that patent malt performed a

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[468] Mathias 1959: 423

[469] *PP* 1819, v5, 82

[470] Accum 1820a: 168-170

[471] Tuck 1822: 48

[472] Mathias 1959: 423

similar function to the old brown malt in a more reliable fashion — came to dominate. Already in 1819 Hayman, an avowedly saccharometric brewer, was beginning to refer to brown malt as a source of colouring, rather than as an intrinsic feature of porter.[473] Black or patent malt ultimately gained the additional name of *porter malt*, the name formerly applied to the 'traditional' browns.[474] William Chadwick, addressing the private brewer in 1835, believed that the use of amber and brown malts had been discontinued entirely in commercial brewing, on account of the "weak" worts, and that all colour was now due to the patent "charred malt." His advice to domestic brewers was not to continue with the old methods, but to emulate the patent maltsters "[b]y charring barley in a coffee roaster, or an oven."[475]

Even as use of the new porter malt became general, however, the 'traditional' objection never truly disappeared: as late as the 1860s, William Loftus considered it important "to maintain a due proportion of brown malt, as black malt communicates no flavour or character to the beer; and neither the pale nor black can excite that astringent sensation on the palate, produced by the brown."[476] The most articulate form of the objection, however, came from Wigney, a brewer writing as an outsider to the customs of London. "[T]he consumer," he wrote in some puzzlement, "might drink with almost as much zest, a decoction of raw and burnt coffee" as the curious compound of pale and patent.[477] To Wigney, the 'reverse-engineering' project which treated porter reductively, synthesising its character from two essential attributes (colour and extract), was incomprehensible.

It might well be asked why Accum, a practising analytical chemist, and Wigney, one of the most zealous champions of scientific method within the brewery, both supported the 'traditional' brown malt against the new colourings: both were enthusiastic supporters of the thermometric and saccharometric project which, in Shannon's view, led inexorably to an all-pale grist. The solution lies in realising that the new porter grist was not a necessary, 'science-directed' innovation. The question of whether it

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[473] Hayman 1819: 102

[474] Loftus 1863: 14

[475] Chadwick 1835: 13-14. We may doubt whether Chadwick had tried the oven method in practice: the barley would have been liable to smoke and catch fire, even when prepared on the smallest scale.

[476] Loftus 1863: 46

[477] Wigney 1835: 234

did, or did not, acceptably emulate traditional porter was a contingent one, and those who attempted to answer it did so with various expectations and constituencies in mind. Accum gained nearly all his brewery information at second hand: here, he represented the views of major brewers keen to publicise their commitment to brown malts, in order to damage smaller and less well-capitalised competitors who were forced to use colouring.[478] Wigney, it seems, was in a similar position, being a first-generation provincial brewer whose capital shielded him from the necessity of the new methods.[479]

Overall, however, patent malt was swiftly assimilated as the characteristic cause of porter's colour: the large brewers' acceptance would in its own right have practically sufficed to standardise the innovation. What is interesting is that porter, by 1830, reaches a state of being defined in terms of its colour *alone*. As the brown malts disappeared, so too did the long maturation periods on which its former character had equally depended: the vast scales of production remained, but porter might now be matured for a matter of only a month. Porter came more to resemble ale, and indeed the largest porter breweries began, for the first time since porter reached dominance, to develop their own ale-brewing operations.[480] Thanks partly to the increasing precision of temperature control, a production method more similar to that of traditional ale was now possible, and the low maturation times suited the brewers economically. The porter brewers in general claimed that the public taste had favoured this change, a claim which found general acceptance: occasionally it was applied to account also for the initial loss of brown malts.[481] John Burnett, however, makes the point that these brewers were "in a position to coerce the consumer" through a stranglehold over the London market; the question of their sincerity is thus "impossible to judge."[482]

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[478] This complication is covered by Mathias 1959: 422.

[479] Lorna Logan (*née* Wigney, author's great-great-granddaughter), personal communication, 18 July 2002

[480] Donovan 1830: 202; Ure 1839: 107; Dodd 1843: 31-3

[481] Evidence of John Barrett, *PP*1817, v7, 213; evidence of John Martineau, *ibid* 241; Ure 1839: 1005

[482] Burnett 1958: 332

4.4.4 Blackness as novelty: the analogy to skin

The upshot of this development has interesting consequences for the 'replication' interpretation: as it was increasingly defined in terms of its colour, it gradually became darker. The explanation is hinted at by John Richardson, writing in the 1780s (in the private notes later published by David Booth), when he indicates that porter can, with safety, be made paler in London than "in a country where its production is novel," since there is not the competition from the paler ales:[483] in an era when pale ale was entering large-scale production, with the porter brewers moving into ale production themselves against competition from the new provincial centres, the point of distinction had to be intensified to retain the porter drinkers' loyalty. In the event, it darkened to a level which the old brown malt could not have allowed.

Andrew Ure in 1839, stated porter to be "characterized by its dark-brown colour";[484] the case is more subtle, however, since the combination of pale and patent malt allowed very subtle gradations, across the colorific scale originally publicised by Combrune, but with negligible effect on mashing temperatures, fermentation chemistry or fining potential. The chemist Donovan, one of those who characterised the product as chiefly determined by the public taste, suggests there was a capricious vacillation between darker and lighter colours: at some point (before 1830), he notes, it was "the *ne plus ultra* of perfection to be nearly black."[485] At some point over the course of the nineteenth century, it became the common practice for porter to be made truly jet-black.

The growing equation of porter with blackness is illustrated by a curious development in brewery lore. William Black, in the 1830s, tells a picturesque story said to have occurred "during the last century": a Dutch brewery clerk, visiting one of the great London porter breweries to arrange exports, inadvertently "tumbled into a copper of boiling worts" and "was actually boiled to death." The resulting gyle of beer was, of course, sent out to Holland and found to be superb: on an enquiry as to whether this standard could be maintained, the London brewers replied "that they had no means of giving them precisely the same flavour, unless they would send them over another

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[483] [Booth] 1829: 46

[484] Ure 1839: 1005

[485] Donovan 1830: 197

Dutchman."[486] Fifty years later, 'John Bickerdyke' in the *Curiosities of Ale and Beer* produces two very similar tales, both in the chapter devoted to porter. What is interesting is that both feature the same modification: the unfortunate man is not Dutch but black, and the resulting beer is explicitly dark in colour.

One version, a comic poem titled "Patent Brown Stout," is structurally identical to Black's anecdote: the victim here, a country brewer's foreman, falls into a boiling vat while drunk; his death somehow goes unnoticed, the beer is a tremendous success, and the brewer is left wondering how to procure a new black servant for each brewing.[487] The connotations of this tale require careful handling. Legends of inadvertent cannibalism, of course, have a peculiar resonance (most notably in the legend of Sweeney Todd, a characteristic product of Victorian sensationalism), and the particular subgroup involving an unnoticed death in a source of drink is well known to chroniclers of urban legend.[488] Such stories, rendered comic in the hearty, masculine (and exclusively white) culture which provided 'John Bickerdyke' with an audience, often feature a racial element. This might operate on a crass appeal to disgust at consuming the 'Other,' or alternatively, in the view of some folklorists, present a subversive case of poetic justice, with a low-born or apparently defeated individual triumphing in death by alarming the complacent drinkers.[489]

In this instance, however, status and notions of just deserts play less of a role. The hapless foreman is evidently a free man, "an honest fellow" though a drunkard; pen-portraits of white brewery servants in the period were generally no better. His colour, like the Dutchman's nationality, does perhaps have a role in presenting an 'otherness' (from the perspective of Bickerdyke's readership) allowing him to be made comically expendable; yet the primary significance of his colour is *novelty*. In fact there were many black workers, mostly servants, in the England of the nineteenth century — though more often in urban centres than in the country, where the verse account is set[490] — but the man's situation is presented as unusual, and so too is the "brown stout" into which, crudely, he is transmogrified.

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[486] Black 1835: 91-2

[487] Bickerdyke 1886: 369-370

[488] Malchow 1996: 45-6, 49; Mikkelson 2001a

[489] Malchow 1996: 110-123; Brunvand, quoted in Mikkelson 2001b

[490] Fryer 1984. I am grateful to Sadiah Qureshi for guidance on this point.

This is confirmed by the other recounting in *Curiosities*, a much simpler anecdote said to be told to visitors at Truman Hanbury's mammoth porter plant. "[A] negro," for unspecified reasons, once fell into the boiling copper: "Nothing but his bones were found when the copper was emptied, and it is said that the beer drawn off was of an extraordinary dark colour. Some say this was the first brew of porter." This, then, is most definitely an origin story — a self-evidently incredible tale, but one which preserves, and purifies, the notion that porter was invented in a single act, at a single point in space and time. "A similar tale," adds Bickerdyke, "is told of nearly every London porter brewery."[491]

This shows us what had changed by the late nineteenth century, or perhaps (Bickerdyke does not date his sources) somewhat earlier. Colour, now, was *the chief determinant of porter's identity*: from being a colloquial synonym for London beer matured in butt, a brown beer among other browns, 'porter' now described a black beer in a world in which pale ales approached dominance. This position was projected back anachronistically, in the characteristic process which fashions 'heroic' endeavour, so that the instantaneous invention — generally Harwood's, of course — telescoped one hundred and fifty years of technological, material and legislative change. To the Truman's brewery workers, porter had *always* been a black drink. The alteration, thus presented, was so dramatic that it could be jokingly presented as operating at the literally carnal level.

This late nineteenth-century perception of a radical disjunction carried down to the 1959 work of Mathias, who, whilst initiating the problematisation of the construct, remained constrained by it: "From the first," he writes, "[porter] was evidently a black, thick beer, bitter to the tongue, and of greater apparent strength and nourishment than existing ales."[492] Those sources which treat the Harwood myth ingenuously tend also to repeat the blackness claim;[493] it has been most firmly entrenched, however, through the eclipse of porter by stout, formerly its stronger variant,[494] and by the gradual rise of

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[491] Bickerdyke 1886: 366

[492] Mathias 1959: 15

[493] eg Monckton 1966: 145. Accounts following Corran 1975 tend to be more circumspect.

[494] 'Stout' being synonymous with 'strong,' brown stout around 1820 had typically 5 to 7% spirit by volume, as against 4 to 5% for ordinary porter [Accum 1821: 11; Accum 1820a: 173.] The high alcoholic content associated with the name (much as in the case of 'India Pale Ale,') gradually disappeared, however: modern stouts tend to have

Dublin's Guinness brewery to a commanding dominance over the connotations of 'stout' among British and Irish drinkers. Corran relates a widespread belief that Arthur Guinness invented what is popularly characterised as 'the black stuff' in the 1750s. Guinness, in fact, was an ale brewer at that time; the name 'porter,' the techniques associated with the London product, and the subsequent darkening passed to Dublin and most other urban centres over the years to around 1850. It was only then that a later Arthur Guinness, substituting roast barley for patent malt as a cost-saving measure, began to establish Irish dry stout as a distinct style.[495] It was Guinness's Greater London-based British operation, in 1996, which finally laid claim to the whole account, with the marketing of a dark beer named Harwood's Porter Ale.[496]

4.5 Conclusion

Porter was, by 1830, an immensely successful product which was characteristic of both an unprecedented change in scale and the importation of thermometry, saccharometry and associated techniques into brewing. It did not, however, spring fully-formed from any individual brain, brewhouse or laboratory as a scientifically-directed invention destined to conquer the inferior techniques of tradition. This, of course, solves the riddle in the 'heroic' account, as to why the 'inventor' Harwood did not rise to prominence from his small-scale common brewhouse in Shoreditch. Had porter-brewing been at any stage a wholly new brewing process, it *might* have been protected by the inventor with a view to a monopolist's advantage: we may compare, for instance, the patents filed for production of beer concentrates in the 1770s.[497]

Since, however, we are in fact dealing only with a series of (occasionally profound) modifications of the antique mother process, the possibility evaporates. A small brewer like Harwood could not, by definition, have brewed the porter of later generations, since that porter's characteristics embodied the necessities and opportunities of the industrial scale. What initially protected the porter brewers'

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roughly the same alcoholic content as the 1820s porters, or of modern porter revival styles.

[495] H S Corran, personal communication, 30 January 2002

[496] The product was short-lived, being discontinued in the year of its production, and received limited marketing. *The Good Beer Guide 1998* (St Albans: CAMRA Books) mentions plans to resume production [524-5]; to the best of my knowledge, nothing came of this.

[497] Appleby 1986: 156

oligopoly, as Christine MacLeod rightly points out, was not the proprietary status of 'invention' but, in effect, the old-style 'mystery' of the closed craft.[498] In later years, however, as operations became ever larger, this traditional protection became less important than the barrier presented by the enormous capital investment required.

Given this continuity, do we have any justification in calling porter an 'invention' at all, or for following Mathias in characterising porter as 'revolutionary'? The question is more than analogous to the age-old debate as to whether the term 'industrial revolution' itself has any historiographic validity. I believe that such a signpost, provided it is not mistaken for a definitive framework for all investigation, is indeed helpful to anyone wishing to demonstrate how and why a process of a particular kind occurred: what happened to brewing in the eighteenth century *was*, in the sense of being unprecedented, dramatic and influential on later events, revolutionary. As Ian Inkster points out, "removing the industrial revolution may simply lead to boredom":[499] correspondingly, removing the porter revolution would unnecessarily deprive us of a valuable framing device.

At the same time, the introduction of the colorific change has implications for our understanding of 'scientific' appeals to continuity: the consequence of the changes in malt usage was not to replicate the old porter, but in effect to *caricature* it, exaggerating the feature which had (in a contingent process) become the received dominant characteristic. While there is relatively little which can truly be known of the porter of Ralph Harwood's time, we can at least be certain that it was not black. 'Brown' is the term most commonly used in early accounts, but this may simply reflect the name of the malt: the *London and Country Brewer* refers to the Londoners' preference for "blood-red" beers.[500] The early (and, on the traditionalist account, 'true') porters, if presented to a drinker of the late nineteenth century, would not have appeared particularly characteristic of porter at all.

Given the willingness of observers to accept beer as the comic analogue of skin, we should note that the exact same process took place in the sphere of race perception, as Howard L Malchow's work on racial imagery demonstrates:

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[498] MacLeod 1988: 106-9

[499] Inkster 1991: 61

[500] [Ellis] 1750a: 173

> [T]he popular images of the dancing cannibal and the nigger minstrel drew further and further away from their originals and became entertaining theatrical substitutes created by and for a white audience. In this sense, they became more "real" than the originals from which they were drawn, and went to define in the popular mind an essential quality of the racial Other that was then reimposed on the original. In 1884 a writer in the *Saturday Review*, a London weekly, depicted just this process, telling of "genuine darkeys" in a recently performed "nigger minstrel" show who were lighter and more varied in skin color than the audience expected, and who had therefore been "blacked up" to resemble (white) professional minstrels.[501]

The general acceptance of colour among the brewers had other effects significant for our understanding of the 'scientific' agenda. As briefly noted above, the rise in colouring coincided with the growing notoriety of various additives, often deleterious, intended to mask the more general deficiencies of a weak extract. The legitimacy of colouring was often blamed for encouraging further abuses, as the trades of colouring-factor and druggist (as in the cases of Wood and Wheeler) often overlapped; all 'scientific' writers who supported the reductive project of porter colouring were thus in danger of being caught in the backlash against adulteration, whilst those who presented chemical credentials, through the commonplace association of chemistry with the druggist's art, faced the danger more directly. This situation forms the basis of my next chapter.

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[501] Malchow 1996: 117

Chapter 5: Adulteration, 'purity' and the rise of chemistry

5.1 Introduction

At a parliamentary hearing into the state of beer in 1817, John Barrett, a London publican, expressed his wish for a device to detect adulteration in beer. He had, he said, consulted an instrument-maker seeking a device to show the quality of beer when received from the brewer and when sent for return as waste-beer, to prove it had not been interfered with.[502] Presumably he had in mind some kind of flotation device, like the saccharometer. The maker was unable to oblige him: as the early hydrometrists learned, the "quality" of a beer sample (whether determined by spirit content or original gravity) cannot be established from the gravity of the finished product.[503] The adulterative practice Barrett had in mind could have been detected by distillation and weighing of the alcohol fraction, but this process required the facilities and techniques of the static laboratory: a publican could not provide these, and they were no more available in practice to the roving enforcers of Excise law.

This episode illustrates the faith in instruments which the thermometric and saccharometric endeavours had diffused through the beer business by the 1810s, and also the inability of the established instrumentation approach to penetrate questions of adulteration. The presence of prohibited substances in beer had become, by that point, an issue of major public and professional concern, and the long-running controversy over adulteration and contamination was a deeply problematic episode for the early 'scientific' brewery writers. This episode is worthy of significant study because it highlights the historical contingency of any appeal to scientific (and specifically chemical) authority in the establishment of probity or the settlement of disputes.

Accounts alleging and decrying the addition of deleterious substances to beer had widespread currency throughout the eighteenth and nineteenth centuries. In Section 5.2, I outline the nature of the adulteration claim and its propagation through a general audience over the decades from 1760. I pay particular attention to the demand for 'purity', defined as the exclusion of all ingredients beside malt and hops as fraudulent 'sophistications' of the 'genuine' product. This agenda, generally invoked from

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[502] Evidence of John Barrett, *Parliamentary Papers* 1817, v7, 212-3

[503] See Section 3.2.3

outside the brewery, assumed a traditional corpus of brewery practices from which any departure was illegitimate: it also excluded subjective and empirical criteria of judgment, such as the taste of the product, and the question of whether any additives applied were harmful.

Historical accounts of the controversy have tended to distinguish a hyperbolic, muck-raking tendency, prone to exaggeration, from the ostensibly more objective and analytical writings of practising chemists who investigated the problem. On this interpretation, we might expect the supporters of 'purity' to line up with chemists and chemical brewers against an old guard whose oral traditions might conceal a multitude of nefarious practices. I aim to demonstrate, however, that the renunciation of brewery tradition, the changes in colorific practice described in Chapter 4, and the ongoing attempts to analyse beer into its component parts and to obtain a standardised, reliable product all contributed to a perception among the drinking public that beer had become an unnatural and potentially dangerous potion, and that the remedy should be sought not in science but in a resurgence of the old craft methods. Any appeal to the utility of chemistry was viewed with particular suspicion, on account of the known activities of 'brewers' druggists,' generally established pharmaceutical suppliers who developed a sideline in supplying brewery additives.[504]

'Respectable' chemistry, in the universities and learned societies, existed alongside the druggists; but it was not so conspicuous to a popular audience. The ambiguities thrown up by the multiple available readings of 'chemistry' are invoked in Section 5.3 to explain the curious case of Humphrey Jackson, an eighteenth-century chemist who wrote against brewery adulteration but was ultimately enshrined in the historical record as its originator, and the fact that Friedrich Accum, author of perhaps the most widely-read anti-adulteration treatise ever written, was the subject of hostility from brewery quarters which led him to be viewed in much the same terms. An important feature of this account (subsection 5.3.3) is an analysis of the possibilities opened up by the

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[504] The iniquities of the brewers' druggists are much discussed by anti-adulterationists, yet little evidenced in surviving primary material; this is perhaps unsurprising, however, since their activities as commonly reported were primarily illegal and carried on behind licit 'front' activities such as pharmaceutical drug supply. Burnett 1958: 411 quotes a 'respectable' chemist of 1850's claim to have witnessed the trade of brewer's druggist advertised "in broad daylight": this must have been a rare occurrence.

conventions of brewing and publican literature, and the ways in which ambiguities of intent and readership could be manipulated.

In Section 5.4, I show how the conservative purist position received strong support, at least for a time, from what may appear an unlikely source: the vast, industrial common brewers of London characterised in the preceding chapter. Despite their association with prodigious technological advancement, the "power-loom" brewers' public and parliamentary representatives professed complete antipathy to, and often ignorance of, chemical techniques to manage beer, which they said were a smokescreen for toxic adulteration. Their object, in a period of anti-monopoly agitation, was to establish their probity as greater than that of their smaller competitors who, they suggested, lacked the resources to turn an honest profit: such brewers' interest in chemical possibilities was not 'progressive', but would leave the public cheated and poisoned.

Thus I demonstrate that by 1830 the importation of 'scientific' theory and practice into the brewery remained a problematic business. In Section 5.5, however, I extend my survey somewhat beyond the principal scope of this thesis in order to explain the resolution of the adulteration controversy. As the economic landscape changed with the rise of the provincial brewing centres, the 'purity' stance lost its value to London's industrial brewers, while hostility to chemists faded as the wider profession shook off its druggist associations, and the institution of public laboratories offered new instrumentation possibilities. Yet the modern presumption (no more than a hundred years old) that malpractice in brewing is both uncommon and detectable is due not only to more rigorous monitoring, but to a drastic redefinition of what constitutes malpractice. With the significant exception of those additives generally agreed to be toxic, most of the practices considered 'adulterations' in 1817 were ultimately legitimated as brewing became, in the current sense of the word, a scientific discipline.

5.2 Adulteration, 'purity' and its problems

5.2.1 The propagation of brewery adulteration claims

The literature of brewery adulteration, like that of brewing in general, presents a common corpus of claims and beliefs, which echo through periodical and book publications across the decades. Peter Shaw, our link between Boerhaave and Michael Combrune, asserts as early as 1724 that much beer and wine is retailed in an adulterated state, and suggests that in a future treatise he will discuss chemical

techniques to detect the presence of known adulterants, of which he has learnt from the vintners.[505] The claim only became widespread, however, towards the turn of the nineteenth century, as failing harvests and continual war against France caused wild fluctuations in the cost of raw materials. It was stoked by brewery advice manuals such as Samuel Child's pamphlet *Every Man His Own Brewer*, probably first published in 1790, which recommended practices others found outrageous.[506]

1795 saw the publication of a sixpenny pamphlet, *The Crying Frauds of the London Markets: proving their deadly influence upon the two great pillars of life, bread & porter*, which in fact alleged quite general malpractice in the production of food and drink. In a passage which veers from apparent sympathy into evident sardonicism, the writer records the "mortifying" (the word is well-chosen) financial straits which compel the brewer to adulterate. Just as in the identification of porter, we receive an origin story: at one time there was "but one brewhouse in London, which *sophisticated*, or in more applicable language, *poisoned* its porter," but its customs have now spread to the remainder.[507] Another route for dissemination was the newspaper and periodical press. Claims against the brewers were often stoked by suppliers of the raw materials (whose trade was harmed by adulteration), as in 1796 when the *Monthly Magazine* carried an account of a meeting by Kent hop planters, alleging that beer, "formerly a valuable beverage," was now frequently a "poisonous preparation" with "little malt, and less hops."[508]

In 1807, anonymous allegations of deleterious additives in porter appeared in many of the London daily papers.[509] Some time around 1817 a 42-page volume no longer extant, the work of 'Terence Taptub,' was published in London under the title *The Alarm Bell; or, Hints to travellers, private families... and the public at large... exposing the artifices... of brewers, distillers, wine merchants…*[510] Doubtless this

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[505] [Shaw] 1724: 51-4

[506] Burnett 1958: 389-391

[507] *Crying Frauds* 1795: 5

[508] *Monthly Magazine*, August 1796, 596

[509] The *Times* declined to reproduce the "atrocious representations": *Times*, 12 February 1807, 2.

[510] Information from the British Library catalogue. The item, D-7945.bbb.12.(4.), is now recorded as destroyed; no copy has been found to exist in the RLG or COPAC union catalogues. The pseudonym apparently covered two authors, "L. V. L." and "L. E. W."

volume collated the various claims which had been simmering in the popular literature. These claims first reached true public prominence, however, with the chemist Friedrich Accum's bestselling *Treatise on Adulterations of Food…* of 1820. Accum, as we will see later, set out quite deliberately to cause public alarm over what he presented as dangerous levels of adulterative behaviour in the commercial preparation of food and drink: he devoted one chapter to beer, which was, he said, "amongst those articles, in the manufacture of which the greatest frauds are frequently committed."[511] Accum's writings strongly informed several subsequent publications, establishing the tone of the adulteration controversy for most of the nineteenth century.

A prominent feature of virtually all accounts is that the principal sin of the adulterating brewer or publican is seen to be not fraud, but *deliberate contamination*. The commonest act of adulteration was always, in fact, the addition of water or small beer to strong after brewing, in order to cheat the Excise: but this practice, where mentioned, is barely discussed. The focus was instead on the arsenal of ingredients alleged to be used in concealing this primary adulteration, or supplementing limited quantities of malt and hops: these additives could be exotic or even toxic in nature. Since most texts specify these ingredients in some detail, it will be useful to give some account of them here.

5.2.2 The alleged materials of adulteration

One of the clearest and most extensive accounts of brewery additives is that found in the *Domestic Chemist* of 1831. This pocket-sized volume was one product of the wave of public anxiety that followed Accum's work: it detailed, in terms suitable for a lay audience, the fundamentals of analytical chemistry and its use to detect poisons and adulterants in food and drink. The substances alleged to be in use in the brewery are mostly to be found in Accum, and in earlier reports; the anonymous author's innovation is to arrange them systematically, according to the various deficits in substandard beer which they are intended to correct.[512]

The first group is headed "Remedies for want of alcohol", and comprises cocculus indicus, opium and extract of poppies, St Ignatius' bean, nux vomica, tobacco,

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[511] Accum 1820a: 153

[512] The substances are enumerated in tabular form [*Domestic Chemist* 1831: 96.] A similar, though less detailed scheme is presented in [Booth] 1829: 25-31.

Bohemian rosemary and henbane. These substances were always the chief *causes célèbres* in the adulteration controversy, being generally labelled as outright poisons which could be fatal in their effects: cocculus indicus contained picrotoxin, while both nux vomica and St Ignatius' bean contained strychnine. Adulterators, said the writers, relied on their stupefactive properties in place of the alcoholic intoxication a weak beer could not provide (or, at least, simulated the relevant after-effects the next day.) Particularly notorious[513] was cocculus indicus, a berry native to India and Sri Lanka, mentioned as unwholesome in the *London and Country Brewer*:[514] some accounts offer the picturesque but alarming story of the berry's use by native peoples to stupefy fish, allowing them to be caught in the hand.[515] Cocculus indicus tended to be used not in its native state: the crystalline picrotoxin could easily be extracted by chemical analysis and provided the effect in an intensely concentrated form.[516]

There were then "Remedies for want of bitterness" — aloes, quassia, gentian, flag, wormwood, horehound and bitter oranges. These could be used in place of hops, which were subject to Excise duty. One former Exciseman claimed in 1818 that the hop was no longer the bittering agent in beer, although this was undoubtedly an overstatement.[517] Similarly, a lack of sweetness and body, due to insufficient malt, could be masked by Spanish liquorice, molasses, treacle, honey and the "mucilage" of flax (linseed), whilst "want of pungency" could be offset by the hot and spicy flavours of capsicum, ginger, cassia, grains of paradise, coriander seeds, orange peel or caraway. Finings, such as isinglass, egg-whites and hartshorn, appear in the table as "Remedies for muddiness."

"Want of colour", too, had its remedies: the *Domestic Chemist* lists burnt preparations of flour, sugar, malt itself and treacle. In the previous chapter, we saw how the new, saccharometric understanding of extractive potential led brewers to favour the use of pale malt from around 1800, creating conflicts with the London drinkers' established

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[513] In the summary to the 1811 Act on porter colouring, the extensive list of banned ingredients is glossed simply as "Coculus Indiæ" (actually sixth in the list): this is symptomatic of its status as the quintessential adulterant, prominent in almost every account. [Statutes at Large, 51 George III (1811), cap 87, sidebar summary to §17.]

[514] [Ellis] 1736: 98

[515] [Booth] 1829: 31; Ure 1839: 303. The source is conceivably Neumann 1759: 345.

[516] Evidence of Thomas William Carr, Solicitor of Excise, *PP*, 1819, v5, 34

[517] Evidence of Joshua Rogers, *PP* 1819, v5, 23

preference for the dark colouring and 'empyreumatic' taste characteristic of brown malt. Accum, in 1820, argued that the growing prevalence and legitimation of colouring exposed the consumer to its use in concealing poor strength, and had opened the door to greater use of additives in general: though intermittently legal under various arrangements, it was therefore tarred with the brush of adulteration, and had no part in 'pure' brewing.[518]

The class of "mineral" or inorganic additives provided yet more possibilities. Porter was typically supplied in its "stale" (matured) and "mild" (new) forms, which could be blended to the customer's taste: it might be desirable either to bring mild beer "forward", increasing its apparent age, or, conversely, to make old beer seem younger. Staled porter had various distinctive characteristics, but chief among these was a greater acidity: age, therefore, was said to be enhanced by the addition of sulphuric acid, and diminished by various alkaline materials including potash, gypsum and marble. Finally, there was 'beer heading', a preparation of ferrous sulphate, alum and (sometimes) common salt. When applied to flat or insipid beer, to which a little molasses or treacle had been added, this would promote foaming and throw an impressive white head on a pot of beer. Echoing earlier accounts, Accum said that because drinkers considered this 'cauliflower head' an essential property, the addition of heading, usually by the publican, was quite general.[519]

5.2.3 The anti-adulterationists' purity position

Against this panoply of additives, those who detected and decried adulteration mostly argued that beer should be made from malt and hops *alone*. The precise collocation 'malt and hops' came to be adopted emblematically (though seldom, significantly, by any common brewer) to describe the constituent parts of unadulterated beer — what was ultimately termed *pure* beer. Conversely, adulterators were talked of as 'brewing without malt or hops': an inaccurate description, since the aim was generally to supplement rather than to substitute outright either ingredient, but evidently an arresting one, emphasising the artificiality involved. Peter Shaw, for instance, quotes the warning of a "learned Author" (unnamed) against "Men arrived to that degree of

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[518] Accum 1820a: 165-70

[519] Accum 1820a: 182-4; *Domestic Chemist* 1831: 112-3

skill in Brewing, as to make Beer without Malt, Cyder without Apples, and Wine without Grapes."[520]

The resurgence of such charges is exemplified by a Gillray cartoon (figure 5.1) of 1806. A barrel of "True Quassia, Free from Taxation" and a grotesque black figure (conceivably Quassi, the Surinamese healer for whom the product is named) are borne in triumph by a procession of brewers; the figure holds a tankard from which the supposed consequences of the product — apoplexy, palsy, consumption and so forth — radiate in a halo. Another brewer bears a placard: "Pro bono Publico, Quassia for Ever. No Hops! No Malt! Down with all the Private Breweries!" Jutting from the pocket of his apron is a pamphlet labelled, "Receipts to make a Cauliflower Head."[521] Another cartoon (figure 5.2), Isaac Cruikshank's "Porter Brewer and his Family — or the Modern Druggist," dated 1807, personifies Malt and Hops as the brewer's two legitimate children, huddling neglected in a corner while a demon brood of "bastards" — tobacco, cocculus, nux vomica and others — are gleefully introduced to the vat.[522]

This rage (as it may fairly be termed) was epitomised, characteristically, by the radical William Cobbett, whose *Cottage Economy*, as we noted in Chapter 2, encouraged cottagers to brew at home and thus free themselves from the brewers' and publicans' impositions. Cobbett is not at all concerned to emulate the commercial product: his 'pure' recipes are strongly contrasted with other contemporary directions:

> The following instructions for the making of *porter* will clearly show what sort of stuff is sold at *public-houses* in London; and we may pretty fairly suppose that the public-house beer in the country is not superior to it in quality. "A quarter of malt, with these ingredients, will make *five barrels of good porter.* Take one quarter of high-coloured malt, eight pounds of hops, nine pounds of *treacle*, eight pounds of *colour*, eight pounds of sliced *liquorice root*, two drachms of *salt of tartar*, two ounces of *Spanish-liquorice,* and half an ounce of *capsicum.*" The author says, that he merely gives the ingredients as *used by many persons.* This extract is taken from a *book on brewing,* recently published in London. What a curious composition! What a mess of drugs! But, if the brewers *openly avow* this, what have we to expect from the *secret practices* of them and the *retailers* of the article! When we know, that *beer-doctor* and *brewers'-druggist* are professions, practised as openly as those of *bug-man* and *rat-killer*, are we

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[520] Shaw 1724: 53

[521] Wellcome Photographic Collection, London, image V0019386. Cf Ritchie 1992: 42

[522] Library of the Royal Pharmaceutical Society, London, accession PZ27. I am grateful to Matthew Copping for this reference.

Figure 5.1: James Gillray, ‘The Triumph of Quassia,’ 1806.

Figure 5.2: Isaac Cruikshank, ‘The Porter Brewer and his Family — or the Modern Druggist,’ 1807. The ‘black’ figure (blue in the hand-tinted original) represents cocculus indicus.

> simple enough to suppose that the above-named are the *only* drugs that people swallow in these potions, which they call *pots of beer*?[523]

5.2.4 Purity problematised

The 'purity' position, not surprisingly, had considerable public appeal; yet it was liable to attack, particularly from within the brewery itself. The 'malt and hops' criterion was hard to take literally: trivially, yeast and brewing liquor were also essential requirements. Moreover, unhopped ales, brewed using a variety of herbs, had a long traditional history in Britain, while the use of oats and other cereals (sometimes mashed unmalted) in certain areas was documented well into the nineteenth century. Whereas the 'purists' asked why other materials should be used, if beer could be made without them, their opponents asked why they should *not* be used, unless found to be poisonous: and the most toxic additives had a notoriety out of all proportion to the rate of convictions.[524]

A common brewer of the 1830s might have been particularly surprised to see isinglass in the *Domestic Chemist*'s list of adulterants. Use of the product for fining, mentioned prior to 1700[525] and probably widespread from the 1730s or 40s onward, occurred not only in cases of mismanagement but as a routine and accepted feature of porter production, and was freely admitted by those who denied all adulteration.[526] Other substances were more ambiguous: the use of liquorice and other non-toxic flavourings might be taken as indicating a poor basic product that would also require more deleterious additions.

Yet some brewers were prepared to defend even the most notorious poisons, on grounds including 'custom', financial necessity, and the desire to meet the consumer's

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[523] Cobbett 1916: 43-4. Italics original. I have not traced the precise version of the recipe cited, though it almost certainly derives from the work of Samuel Child: cf Child [1794]: 5-6.

[524] In 1818 the Registrar of Convictions stated that, of around 56 convictions obtained against brewers and suppliers since 1813, 31 related to molasses. Three were for mixing table beer into strong; two for having casks of table beer not marked as such; two for "obstructing the officers"; two for concealing colouring; two, relating to the same individual, for retailing liquorice to brewers; and about 13 were for variously "making beer with other ingredients than malt and hops." [Evidence of Edward Jackson, *PP*, 1819, v5, 35.]

[525] Lightbody [1698?]: 44

[526] For instance, evidence of Frederick Perkins, *PP* 1819, v5, 58-9.

desires. Samuel Child's abovementioned pamphlet — which was evidently successful, running through eleven editions to 1810 — details the use not only of treacle, liquorice, burnt sugar, capsicum and ginger but also of beer-heading and the notorious cocculus indicus, notwithstanding that this last ingredient is described as "poisonous, stupefactive and unlawful."[527] Child, who professes himself a practising brewer, offers the following justification:

> [T]hough several Acts of Parliament have been enacted to prevent public Porter brewers from using many of [these ingredients], yet the author can affirm from experience, he could never produce the present flavoured Porter without them. If any person will make trial of the Receipt, he will then be enabled to judge whether all Porter brewers do or do not make use of prohibited articles; but while the laws of the country are express, it would ill become any individual to say they are broken daily and hourly for interested purposes… however much they may surprize, however pernicious or disagreeable they may appear, the Author has always found them requisites in the Brewing of Porter, and thinks they must invariably be used by those who wish to continue the taste, flavor, and appearance which they have been accustomed to.[528]

Elsewhere, in a statement which may surprise the modern reader, he states that the "intoxicating qualities of Porter are to be ascribed to the various drugs intermixed with it… Malt to produce intoxication must be used in such large quantities as would very much diminish, if not totally exclude the brewer's profit, when Porter is retailed at seven farthings the pint."[529]

Another factor productive of ambiguity was the legislation proceeded more often from economic motives than from a public health or 'purity' agenda. Molasses, sugar and honey in beer were banned by statute of law from 1689: this measure was initially intended to encourage the consumption of domestic barley, but after the imposition of beer duty in 1697, served chiefly to protect this lucrative source of Excise revenue.[530] In 1710 came a measure requiring hops to be used instead of wormwood, broom or other bitters (except as added after brewing, by the retailer, to make wormwood or broom ale sold as such): the stated rationale was that hops "are more wholesome" than

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[527] Child [1794?]: 17

[528] Child [1794?] 4-7; cf *ibid* 18

[529] Child [1794?] 15

[530] Statutes at Large: 1 William & Mary (1688), session 1, cap 24. This restriction seems to have been widely ignored, hence a stiffening of the penalties a decade later: 10-11 William III (1699), cap 21.

the alternatives, though we may note that this was also the point at which they first became a taxed commodity.[531]

"Unwholsome" [*sic*] ingredients such as cocculus, guinea-pepper and "foreign Grains" had already been banned in 1701, as had the burnt-malt compound "*Essentia Bine* [*sic*]," which, despite its 'purity' under the strict definition, was also deemed "unwholsome."[532] True 'purity' legislation, in fact, was not enacted until 1802. The Act of that year states an explicit motivation for its restrictions: under a variety of pretences, such as "recovering Stale Beer, or making or preparing Beer Finings or Colouring for Beer", certain individuals "have compounded, fabricated, or prepared from divers Materials and Ingredients, noxious and unwholesome, and injurious to the Health of his Majesty's Subjects, Liquor to imitate or resemble Beer or Ale, brewed entirely from Malt and Hops, or to be mixed with Beer or Ale so brewed."[533] The Act firmly proscribes all such practices. A list of banned substances — "Beer Grounds, Stale Beer, Sugar Water, Distillers spent Wash, Sugar, Melasses, Vitriol, Quassia, Coculus Indiæ, Grains of Paradise, *Guinea* Pepper, Opium" — is repeated like a litany at each stage of the definition of the measures, but is intended to serve only as example: the act applies likewise to "any other Material or Ingredient whatever, (except Malt and Hops)".[534]

Two points should, however, be borne in mind concerning this legislative endorsement of 'malt and hops' purism. The first is that the brewing lobby was influential enough to obtain its suspension when raw materials were scarce. The variations in colouring restrictions have already been noted;[535] the 1811 permission for sugar-based colouring, introduced to appease West Indian sugar interests, was extended, for a short period from 1812, to allow all use of sugar in beer, subject to the brewer's giving the Excise twenty-four hours' notice: no maximum quota was specified, though consignments were limited to a weight of ten pounds.[536]

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[531] 9 Anne (1710), cap 12

[532] 13 William III (1701), cap 5. The measure was repeated in 12 Anne (1713), stat 1, cap 2.

[533] 42 George III (1802), cap 38 §20

[534] *ibid* §§20 and 21. Italics original.

[535] See Section 4.4.2

[536] 52 George III (1812), cap 65

Secondly, enforcement of the 1802 prohibitions was haphazard and occasionally confused: interpreted with absolute literality, they made a criminal of nearly every brewer in the land. Water was "no doubt understood,"[537] yet genuine controversy arose over the isinglass used to make finings which was also in general use. In 1809, the proprietors of the monopoly-breaking Golden Lane brewery[538] were indicted for possessing quantities of James Butcher's substitute, prepared from domestic fish at a time when true isinglass was in short supply; it seems there was never a prosecution relating to true isinglass, but the Crown's arguments did not hinge on any distinction between the two. In an episode Mathias characterises as farcical, the case was tried in the Court of Exchequer, only to collapse as the defence brought witnesses including the chemist Humphry Davy to testify to the validity of the fining process.[539] While the judge's dismissal invoked the technicality that the material used (by its nature) did not remain dissolved within the beer, isinglass was, like colouring, subsequently permitted outright by new legislation.[540]

More generally, the 'malt and hops' strictures were regarded as unreasonable and unworkable, not only by brewers but by many of those charged with applying them. Samuel Child, as we have seen, was prepared to claim in print (albeit by an equivocal wording) that *all* common brewers resorted to banned additives in the face of economic pressures. No less an official than the Solicitor of Excise, Thomas William Carr, declared in 1818 that since the term "adulterating ingredients" covered "any thing that is not malt and hops", it was too broad to have any distinct implications regarding a brewer's probity. Prosecution was by no means automatic: when, for instance, a single consignment of the formerly-legal sugar colouring, made under Excise inspection, was found to have been used by Calvert's shortly after its prohibition, the Solicitor considered the matter "a very improper case" for any further action.

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[537] [Booth] 1829: 19

[538] See Section 4.2.2. The speculation that the prosecution was influenced by the concern's powerful brewery enemies is attractive, but unevidenced.

[539] Mathias 1959: 52-3; evidence of John T Barber Beaumont, *PP* 1819, v5, 9

[540] Accum [1820a: 168] believed that, at the time of writing, isinglass was again officially banned in beer, although a reading of the 1816 Act, which bars "any Article or Preparation whatsoever, for or as a Substitute for Malt or Hops", does not bear this out. David Booth singles out isinglass as "the only ingredient that can be *legally*

Most cases brought in practice, being more serious than this yet not indicating major fraud or danger to the public, were settled on "various terms of compromise,"[541] and matters were not clear-cut even in respect of the most toxic additives: one former Exciseman, in 1818, stated on the authority of "two or three chemists" whom he had consulted that cocculus indicus was harmless in small quantities. The same man had, in his time, found cocculus in brewers' jack-backs — an undeniable breach of law — but had not troubled to prosecute since the amounts involved were small.[542]

A further complication is provided by the remarkable range of views held in respect of particular ingredients. Quassia was defended on account of its medical application, in quantities dwarfing those used in the brewery.[543] Michael Donovan, a chemist rather than a brewer, uniquely gives liquorice special legitimacy in his work of 1830.[544] Samuel Child, though prepared to instruct in the use of cocculus, held a particular horror of the coriander seed, which he considered "vehemently poisonous and stupifying [*sic*]", liable to be employed only "to satisfy an avaricious desire of an unjust gain":[545] though it may surprise the modern reader, this claim is not isolated. The *London and Country Brewer* presents the pernicious effects of coriander along with those of cocculus and deadly nightshade, whilst the sensational *Deadly Adulteration and Slow Poisoning* of 1830 classes it with opium and henbane, with the unreferenced aside that "[c]hemical experiment has proved that less than one pound of [coriander seed] equals in strength and stupefactive quality one bushel of malt."[546]

There was thus a significant gap between the simple, easily-propagated 'purity' conception of adulteration, and the complex and subjective readings introduced by brewers and by the Excisemen who policed them. In the next section, I look at the further complications thrown up by the multiple meanings of 'chemistry.' The 'malt and hops' purity position was undercut, as has already been noted, by the results of

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introduced into malt-liquor" [1829: 24; italics original.] There were no prosecutions for isinglass subsequent to 1809.

[541] Evidence of Thomas William Carr, *PP* 1819, v5, 33

[542] Evidence of Joshua Rogers, *PP* 1819, v5, 25

[543] [Booth] 1829: 27

[544] Donovan 1830: 33. By contrast David Booth (again, a non-brewer) claimed that liquorice had more or less passed out of use by that time: [Booth] 1829: 26.

[545] Child [1794]: 13

[546] [Ellis] 1736: 98-9; *Deadly Adulteration* [1830?]: 55

chemical analysis, and also by the synthetic schemes of chemical projectors: consequently, appeals to the 'respectability' of chemists had little appeal for the dedicated purists whose views were propagated in popular literature. The received interpretation which associates chemistry with anti-adulterationism is thus distinctly problematic.

5.3 The ambiguities of the appeal to chemistry

5.3.1 The case of Humphrey Jackson

Established writing on the history of adulteration and contamination in Britain strongly invokes the image of the chemist as public analyst. This identity developed primarily in the late nineteenth century: the focus is usually on the 1875 Sale of Food and Drugs Act, which imposed a regime of compulsory testing, and on the Society of Public Analysts which helped to bring it about. It so happens that those earlier writers who made a significant public impression — Accum in the 1820s and Arthur Hill Hassall, the microscopist and author of the *Lancet*'s "Analytical Sanitary Commission" reports, which attracted similar attention in the 1850s — display convenient backgrounds in analytical chemistry and medicine, allowing them to be slotted neatly into the story as precursors to the public analysts, men ahead of their time.[547] Their 'responsible' work, grounded in quantitative empirical investigation, are contrasted with the hysterical (and hence, ultimately, less effectual) rumour-mongering of popular writers unable to draw on the same breadth of chemical knowledge.

This reading of the concept of 'chemist', however, was certainly not predominant among the eighteenth- or early nineteenth-century public: in fact, it attained its dominance only as the public analysts cemented their control. To understand the complexities of the brewery adulteration case, we must consider some alternative and distinctly more negative connotations of chemistry: those of impractical obscurantism, opportunistic projecting and, most significantly for our purposes, the production and retail of patent drugs. Attention to this point may go some way to explaining the

[547] Dyer and Mitchell 1932: 1; Smith 2001: 2

remarkably ambiguous reputations of both Accum himself and, sixty years before him, Humphrey[548] Jackson.

Jackson, a projecting chemist and friend of the brewer Henry Thrale, in 1758 penned a contribution to the literature of adulteration, entitled *An Essay on Bread, wherein the bakers and millers are vindicated from the aspersions contained in two pamphlets.* The publications in question, produced by two physicians, alleged that the bakers — characterised as a homogeneous, uniformly delinquent faction, an approach that persisted in later literature — added to their flour large quantities of alum, chalk, bone-ash and other materials. Frederick Filby, reviewing the controversy in 1934, held up these pamphlets as models of an 'irrational', hyperbolic approach: struggling to find any interpretation of one claim, that poisonous bread has killed half the population of London, he marvels at the "amazing exaggerations" and for the complete disregard for supporting evidence in a matter "as much legal as it is scientific."[549] Filby sharply contrasts such wildfire claims with Jackson's 1758 *Essay*, which, in the established literature of the controversy, has consequently attained the status almost of a beacon of sanity.[550] Jackson denies the commonplace use of all adulterants except alum, used to whiten the flour to the public's taste: this practice, he says, is hardly life-threatening but should ideally be discontinued.

Beer, by contrast, says Jackson, *is* frequently adulterated, and probably causes some of the illness ascribed to bread. Interestingly, he describes the use of 'copperas' (properly ferrous sulphate) as heading, and oil of vitriol to enhance acidity, along with chemical

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[548] One 'Henry Jackson', assumed to be a relative of Humphrey, is asserted in much secondary literature as author of this work, and sometimes of two others, *Reflexions Concerning the Virtues of Tar Water* (1744) and the *Essay on British Isinglass* (1765). The title page of each mentions only "H. Jackson." Appleby and Millburn 1988 establishes beyond reasonable doubt that 'Henry' owes his existence to the proliferation of an eighteenth-century cataloguing error: while his existence cannot be *disproved*, their paper eradicates all supposedly independent evidence for it. Whereas much is known of Humphrey Jackson's affiliations and activities, those few sources which discuss 'Henry' (chiefly in connection with the Thrales) proceed speculatively from the evidence of the catalogue; the supposition that Humphrey and Henry were brothers, made in Mary Hyde's *The Thrales of Streatham Park* (1977), has been established as an artefact [JR Millburn, personal communication, 28 March 2002.] 'Henry' survives in the current catalogue of the British Library, although some institutions attribute the works to Humphrey.

[549] Filby 1934: 82-3

[550] Filby 1934: 96-104; Drummond and Wilbraham 1939: 225-6 (and thereby Clow and Clow 1952: 533); Appleby 1986: 150-152

tests to determine their presence.[551] While his procedures are not equivalent to Accum's sixty years later, the similarity in intent is striking, and led Filby to describe Jackson as a "forerunner of the public analysts."[552] Whilst it would be unduly presentist to assume that a dispassionately-toned narrative, grounded in chemical analysis, would naturally convince the public and settle the dispute — and, indeed, there is no evidence that it did so — Jackson's work does illustrate that such an approach could be articulated before 1760, and was deemed worthy of public presentation.

Yet an examination of Jackson's subsequent reputation shows clearly that an appeal to chemical credentials could cause problems, even in natural-philosophical circles. Jackson was elected Fellow of the Royal Society 1772, and died in 1801. Both the 1809 *Philosophical Transactions… Abridged* and the 1810 *History of the Royal Society* of Thomas Thomson, mentioned in Chapter 3 for his saccharometric work, deal with Jackson in brief and strikingly unflattering terms, rubbishing what have since been viewed as significant achievements.[553] Some long-lost professional jealousy might be supposed; yet Thomson gives the curiously specific statement that Jackson

> was originally an apothecary on Tower Hill, and amassed a large fortune by teaching the London brewers the method of substituting other and cheaper ingredients for malt and hops in the manufacture of Porter. By this unfortunate and wicked practice, he destroyed the goodness of our National liquor for ever.[554]

Ironically it was Accum, in the *Treatise on Adulterations* ten years later, who, in a similar account, cemented Jackson's position as the godfather of the brewers' druggists.[555]

How did what is, on the surface, such a remarkable inversion of Jackson's connection with brewery adulteration come about? John Appleby, author of the standard Jackson survey, blames Henry Thrale's wife Hester, the well-known confidante of Samuel Johnson: her writings portray Jackson as an unscrupulous projector who persuaded her husband it was possible to brew "without… malt and hops," and whose costly

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[551] Jackson 1758: 32-42

[552] Filby 1934: 96

[553] Appleby 1986; Millburn 1986: 42-3

[554] Quoted in Millburn 1986: 42-3

[555] Accum 1820a: 159-160. Cf, however, [Booth] 1829: 23-4 for a subsequent approving mention of "Mr. Jackson", clearly the *Essay on Bread* author.

experiments to develop a preservative for ships' hulls brought Thrale to the brink of bankruptcy.[556] This claim, however, seems not to survive in correspondence and did not appear in print until Hayward's edition of Thrale's *Autobiography* (1861), so we are left with an influence by word of mouth which can only be conjectured. It is at least as likely that Jackson's ill reputation was propagated by the brewing staff and clerks, who on Mrs Thrale's account took great exception to Jackson's hold over her husband and his interference in the brewery. Her chief informant was the head brewer, John Perkins, who, as previously noted, became co-owner of the brewery after Henry Thrale's death in 1781, thus rising to a commanding position in the London brewing community.[557]

Other factors helped to make the association plausible. Jackson, among his other lines of business, was certainly a 'druggist', vending a variety of medicinal preparations. In 1753 he obtained a patent on a ginseng-based tincture subsequently sold as "Purl Bitters": *purl* was the name for ale or beer infused with bittering additives and drunk warm. He produced a number of chemically-inspired proposals for the reform of brewing practice in his *Essay on British Isinglass* (1765) and, like several other projectors, worked in the 1770s to answer the Navy's call for a beer concentrate that could be used on long voyages for refreshment and as an antiscorbutic.[558] Conceivably, this scheme of brewing from wort concentrate was somehow reported out of context, giving the otherwise unlikely charge that Jackson sought to brew without malt.

The slight shift from Thomson's to Accum's account — which makes Jackson the founding father of institutionalised adulteration, and thus inferentially responsible for poisoning as well as fraud[559] — was probably speculation: the story of a class of itinerant brewers' druggists arising, like the Harwood account of the invention of

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[556] Piozzi 1861, i: 257-8

[557] See Section 4.2.2

[558] Appleby 1986: 150, 156, 163-4; Mathias 1959: 206-7

[559] Accum's account is awkward in that it dates the rise of the brewers' druggists to "the period of the late French war", which most naturally suggests 1793-1815. Humphrey Jackson served as a Justice of the Peace from 1783 (being then in his middle sixties) and had apparently left his chemical practice behind him by that period; he died in 1801. Accum's text mentions only the surname "Jackson", but — despite the evident existence of other chemists of that name [cf Appleby and Millburn 1988: 42] — all accounts have assumed that Humphrey Jackson was indeed the intended target, and that Accum's second-hand account was simply confused.

porter, or the 1795 *Crying Frauds*' explanation of the spread of adulteration, was rendered more plausible and more readable by the nomination of a distinct origin point. In much the same way, the sixteenth-century physician Andrew Boorde was presented as the "founder of the class of itinerant quacks termed Merry-Andrews."[560] A chemical reputation, then, could have a variety of consequences: Jackson was perhaps lucky in that it did not rebound on him in his own lifetime. Accum himself, as we shall shortly see, was less fortunate.

5.3.2 Friedrich Accum and the 'Treatise on Adulterations'

Friedrich Accum (who adopted the name 'Fredrick' when writing for an English audience) became involved in chemistry at an early age through connections with the Anglo-Hanoverian Brande family, apothecaries to King George.[561] He served his apprenticeship at the Brandes' pharmacy in Hanover and moved in 1793 to London, initially to work as assistant at the Brandes' Arlington Street outlet, run by the father of the William Thomas Brande who subsequently became Professor of Chemistry at the Royal Institution.[562] Accum's concern with adulteration and contamination issues probably developed in the commercial context of the pharmacy. Accum became an associate of William Nicholson, and seems to have absorbed the well-known natural philosopher's methods and populist style.[563] His first published paper, in *Nicholson's Journal* for 1798, describes chemical processes for testing the purity of various drugs and acids, with a warning against the frauds of "mercenary traders."[564]

In 1800 Accum opened a private laboratory and began to establish himself as an analyst, a manufacturer of instruments, and a public lecturer and author on chemical

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[560] Paris 1830: 211n, although note that a "Merry-Andrew" was more often taken to be a simple buffoon or charlatan, rather than specifically a quack. The widely-dispersed Boorde etymology is almost certainly spurious.

[561] There is no recent, detailed biographical treatment of Accum. The established sources are Browne 1925, supplemented by Browne 1948, and Cole 1951. Stieb's account (referenced below) proceeds in the main from Browne's texts and, concerning the episode of the Royal Institution's library, from Vernon 1954; Vernon, however, despite his position as RI Librarian, draws his account directly from the same minutes published verbatim by Cole.

[562] *DSB*, s v Brande.

[563] Stieb 1966: 164-5; cf "A. C."'s comments of 1821, reproduced in Browne 1925: 1143.

[564] Accum 1798: 118

subjects. Works such as the *System of Theoretical and Practical Chemistry* of 1803 were geared to be comprehensible by a popular audience. Accum cultivated many fashionable and aristocratic acquaintances; the American chemist Benjamin Silliman Sr is said to have described him as the Londoners' "pet chemist."[565] It was probably Accum's concern to engage attention of the general public which led to a focus on domestic chemistry, and in particular the chemistry of food and drink: 1820 and 1821 saw the publication of treatises detailing *The Art of Brewing*, *The Art of Making Wine from Native Fruits*, *The Art of Making Good and Wholesome Bread* and *Culinary Chemistry*.

Yet Accum's greatest public success, first published in January 1820, was the *Treatise on Adulterations of Food, and Culinary Poisons*. This book has often been considered to mark a turning point in the history of adulteration.[566] Accum set out with the unabashed — and to his supporters justified — intention of provoking popular alarm: most of the familiar items of household consumption, not least beers and wines, he announced to be routinely adulterated, often with harmful consequences; only with appropriate chemical testing could the fraud be uncovered. A sense of the dire revelations to be expected within could be gained immediately from the work's unorthodox cover, bearing a grisly motif of serpents, darts and a spider devouring a fly, below the obligatory biblical quotation: "There is Death in the Pot" (2 Kings 4:40.)[567] The first edition's title-page bore a tinted vignette incorporating an overturned hourglass and a sagging staff of life; this was replaced, for subsequent editions, by a less subtle design, featuring a death's-head and funeral urn with "Death in the Pot" repeated. The memorable quotation was soon adopted as a popular nickname for the book, and for Accum himself.[568]

The initial thousand copies sold out within a month, with three further editions, an American reprint and a German translation appearing to 1822; some of the material used had already appeared in journals, and the text was partially serialised in the *Repository of Arts and Manufactures*. In addition the book was exceptionally widely reviewed for a chemical work: notices, mostly with extensive quotation, appeared in

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[565] Cole 1951: 135; Browne 1925: 1142

[566] Filby 1934 (especially page 19) has guided subsequent accounts on this point.

[567] For a brief analysis of the quotation, see Cole 1951: 137 n 64.

[568] Browne 1925: 1034. Browne's unreferenced claim is confirmed by a letter published in *Blackwood's* **6** (1820) 621-3, reproduced in Schuette 1943: 294-5.

the *Edinburgh*, *Quarterly* and *British Reviews*, the *London Literary Gazette* and *Blackwood's Edinburgh Magazine*.[569] Accum had scored an instant hit; yet he had also stepped outside the conventions of the chemical and pharmacological establishment from which he drew his authority. The complexity of his position can be seen from the reviewers' several responses.

The *Literary Gazette* gave a strong endorsement to both aim and execution; so did the *British Review*, which, though a little taken aback at the cover, drew attention to Accum's status as "name not unknown to the scientific world," pointing out in particular his connection with the chemically-inclined Duke of Northumberland, to whom the volume was dedicated.[570] By contrast *Blackwood's Edinburgh Magazine*, and more strongly the *Quarterly Review*, responded with parody, dismissing most of Accum's fears. The cover, of course, served as an obvious target; yet the *Quarterly* brought an objection to the overall intent of the book which, though wrapped in exaggeration, was undoubtedly sincere:

> Including [Accum], there are about twenty chemists in England; and about two millions of people who are exposed to poison by wine and custard, seven by ale and porter, and the whole population by bread, water, and small beer. Out of these, how many can have Mr. Accum at their elbow, with his hydrosulphuretted muriatic water, his filtres, his crucibles, his ammonia, his muriate of barytes, and his chemical knowledge?… in spite of his science and his toils, we fear that there is not one of all his numerous hearers who could perform any of Mr. Accum's experiments, simple as they are to him, even with the terrific blue book in their hands.[571]

Much the same objection appears in *Blackwood's*. While castigating Accum for his scientistic impracticality, the reviewers adopt a hearty disregard for the dangers lurking in produce (which are inferentially denied): death will find us in the end, if not through our attempts to feed and water ourselves, then by some other means. Yet *Blackwood's* accepts that some of the abuses are genuine, particularly in the section on beer where evidence of prosecutions is given.[572] The *Quarterly* account is wholly damning. What is particularly interesting is that the standard, John Bullish persona gives way in mid-

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[569] Browne 1925: 1027-1034

[570] *British Review* **15** (1820) 171

[571] *Quarterly Review* **24** (1820-1) 342-3

[572] *Blackwood's Edinburgh Magazine* **6** (1820) 542-553. To sugar the pill, the reviewer strives to suggest that Accum's more alarming findings may not be applicable in a Scottish context.

review to a sharply distinct line of attack: Accum is now shown as inappropriately *ignorant* of specialist knowledge, guilty of second-rate populist hackwork!

> Mr. Accum specifies a number of ingredients, which are employed in the spurious manufacture of wines of various names and qualities: some of these sophistications are, however, not only innocent but necessary, since they are used in the wine countries to impart those qualities which are held essential to the flavour and appearance of the best wines. Mr. Accum ought to know this, if he has read the works whence his matter is extracted, for the purpose of understanding them, and not for that of filling a page and frightening his audience with a formidable array of hard words...[573]

Concerning beer, Accum's knowledge "is all derived from the newspapers":[574] hence the chemist becomes merely another mouthpiece for the established, self-replicating rumour. Accum's occasional reliance on the "loose statements" of the papers is also, we should note, the only real criticism to be found in the *Literary Gazette*'s much more positive review.[575] In pursuing the populist line, Accum sacrificed the automatic authority that went with the office of 'respectable' natural philosopher.

It cannot be denied that the prolific Accum sometimes resorted to scissors-and-paste methods, an approach Ernst Stieb suggests was again due to Nicholson's influence.[576] The 1820 *Treatise on the Art of Brewing*, for instance, reproduces directions on heating verbatim, without attribution, from William Ploughman's *Oeconomy in Brewing* of the 1790s (or from some common prior source.)[577] Even the "Death in the Pot" motif made famous by Accum is not original: the prefatory text which accompanies it has been borrowed directly, as Stieb points out, from Joseph Robertson's *Essay on Culinary Poisons*, a work of 1781 dealing principally with inadvertent contamination due to copper and earthenware vessels, poisonous plants and so forth.[578] The allusion, in fact, was a venerable one: a treatise on the dangers of metal containers, published by Johann Heinrich Schulze, a professor at Halle, around 1722, had the title *Dissertatio*

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[573] *Quarterly Review* **24** (1820-1) 347

[574] ibid 348

[575] *London Literary Gazette* no 156 (1820) 38

[576] Stieb 1966: 32, 166

[577] Accum 1820b: 55; cf Ploughman 1797: 10

[578] [Robertson] 1781: [7]-8; Stieb 1966: 299 n4

qua mors in olla seu metallicum contagium…, "*mors in olla*" being the Vulgate rendering of the phrase.[579]

Accum's reliance on second-hand sources should be borne in mind when assessing the reaction of another group in a position to assert authority: the brewers themselves. Our best source is the *Private Brewer's Guide* by John Tuck, a practising brewer at the time of publication. The title, perhaps chosen to solicit a wider audience, belies the content: this is one of few early manuals which explicitly addressed, and was bought by, a professional brewery audience, as demonstrated by a list of brewery subscribers, proudly included in testament to the volume's utility. Tuck's second edition,[580] which appeared in 1822, was presented as a counterblast to Accum's "violent accusations" against the brewers.

Just like the *Quarterly* reviewer, Tuck faulted Accum's "reliance on science instead of practical acquirement". Accum's *Art of Brewing* had appeared on the heels of the adulteration text, and this allowed Tuck to compound the attack by presenting mistakes in Accum's descriptions of brewery processes including malt-grinding and the brewing of ale and porter.[581] Tuck appeared to see chemists in general as ignorant meddlers in the brewery business:

> I would ask, who learned Brewers the use of Drugs? The answer must be, *Chemists*; Brewers were tempted, and have since completely discovered the fallacy of the experiment; and now the game is up, one of their own body comes forward to expose the evils they have brought on the Brewery.[582]

Tuck's outlook is wholly factional: chemists or druggists, like brewers, act as a body to protect their common interest, and Accum's publication is only a part of the chemists' extended scam. At one point, Tuck goes so far as to draw a connection between Accum and Samuel Child (of whom both Tuck and Accum are sharply critical), accusing Accum of "plagirism" [*sic*] of Child's suggestion that the domestic brewer ferment in a wash-tub (an idea which, Tuck hints, is the ludicrous invention of an

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[579] Stieb 1966: 16 ; Schuette 1943: 283, and facing plate

[580] The date of the first edition is uncertain: I have been unable to trace any copy of that text through standard bibliographic databases. An unamended reference to "the present day, 1818" in the second edition [126] indicates, at least, that part of the manuscript was compiled in that year. From Tuck's comments in the second edition's preface it seems clear that the first edition was completed before either of Accum's works were published in 1820.

[581] Tuck 1822: [viii]-ix, 63 n, 130-3, 146-50

[582] Tuck 1822: xi-xii

amateur — ignoring the fact that Child proclaimed himself a commercial brewer.)[583] This manoeuvre of Tuck's — placing Accum among those who *condone* adulteration — may strike the reader as far-fetched. It is easily understood, however, in the context of the ambiguities of contemporary literature, and especially of the guides aimed specifically at publicans.

5.3.3 Adulteration and the conventions of publican literature

Like the brewery manual, the publicans' guide became established from the late eighteenth century as a small genre whose authors borrowed freely from each other's works, so that a set of more or less conventional features developed. The typical text contained a summary of the laws relating to publicans, a selection of recipes, and warnings against the sharp practices of distillers and spirit-vendors, which included adulteration. The story in William Smyth's 1781 *Publican's Guide* of a customer who puts his seal on a cask of genuine rum, only for the supplier to adulterate it through a hole bored and concealed under the bulge-hoop, is recited in later works.[584] Mention is also customarily made of a preparation, generally based on the oils of vitriol and almonds, to give watered spirits a 'bead', or the light foam of viscosity, and thus the appearance of strength. This is termed 'the Doctor', because it is 'sent for' to 'treat' cases of weak or sick spirits.

The medical allusion had a rhetorical use beyond the normal function of euphemistic concealment. Its associations are ambiguous: the "doctoring" of spirits may be presented on the one hand as quackery, on the other as cure (or at least as the amelioration of an unavoidably bad state.) This suited the writers of publicans' guides, whose constituency required them to excoriate adulteration when practised by distillers against publicans, yet remain silent when the publicans applied the same techniques to the detriment of drinkers.

It was perhaps from this delicate position that a convention arose whereby virulent attacks on an adulterative technique could sit alongside directions for performing it, so clear and precise as obviously to have been designed with emulation in mind. Thus, discussing the distillery, Smyth states categorically that Doctoring is adulteration, and

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[583] Tuck 1822: 84, 182

[584] Smyth 1781: 38

that claiming the practice as "custom of the trade" is no defence.[585] Later in the book, however, no less than four recipes for the Doctor are given (one "said to be the receipt for which a *certain* celebrated *Distiller* paid the enormous sum of ONE THOUSAND POUNDS, to an equally *celebrated Chymist*") with instructions for their use.[586] John Hardy, around 1795, gives two recipes for the Doctor similar to Smyth's: one, containing pearl ashes, potash and lye, is a "horrid receipt" and "very unwholesome", yet he still gives full directions for its use, "as it is proper to mention every thing that may occur in a work of this kind."[587] Peter Boyle, a little later, describes the "complicated iniquity" of spirit dealers vending "adulterated" and "contaminated" products to the publican only after providing these same two recipes: in place of Hardy's censure, he says he "will leave the reader to judge of its good and bad qualities."[588]

It will be noted that these directions (and the bulk of the early guides in general) concerned spirits, which were of the greatest financial significance to publicans where adulteration was concerned. The aforesaid Boyle's *Publican and Spirit Dealers' Daily Companion* of around 1800, however, reproduced alongside the stock of customary material much of the content of Child's *Every Man His Own Brewer*, including a recipe for brewing with liquorice, essentia bina, treacle, capsicum and ginger.[589] Thus brewery adulterations were assimilated into the standard literature, and publicised among the victuallers and small brewers: Boyle also advertised himself as providing hands-on tutoring in the techniques described in the book, which the publican might have purchased from vendors including Dring and Fage, the most prominent makers of saccharometers,[590] while the Registrar of Convictions stated in 1818 that the druggist Desormeaux, convicted of retailing liquorice to brewers, provided publicans with "a book of instructions how to mix up those ingredients with their beer."[591] The author of *Deadly Adulteration and Slow Poisoning* (1830), whom we will meet later, chiefly

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[585] Smyth 1781: 22-3

[586] Smyth 1781: 64-6

[587] Hardy [1795]: 78-9

[588] Boyle [1800]: 45, 47; 37

[589] Boyle [1800]: 60-73

[590] Boyle [1800]: title page, [146]

[591] Evidence of Edward Jackson, *PP*, 1819, v5, 35

blamed the "vile and infamous publications… known by the name of Publicans or Vintners' Guides, Directors, Friends, &c" for the spread of adulterant knowledge.[592]

From the turn of the century, accounts of additives became almost general in brewery as well as publican literature. Writers such as Morrice and Shannon exploited the multiplicity of their readerships: actions prohibited in the commercial brewery were perfectly legal at home, and even those additives and procedures were described, under the pretext of giving as much information as possible.[593] In this climate, the most crusading tone was open to alternative readings. Consequently Tuck, who as a brewer himself would have been as aware as anyone of the conventional ambiguities of brewery literature, did not hesitate to deposit Accum among his mortal enemies the brewers' druggists — much as Humphrey Jackson had been reinterpreted by Accum himself.

We may prefer to believe that Accum was sincere, if sensationalistic; yet, even were that the case, Accum might still be convicted of innocently abetting his enemies, as the *Analectic Magazine* of Philadelphia remarked on the American edition of the *Treatise*:

> We cannot help fearing… that the distinguished chemist has been laboring unwittingly in aid of fraud rather than for its detection. For one reader that is taught how to avoid adulterated food, ten will have occasion to regret that Mr. Accum has furnished the dishonest vendors with so complete a manual and guide in the manufacture of the most cunningly devised poison.[594]

Death's Doings, a comic verse compendium of 1826 showing the grim reaper in a variety of situations, includes the poem "Death (a Dealer) to his London Correspondent," in which Death glories in "extracts of coculus, quassia and copperas", playing on the words *ail* and *bier*; Accum is mentioned by name, and the accompanying cartoon, with Death surrounded by adulterative poisons including cocculus, shows a copy of "Accum's List" pinned to his wall for ease of reference.[595]

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[592] *Deadly Adulteration* [1830?]: 63

[593] Morrice 1802: 131-148; Shannon 1805, passim

[594] Quoted in Browne 1925: 1032

[595] Dagley 1826: 297-300. The poem is by W J Forbes. The illustration, by Richard Dagley, is reproduced in Stieb 1966, plate X (facing page 97.)

5.3.4 Accum as martyr

By the time Tuck's objections reached print, Accum had suffered a swift and spectacular fall from grace. At the end of 1820 he was indicted by the managers of the Royal Institution, where he had once served as a chemical operator and of which he remained a subscribing member, to stand public trial on the extraordinary charge of mutilating volumes in the Institution's library.[596] There followed a storm of publicity and scrutiny which, it seemed, was too much for Accum to bear. He failed to attend trial in April 1821: probably by this point he had already emigrated to his native Germany. He never returned.

To Charles A Browne, who produced the first detailed study of Accum in 1925, the implication was obvious: the charges were certainly propagated by practitioners of adulteration whom Accum had offended or jeopardised through the *Treatise*, and may have been wholly fabricated.[597] This chimes with the *British Review*'s prescient comment that "of course [Accum] will be exposed to obloquy" through "the rage of those whose delinquency he has exposed," and with Accum's own indication, in his second edition, that the *Treatise* had already drawn certain anonymous "maledictions."[598] It seemed that his enemies had ultimately established a convenient pretext with the intention of shutting him up, and had succeeded.

Browne's assumption was later problematised by R J Cole, whose account reproduces minutes from the Royal Institution's managers' meetings: it is recorded that the initial action against Accum was due not to outsiders, but to the suspicions of an observant assistant librarian.[599] We might further add that an identical pose to Accum's, in

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[596] The *Allgemeine Deutsche Biographie* (1875) and former editions of the *DNB* mention a charge of "embezzlement" against Accum, but subsequent scholarship has not established that any such charge was or could have been raised. The *DNB* claims that Accum was the Institution's librarian, whereas there is no evidence in the Institution's minutes that he held this or any other position of responsibility at the time of his indictment. [Cole 1951: 137 n66, 142; Stieb 1966: 302 n21]

[597] Browne 1925: 1140-4; and cf Browne 1948: 7

[598] *British Review* vol 15 (1820) 190

[599] Cole 1951: 137-142. Cole's understanding of Browne's account appears to be slightly mistaken. According to Cole, "Browne says that a few months after the publication of the *Adulteration of Food* 'complaints were made to the Royal Institution etc.' suggesting that this was the action of Accum's enemies" [142], whereas, Cole says, the assistant librarian Sturt was responsible. The apparent quotation from Browne, which lacks a precise reference, does not seem to correspond to anything in the source: Browne does however state that "a complaint was made *by an assistant to*

respect of "*threats*… conveyed to the EDITOR, by those immediately interested in the continuance of abuse," had been struck by the author of *Crying Frauds of the London Markets*, possibly one of Accum's sources.[600] To trace the development of the adulteration controversy, however, it is arguably unimportant to establish whether there was genuinely a plot against Accum: *belief* in such a plot, and Accum's consequent enshrining as an apostle of what became the pure food and drink movement, began to develop almost immediately.

The influence of Accum's *Treatise* is evident in such books as the anonymous *Domestic Chemist* of 1831, and a text entitled *Deadly Adulteration and Slow Poisoning, or, Disease and Death in the Pot and Bottle*, published in 1830 or 1831 by a writer titling himself "An Enemy to Fraud and Villainy" — possibly the lawyer John Dingwall Williams.[601] This latter text, in particular, frequently cites Accum as an authority, and the writer responds to the scandal of the chemist's departure in the rhetoric of martyrdom. Accum is the "intrepid advocate of offended justice, whose civil death to science and suffering humanity is to be sincerely deplored." Elsewhere we learn that the "advocate of fair dealing… has been offered a vindictive sacrifice on the altar of trading cupidity and fraud. Every honest man must allow that *the expatriation of that gentleman is a disgrace to the country which he has adorned and benefited by his talents, and ought to be deplored as a loss to the real interests of science and humanity.*"[602]

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the managers of the Royal Institution…" [Browne 1925: 1141, my italics], and gives an account of the actual alleged discovery very similar to Cole's. Browne does imply a conspiracy against Accum, but this seems to be based on the negative publicity given the case, not the detection. His account is agnostic as to Accum's actual guilt. Vernon 1954: 244 draws attention to the Library's stringent regulations, and states that a particular volume mentioned in the Institution's Minutes does indeed survive in a mutilated condition.

[600] *Crying Frauds* 1795: [2]. Italics and capitalisation original

[601] Williams, an Inner Templar, was the author of a petition for the repeal of the Patent Medicine Act and the abolition of itinerant vendors of "poisonous nostrums", presented by Joseph Hume in the Commons, and reproduced in *Deadly Adulteration* [p iii, and cf 65-6 n.] Clayton 1909: 41 attributes the whole work, without comment, to "J. D. Williams"; to the best of my knowledge, the attribution is otherwise unsupported. Cf Stieb 1966: 236 n11. For citations of further texts influenced by Accum, see Burnett 1966: 77.

[602] *Deadly Adulteration* [1830?]: 39-40. Italics original.

Proponents of 'science,' however, would have found the Enemy to Fraud a problematic ally. For all that the reviewers made fun of Accum's dramatising tendency, the text of *Deadly Adulteration* is vastly more theatrical, swooping often into brittle, sarcastic, mock-archaic affectation. The fears of reprisal, perhaps legitimate in Accum's case, are here taken to lengths we may find absurd, as the anonymous author invokes Socrates and Galileo as precedents, announcing that publication lays him open to the "utmost rancour and bitterest maledictions of wicked and unprincipled dealers"; this is preceded by a warning not to believe those booksellers whom he anticipates will claim to be unable to supply further copies of the book, owing to pressure from those "interested in the propagation of fraud and imposture."[603] It is a matter for conjecture whether the author was truly an outraged consumer, or a disingenuous hack with an eye to a ready market, or perhaps something between the two. What is certain is that he was no chemist, and that the persuasive possibilities of a dispassionate, ostensibly objective approach were wholly alien to him.

The Lancet, a journal then famous for campaigns and crusades of its own, considered the book worthy of its medical audience's attention, and the author sincere, citing his "tone of half-mad honesty." The problems, said the reviewer, lay in "the absence of names and dates and places from his original statements, in the declamatory and puffing style into which he continually lapses, and in the want of satisfactory chemical evidence," to say nothing of "the inaccurate chemical statements he continually thrusts forward, and the utter physiological ignorance he as frequently betrays." While praised for listing some diagnostic techniques for well-known frauds, the author was ultimately assigned to "that class of exaggerating alarmists, which magnifies terrors… to a most nonsensical extent." This was bolstered by a particularly clear assertion of the distinction between toxic adulteration and mere fraud.

> [T]he word 'adulteration' is not necessarily synonymous with injury to health… We can fancy the valetudinarian peruser of a treatise like the present gasping in ignorant horror at the story of his porter being 'adulterated' with quassia, his cheese tinctured with anatto…. these substitutions, though less delicate to the epicure's taste, are as free from any noxious quality in the proportions in which they are employed, as the most genuine article which can be procured. If writers on this subject separated the noxious from the harmless, and dealt not so much in hyperbolical

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[603] *Deadly Adulteration* [1830?]: [page facing title], [i]

> declamation, there would, at the same time, be less terror created, and the ends of public justice would be more effectually attained.[604]

The definition of the word 'adulteration', then, was itself subject to reinterpretation. As we shall see later, this provides the key to the ultimate reconciliation of 'scientific' brewing and public confidence. Meanwhile, however, we must consider another dimension to the controversy: the role of claims over purity and adulteration as weapons in the fight between the largest brewers, established in Chapter 4 as perennially suspected of monopolistic behaviour, and the free-trade movement. Accum drew much of his information, including the lists of convicted brewers and druggists, from two parliamentary committee investigations of the 1810s which discussed the state of beer. These were chiefly prompted not by the adulteration scare itself, but by an organised campaign against the alleged abuses of London's greatest porter brewers, to which I now turn.

5.4 Common brewers and the concept of purity

5.4.1 Adulteration, purity and anti-monopoly agitation

There were, in the late 1810s, eleven major porter breweries in London: Barclay Perkins, Meux Reid, Truman Hanbury, Whitbread, Henry Meux, Calvert, Combe Delafield, Goodwin, Taylor, Elliot, and the Golden Lane Brewery (otherwise known as Cox and Campbell's) which had anomalously leapt the capital barrier in 1805, but was now dwindling towards collapse and had lost most of its anti-monopolist standing. Representatives of these concerns responded to the anti-monopoly campaign in a clever and concerted fashion, their strategy being to establish their own innocence whilst allowing, and even endorsing, the attack on their smaller common-brewing rivals. (The tie system, targeted by the anti-monopolists, was the chief weapon of small brewers in the south-east in freezing out the encroaching giants.)[605] As part of this bid to affirm their own probity, the major brewers strongly espoused the 'purity' agenda, proclaiming a public-minded, malt-and-hops conservatism and an unfamiliarity with the drug-shop. Since these large-scale brewers were also, by this time, increasingly committed to chemical knowledge, new technology and the standardising agenda, a tension developed between the appeals of 'old' and 'new': it

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[604] Quoted in Schuette 1943: 297-9

[605] Clark 1983: 21

was only resolved by a redefinition of what constituted legitimate practice towards the end of the century.

The anti-monopoly movement was apparently instigated by a speculative property developer, John Barber Beaumont, who apparently became involved through attempts to licence a pair of newly-built public houses for his suburban housing development.[606] The pubs, as was obligatory at the time, had had to be completed before licensing could be arranged. Strictly speaking, licences were granted by the Excise, but this was a formality once the house had received the relevant certificate from the magistrates, who effectively controlled the process.[607] However, both of Barber Beaumont's pubs had had their licensing certificates refused. The pubs were intended to be free houses, and Barber Beaumont, himself a magistrate, claimed that the certification process was being interfered with by a local common brewer whose trade would have been threatened. This, he argued, was only one instance of an endemic pattern of common brewers corrupting his fellow justices so as in practice to control the granting and revocation of public house licenses.

The matter was raised at the 1817 Committee on the State of the Police of the Metropolis. Public houses came within the purview of this committee, being perceived as potential sites for civil disorder which required careful regulation: Barber Beaumont claimed that corrupt magistrates were turning a blind eye to rowdiness and prostitution in houses owned by, or tied to, the ruling brewers — "the most profligate houses," in the words of an ally, being "frequently the most profitable."[608] Such magistrates were also alleged to withdraw existing licenses on flimsy grounds, in order to weed out the remaining brewing victuallers and competition from brewers outside the locality ("foreigners" in contemporary parlance.)[609] In the areas where common brewing was the norm — chiefly the south-east of England, but increasingly elsewhere — this meant that local monopolies were established, allowing brewers to raise prices, deteriorate the quality of the product at will, and refuse to accept beer returned as unsaleable. The result, apparently, was that an entire town or village was supplied

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[606] For Barber Beaumont and the Anti-Monopoly Committee discussed below, see Mathias 238-41.

[607] Gutzke 1989: 14

[608] Evidence of Robert Henderson, solicitor: *PP* 1817, v7, 61

[609] "foreigners": evidence of Barber Beaumont, *PP* 1817, v7, 43

with conspicuously bad beer: this could still spell ruin for the powerless tenant publicans, with the populace turning to gin or brewing at home.[610]

Barber Beaumont had carefully solicited support from a variety of sources — free-traders, publicans, churchmen and, it seems, many of those obliged to drink the beer in question.[611] These interests came together under the banner of the Anti-Monopoly Committee, which held regular meetings: many of its supporters (some of them highly-placed) gave evidence to the Police Committee, and 14 000 signatures were gathered from London and Westminster in support of a petition "complaining of the high price and inferior quality of Beer." This was ultimately addressed by a committee specifically empanelled for the purpose in 1818, which reported the following year. Barber Beaumont again led the attack, bringing charges of price-fixing and iniquitous rises.

It should be noted that Barber Beaumont's free-trade rhetoric drew no particular distinction between the behaviour of smaller common brewers in the country and of the major metropolitan combines — excepting in that, since the power and influence of a monopolist facilitated abuse, so the most powerful and influential would be among the most abusive. His claim was "that in many parts of the country there is a complete and literal monopoly; and that in London there is not only a rapid tendency that way, but that in fact at this moment a monopoly does virtually exist."[612] The questions posed by members of the committee, however, often seemed designed specifically to make sure that the 'big eleven' were treated as a separate case. For instance, the registrar of convictions, Edward Jackson, was first asked whether he had any record of a conviction against a major brewer: he was then obliged to answer the question again, in stages, with specific reference to each of the breweries in turn. In all but one case he responded in the negative; by contrast, there were numerous convictions against "inferior" breweries.[613]

It is not at all surprising that some questions were directed in the interests of the large brewers: the committee's members included Charles Barclay and Charles Calvert, two

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[610] Evidence of John Adams, distiller and hop dealer, *ibid* 119-23 and *PP* 1819, v5, 56-7; and of John Barrett, victualler, *PP* 1817, v7, 212

[611] For the wider context of the free trade position, see Harrison 1971: 65

[612] *PP* 1819, v5, 7

[613] *PP* 1819, v5, 35-6

of the several MPs then belonging to powerful brewing families. The major brewers' social and political standing placed them in a naturally strong position for establishing their case, and any attempt to impugn their probity would have to be put to Barclay and Calvert's faces. Unsurprisingly, no such direct challenges emerged: the unthinkability of such a breach of etiquette can be glimpsed in a tactical error made before the Police Committee by Joseph Fletcher, a churchwarden whose efforts to close down offending houses had been thwarted by a coalition of brewers and magistrates. Though his evidence chiefly concerned one of Meux's pubs, Fletcher stated in passing that the brewers responsible in other named cases were equally guilty. It happened that one of the pubs in question was a Calvert's house, and Fletcher was straight away contradicted on this point by Charles Calvert. In the circumstances, and without firm evidence, his only resort was an unconditional apology:

> *Question:* Having of your own knowledge seen this interference on the part of Messrs. Meux & Company, you were led generally to conclude, that the other persons who were equally proprietors, or traded with other houses, were exercising similar influence?
>
> *Answer:* We were… After what the honourable member has stated, I can have no doubt that we were wrong, so far as related to Messrs. Calverts.[614]

5.4.2 The 'purity' position of the major brewers

Nonetheless, the situation was tense: the most vociferous complaints directly related to Sampson Hanbury of Truman Hanbury, who stood accused of manipulating the trade through a placeman magistrate, Joseph Merceron. The big brewers — represented chiefly by Barclay and Calvert themselves, and John Martineau, a partner in Whitbread's — accordingly laid out arguments for their innocence, pleading that their exceptional status sharply differentiated them from adulterating rural monopolists. The densely-populated and ever-swelling metropolis was characterised as a uniquely competitive environment: they pointed out that large breweries, proportionately speaking, supplied more beer to the free market than smaller ones. Half of the pubs supplied with Barclay Perkins' beer were 'free', as against three-eighths tied under loan agreements and one-eighth directly owned.

Barclay added that in his opinion the tied properties were in effect free houses also, since the publicans in London could buy themselves out at will by borrowing an

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[614] Evidence of Joseph Fletcher, *PP* 1817, 146

equivalent sum from any other brewery, and change their supply accordingly.[615] (The possibility that the brewers might act in concert to prevent this was not addressed by Barclay's fellow committee members.) Arguing that they had nothing to fear from competition, Barclay and Martineau said they would be happy for brewery ties, and all other exclusive-supply clauses, to be annulled by law, and even for brewers and distillers to be prevented outright from holding leases on pubs — provided this measure was not retrospective.[616]

As to the use of drugs, the major brewers stated, they had neither motive nor opportunity. Brewing more efficiently than their rivals, and having greater capitalisation to serve as a buffer against unpredictable market prices, they found no need to resort to drugs: implicitly, they were claiming to remain in the happier economic position all brewers had enjoyed before the war, and before the controversy first reached major proportions. Furthermore, the collapse in reputation and trade which would follow a successful prosecution was not worth countenancing, and in any case it would be impossible to conceal a traffic in drugs on the scale required to serve a major porter producer. Most importantly, there was the conspicuous lack of convictions for materials seized on the premises of large breweries; it was true that their beer had been found in an adulterated state at the point of sale, but this could be assumed to imply the publican's rather than the brewer's guilt.[617]

The largest brewers professed themselves vehemently opposed, not only to drugs, but to colourings and all other additives. In 1817, with prohibition on beer colour due to come into force in July, Barclay stated that the window of permission had encouraged the adulteration of porter with small beer. He accepted the inevitable objection — that, since the adulteration itself was unlawful, this would scarcely matter to the perpetrators — but said he felt there was something about the permission which inevitably led to "fraud and deception."[618] The following year, Frederick Perkins claimed that at Barclay Perkins even the legitimate colouring was never used, the colour deriving from a shade of brown malt giving extract "as deep as coffee."[619] Perkins replied in the

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[615] *PP* 1817, v7, 236

[616] *PP* 1817, v7, 238, 241

[617] Paris 1830: 212

[618] *PP* 1817, v7, 239

[619] *PP* 1819, v5, 59

affirmative to a Committee question whether "it would be prudent to prevent the colouring of beer altogether": from the context, this would not have applied to traditional brown malt, but would have included the banning of the black patent substitute legalised in 1817.[620]

These protestations of probity were by no means generally accepted. The 1806 Gillray cartoon, previously mentioned, scurrilously indicted some of the greatest porter brewers in the land: the bearers of "True Quassia" are Combe and the second Samuel Whitbread, whilst the placard ("No Hops! No Malt!") is carried by George Barclay of Barclay Perkins.[621] Stories of deleterious drugs among major as well as minor brewers were certainly established among the roving Excisemen: indeed, the Solicitor of Excise himself received them "by general report." He professed to find the idea unlikely himself, however, reciting the position that adulteration would be against those brewers' interests, and hinting that they had occasionally assisted in the detection of adulterative fraud.[622]

Were the major brewers as 'pure' as they claimed to be? It is important to realise that we can neither prove nor credibly surmise their guilt in systematic drug use, such is the lack of sound evidence available. The registrar's testimony, mentioned above, details only one conviction of a major brewer for prohibited ingredients in six years, and this was explained as non-deleterious to the satisfaction of the committee. John Burnett, who addressed the episode in 1966, found this sufficient for acquittal;[623] but I believe it can be shown that the single case in question raises questions of probity which specifically touch on the chemist's increasing role in brewery management; and that, given the notable silence of the committee on such matters, and the obvious power and influence of the brewing giants, the wider absence of evidence cannot be construed as reliable evidence of absence.

The conviction in question arose from an incident which probably took place late in 1812. An Exciseman, John Fitchew, received a tip-off that Meux Reid's brewery[624]

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[620] *PP* 1819, v5, 60

[621] Identifications as given by Ritchie 1992: 42

[622] *PP* 1819, v5, 33-5

[623] Burnett 1966: 82-3

[624] Often referred to in contemporary literature as "Thomas Meux's." Thomas was the only Meux family member in the partnership after 1808, his brother Henry having set up a rival concern. For the circumstances surrounding the split, see Corran 1981.

was using unauthorised chemicals supplied by a certain chemist. The premises were placed under surveillance. Early one morning, Fitchew and a fellow officer observed a number of casks being loaded onto carts and removed. They gave pursuit and, while the carts were stopped, surreptitiously examined the casks, which contained an unfamiliar salt-tasting liquid. The consignment was then tracked to a wharf where it was cellared, later being collected by dray and taken to Meux's premises. On their removal from the brewery the casks were seized by Excise officers, Meux subsequently being tried and eventually settling with the Commissioners for a fine of £100, plus forfeit of the horses and dray. The cart-driver, when interviewed by the Excisemen, said that the carriage of this liquid had been a regular occurrence; there had unquestionably been deliberate deception, the liquid being passed off as returned beer, indicating that Meux's operatives were well aware it was a banned substance.[625]

The producer of the mysterious liquid turned out to be none other than Daniel Wheeler, patentee of the new black malt.[626] Wheeler had formerly made colouring for Meux's, which was also supplied as a liquid in casks, and carried by the same cart-driver. The colouring, however, was carried directly to Meux's with a special permit, whereas the suspect liquid was transferred via the wharf: the driver, interviewed by the Committee, mentioned that Wheeler had made him set off extremely early in the morning, which was not his normal practice and was clearly done to avoid detection.[627] From the fact that Fitchew was tipped off, we must conclude that some other party knew about the mysterious consignments and had surmised that illegal adulteration was involved. Fitchew at one point mentions in passing what appear to have been seizures of unauthorised colouring by other Excisemen, again at Meux Reid.[628]

Wheeler, brought before the Committee, explained the unauthorised liquid as "merely a solution of salt of tartar". Meux's had been suffering problems of excess acidity due to acetous fermentation, and Wheeler had proposed the alkaline solution as a remedy. He presented what he had done as wholly defensible, stressing the harmlessness of the substance, its commonplace use for similar purposes in domestic situations, and its

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[625] *PP* 1819, v5, 16-7

[626] See Section 4.3.3

[627] *PP* 1819, v5, 21

[628] *PP* 1819, v5, 17-18. The issue is clouded because the seizures seem to have taken place at the time when sugar-based colouring was legal. Not having been present personally, Fitchew could not state with certainty that other substances were involved.

medical virtues. At the same time, he admitted that the operation was carried on in secret because the additive was prohibited; that beer, so doctored, would be inferior to ordinary healthy beer (neutralising the acid did nothing to replace the alcohol which had been acetified); and that it would be flat and unsaleable unless kept for some time or 'married' with sounder beer. None of these points were referred to subsequently by the Committee. Wheeler denied all knowledge of more notorious practices, including the use of "vitriolic acid" to age the beer and the addition of cocculus indicus; when asked if he knew "any shops in town called brewers druggists," he said that he did not.[629]

A less sympathetic audience than the Committee might have drawn some conclusions very awkward to both Meux Reid and Wheeler. The chemist's protestations that the additive was harmless were, of course, beside the point for a 'malt and hops' advocate. Wheeler, patentee of the 'legitimate,' Excise-regulated new malt, stood exposed as a knowing and surreptitious vendor of illegal chemicals — that is, a 'brewer's druggist' in his own right — while the associated hints about colouring would have supported perfectly the purists' argument that normalising any additive (even if innocuous) would encourage more fraudulent additions. The alkali was only necessary because Meux Reid's basic product was consistently out of order, as indeed the beer of even the largest breweries tended to be at one time or another. In at least this one case, the semblance of a reliable product was seen to be due not to the firm's security or efficiency, but to its contacts with a 'sophisticating' chemist.

Another revealing episode, examined by the 1818 Committee, concerned a carpenter who, whilst doing some work in the house of Frederick Perkins (of Barclay Perkins), had seen "drugs and a still," bottles, and what were taken to be brewery adulterants in Perkins' private chambers. This man had informed the Excise, and one of its surveyors, James Titterton, had applied for a warrant to inspect the premises[630] based on this information: the Commissioners had not, however, assented to a search. Perkins told the Committee that the room contained philosophical apparatus used in his private hobby of experimentation, including "analysis of minerals, mineral-waters, the

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[629] *PP* 1819, v5, 80-4

[630] The Excise in fact had no jurisdiction in the room where the apparatus and bottles were seen, which, being part of Perkins' private house rather than the brewhouse, was not 'entered property'. However, the supposed adulterants would have had to be transferred into the brewery at some point: Titterton was probably seeking to make a thorough inspection of the entered premises.

decomposition of alkalies, and repeating several of Sir Humphrey [*sic*] Davy's experiments, as published in the Philosophical Transactions": the still was used for making rose-water and similar extracts, and none of the apparatus had any relation to brewing.[631]

Besides reminding us that members of the major brewing families could be gentlemen of some leisure, interested in abstract philosophical pursuits,[632] the incident presents us with one working member of the public who evidently considered them capable of illegal adulteration. It also suggests that chemical and technical apparatus and products, in a brewery context, were automatically associated in the popular mind with adulterative possibilities. Furthermore, it establishes that the individual Exciseman on the ground might be prepared to suspect, and pursue, the greatest brewers in the land; but that at an institutional level the Excise appeared to offer them a degree of trust, as displayed in the Solicitor's comments above, amounting to a measure of immunity. We are not told why the Commissioners refused Titterton a warrant;[633] while Perkins' explanation is wholly plausible, it is clear that neither the brewery nor the Commissioners were going out of their way to establish a level of scrutiny commensurate with the major brewers' purist probity claims.

5.4.3 Secrecy and scale revisited

Some of those heard by the 1818 Committee saw large-scale brewery operations as directly facilitating adulterative practice. A former Exciseman, Joshua Rogers — who was perhaps not subject to the same pressures as those still serving — stated that the use of prohibited materials would be more difficult to detect in a large, factory-patterned plant than in the traditional brewhouse. He cited the availability of workers to keep lookout for approaching Excisemen; the rambling networks of outlying storehouses, into which prohibited materials could be shunted at a moment's notice; and the systematic organisation and reserves of manpower which meant that even bulk adulterants, such as molasses, could be carried from outside the brewhouse and into a working vat before the attending Exciseman had a chance to notice (the figure quoted

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[631] *PP* 1819, v5, 58-9

[632] cf Sibum 1995: 87

[633] The matter was concluded privately after Perkins reassured an unnamed officer (not Titterton) as to the true nature of the materials.

was twenty barrels of molasses "got rid of" within five minutes.)[634] John Walsby of the Imperial Brewery, which brewed for the Navy and was not involved in public competition, held that the introduction of vats had encouraged bulk adulteration and was responsible for the general decline in beer quality.[635] As to the risks of large-scale drugging, we should note another Exciseman's comment that the mass of picrotoxin, extracted from cocculus, which could be surreptitiously carried by a single man would be "quite sufficient for any brewery in England," including the very largest in scale.[636]

Rogers' characterisation of the great brewery managing its adulterations as systematically as its brewings was implicitly criticised by a Committee questioner, not named in the report, who drew attention to the high turnover of manual workers in the major breweries. The Excise generally proceeded on the basis of tip-offs from workers rather than speculative investigation,[637] and, if the major breweries' staff had been routinely complicit in illegal acts, at least some might have been tempted to inform: the record showed that none (except, presumably, in the Meux Reid case) had done so. It was a common claim of the anti-adulteration lobby that brewers swore their staff to secrecy: this suggestion was put to, and strenuously denied by, several large brewers at the hearings.

What the Committee did not explore, however, was the distinction between foreman-brewers (well-paid, secure and therefore holding a vested interest in their employers' reputations) and unskilled staff (disposable, yet much less likely to concern themselves with the nature of the materials and their standing in law, as in the case of Meux's cart-driver.) Such hierarchical divisions emerged only with the scale and systematisation of the major breweries, and may have offered subtle possibilities for adulteration management.[638] A clear, if questionable, account of the principle of planning against Excise discovery is given by the author of *Crying Frauds*: "the head-brewer… in the dread moment of the poisonous immersion [of cocculus indicus], turns all the usual assistants out of the brewhouse, and does the deed of ruin alone."[639] Besides

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[634] *ibid* 25

[635] *PP* 1819, v5, 48

[636] Evidence of William Wells, *PP* 1819, v5, 41

[637] cf evidence of Thomas Gater, Excise official, *PP* 1819, v5, 42

[638] This was distantly hinted at by another Excise officer: evidence of William Wells, *PP* 1819, v5, 40; and cf again evidence of Gater, *ibid* 42

[639] *Crying Frauds* 1795: 5

minimising certain knowledge of the practice, this would have rendered him the only man who could be obliged to explain the incident under oath.

Accum's *Treatise on Adulterations* makes frequent reference to the Committee reports. His comment on this particular part of the evidence is worthy of inspection:

> That it may be more difficult for the officers of the Excise to detect fraudulent practices in large breweries than in small ones, may be true to a certain extent: but what eminent London porter brewer would stake his reputation on the chance of so paltry a gain, in which he would inevitably be at the mercy of his own man? The eleven great porter brewers of this metropolis are *persons of so high respectability*, that there is no ground for the slightest suspicion that they would attempt any illegal practices, which they were aware *could not possibly escape detection* in their extensive establishments. And let it be remembered, that *none of them have been detected for any unlawful practices*, with regard to the processes of their manufacture, or the adulteration of their beer.[640] [My emphasis]

Accum's recapitulation of the big brewers' innocence echoes that found in the Rees *Cyclopaedia*'s account of a porter brewery.[641] It may be genuine, or it may be a pragmatic manoeuvre to avoid making more powerful enemies than strictly necessary: his 'fearless' naming of names included only smaller practitioners, although this generally reflected the pattern of convictions. However, Accum is not literally accurate in overlooking the practice detected at Meux Reid, which, if not dangerous, was certainly unlawful and clandestinely carried out — and which was attacked as "the worst expedient that the brewer can practise," being liable to cause spoilage, in Accum's own work.[642] Accum also misses the point that a brewery owner without practical expertise was already somewhat at the mercy of his senior "man," hence the customarily high salary of the latter (Henry Thrale and John Perkins providing the model case.)

The major brewers' dilemma around 1830, then, was as follows. On the one hand, they wished to establish themselves as following 'legitimate' practices in a field where smaller common brewers could not be trusted to do so. On the other, as the case of

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[640] Accum 1820a: 215-6

[641] Rees 1819, s v "Porter". The matter is dealt with in a final, stand-alone paragraph.

[642] Accum 1820a: 204-5. In the passage referred to above, following "…none of them have been detected for any unlawful practices," Accum gives a footnote reference corresponding to *PP* 1819, v5, 32: the evidence of Carr, the Solicitor of Excise. Whilst Carr does here claim that there have been no actions against the major brewers, he is speaking only of the preceding three years: the Meux Reid incident happened in 1812 or 1813.

Meux and Wheeler suggests, they were somewhat reliant on the chemists, whose methods were popularly viewed as 'illegitimate.' In the next section, I briefly chart the factors which resolved the problem. The dependence on chemistry only increased, as it was fully integrated into the brewers' own staffing considerations; but, at the same time, the chemical profession shed its drugshop associations as the image of the 'respectable' public analyst was constructed. Finally, the concept of 'illegitimacy' in beer preparation — that is, the concept of adulteration itself — was redefined, legislatively and in the common brewery-chemical context, to exclude the traditional malt-and-hops 'purity' consideration, and its proponents were left largely powerless.

5.5 The ultimate legitimation of brewery chemistry

5.5.1 The major brewers' embrace of chemistry

The anti-monopolist agitation culminated in the Beerhouse Act of 1830, previously mentioned with reference to changes in the Excise of malt.[643] On the surface, this sweeping Act radically deregulated the industry, allowing virtually any householder to set up as a retailer of beer on payment of a two-guinea licence. Supporters characterised it as a blow for honest competition, finally giving the public the opportunity to buy traditionally-brewed beer rather than the 'sophisticated' product of the monopolists' owned and tied houses.[644] A contemporary cartoon, playing on the 'Bill' then being enacted, shows Wellington in command of a gigantic long-billed bird, bringing terror to fraudulent publicans and brewers' druggists: the bird's body, formed from a hop-pocket, bears the prominent legend "MALT AND HOPS."[645] Yet, despite a great and sudden proliferation of new beerhouses, no such free-trade revolution emerged. In practice, the Act did the major porter brewers (who had strenuously opposed it) little noticeable harm.

As David Gutzke has shown, the Beerhouse Act did *not* prove a barrier to the common brewer's tie. There were, it is true, many new 'free' beerhouses; but at the same time there was nothing to stop the common breweries (large *and* small) achieving a simultaneous surge in tied establishments, any restriction on the overall number being

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[643] See Section 3.4.2

[644] Brande 2003: x-xi

[645] Reproduced in Gourvish and Wilson 1994, fig 1 [plate facing 102]

prohibited by the very terms of the Act itself.[646] At the same time, beerhouse-keeping became established as socially inferior to the established trade of publican — it was often a part-time, transient calling — and it was widely considered that the beerhouses were impossible to regulate, with only the well-capitalised existing concerns maintaining persistent operations.[647] While stories associating the 1830 Act with a general "debauch" are primarily an artefact of later, often teetotalist accounts by middle-class writers who would never have attended the beerhouses,[648] its effects certainly did not help the anti-monopolists; Brian Harrison suggests that the overall effect was to *increase* adulteration.[649]

In 1854, a Select Committee of Parliament acknowledged that the Act had failed in its objectives.[650] Although the champions of small-scale, traditional brewing remained vocal in the 1830s and beyond, the metropolitan porter brewers no longer had reason to see them as a threat. From mid-century, their primary concern was instead with the brewers of Burton and other provincial centres who, taking the opportunities afforded by improved transportation, were capitalising and industrialising to compete with the Londoners in their own markets;[651] their methods included careful thermometric control, allowing pale ales to be controllable on the scales traditionally associated with porter, and a growing investment in chemical analysis. In 1845 the Burton brewers Allsopp engaged a laboratory analyst trained at Giessen under Justus Liebig; Bass, Worthington and other Burton firms followed, and by the 1870s Burton possessed the

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[646] Gutzke 1989: 14-20. The new houses were, of course, competing for a trade no larger than before, but the common brewers had other reasons to expand their tied estates as far as possible: they prevented the incursion of local rivals; as reliable assets, they offset the insecurities of the market; and they would instantly become hugely valuable if, as seemed possible, the legislature at some future point reversed the freedom of the trade.

[647] Gourvish and Wilson 1994: 16-17

[648] Archetypically, Webb and Webb 1963: 122-134

[649] Harrison 1971: 350, 82-6; and cf Mason 2001, Burnett 1966: 84-5

[650] Burnett 1991: 121

[651] Gutzke 1989: 20 argues that the railways had effectively created a national market "[b]y 1868."

greatest concentration of brewing chemistry expertise in the world.[652] In Scotland, likewise, the 'brewer-chemist' became an accepted feature of the industry.[653]

As this reorientation took place, then, the London porter brewers' strategy of totally foreswearing additives was not merely rendered superfluous: it began to seem like a dangerous luxury. Arguments of the kind raised by Daniel Wheeler in 1818 — that drugs had a legitimate place in the brewery when their role was not to defraud the public, but to remedy defects — became increasingly palatable. At the same time, brewers of all sizes were concerned to project an image of probity, and continued to deny the use of deleterious substances. Therefore a growing emphasis was placed on the distinction between 'noxious' and 'harmless' additives in beer, as invoked by the *Lancet* in reaction to *Deadly Adulterations*. Sometimes, medical analogies were applied, as illustrated to perfection in William Black's brewery manual of 1835:

> When every thing is going on well, no drug is necessary; but when *sickly*, a chemical remedy must be applied, and it is only then a brewer has it in his power to how his skill, by using proper remedies. He must, therefore, have some knowledge of chemistry, so as not to make use of any thing which may be hurtful, or perhaps cause combinations, which might turn out to be poisonous.[654]

While the term 'chemist', to many people, carried associations of the druggist's shop, if not the yet more shadowy world of the itinerant nostrum-vendor, this was not the only complexion that could be put on the word, of course: 'chemistry' was also a branch of natural philosophy, practised by amateur gentlemen and nobles and by reputable university professors. It is Black's appeal to this form of chemistry which distinguishes his medical rhetoric from the earlier publicans' guides' crude invocation of "the Doctor." By singling out particular dangers, such as the risk of converting sugar into oxalic acid, he neatly established himself as one who is familiar with modern chemical theory, and thus a fit person to conduct the legitimate kind of experiment on beer.

This is not to say that established popular assumptions about chemists and druggists did not persist: in an echo of Frederick Perkins' difficulties, Worthington's chemically-trained brewer Horace T Brown struggled as late as the 1860s to establish laboratories

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[652] Gourvish and Wilson 1998: 59-61; Owen 1976: 89-95. Owen's prefatory slighting of the significance of earlier research should be treated with circumspection.

[653] Donnachie 153-4, 183

[654] Black 1835: 74. Italics original

against "those who failed to see that they could have a legitimate use," and "due to the fear that the display of any chemical apparatus might suggest to customers… that the beer was being 'doctored.'"[655] A similar story is told of the first Guinness laboratory in Dublin.[656] Yet the chemists worked strenuously to overcome such objections inside and outside the brewery. They were assisted in this project by a variety of developments which served to banish the negative connotations of 'chemistry,' to which I now turn.

5.5.2 The wider chemical context after 1830

In 1820 the *British Review*, discussing Accum's *Treatise*, had noted the failure of legislative approaches to the adulteration problem, instead proposing the following solution:

> Perhaps some good might be gained by the formation of a society, of which the object should be, to prevent the adulteration of food, and to put the public on their guard respecting culinary poisons. The society ought to be very limited in the number of its members. Most of them should be scientific men, totally unconnected with any trade or business, which could afford pretence even for a shade of suspicion.[657]

No society along exactly these lines emerged: however, it was precisely through the rise of "scientific men" in a variety of professional bodies that the brewery adulteration controversy was ultimately dissipated.

One such constituency was the druggists themselves — or rather, as they increasingly preferred to be styled, pharmacists. The Pharmaceutical Society, founded in 1841, set out to professionalise the pharmacy, establishing its members as responsible, accountable specialists. Since at least the time of Peter Shaw, there had been institutional tensions between physicians and vendors over the regulation of the drug trade, the retailers' low status helping to foster their image as ignorant quacks.[658] One of the keys to mastery over their field, the pharmacists now saw, was establishing themselves as credible analytical chemists. The Society founded a journal to publish original research in the field, and within a couple of years had instituted examinations

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[655] Brown 1916: 270

[656] Anderson 1992: 94

[657] *British Review* vol 15 (1820) 189

[658] Stieb 1966: 136-7

for members requiring some chemical education.[659] The establishment of this 'acceptable face' of the trade helped to undermine the purist assumption that a brewer who called on 'chemistry' was necessarily exposing himself to a poison-broker.

Another influence was what became known as the Laboratory of the Government Chemist, founded in 1842 by the Board of Excise as an adulteration testing facility which, unlike the Exciseman in the field, could employ the microscopes, precision balances and other equipment found in scientific laboratories. The initial intent, true to Excise form, was to safeguard not the public health but the revenue: its initial work largely concerned tobacco, also constrained by 'purity' legislation. University chemists were often called in to test samples, and from 1845, the Laboratory's own staff were obliged to matriculate and receive classes in chemistry from the University of London, setting a longstanding precedent.[660]

The following year, when the West Indian sugar interests petitioned for their products (banned since 1817) to be readmitted to the brewery and distillery, the question was put to quantitative analysis: the Laboratory was called in to determine what quantity of sugar or molasses should be taken as equivalent to a standard quantity of malt, so that a rise in spirits duty which would maintain revenue levels could be computed. The Excise chemists reported in 1847, and permission was granted by Act of Parliament the same year. This measure embodied the abandonment of 'purity' as far as the legislature was concerned: malt and sugar, now, were viewed alike as potential sources of saccharum, in line with the analytical findings of contemporary sugar chemists. Further, the Act required that the original gravities of brewers' worts should not fall below certain stipulated levels, thus targeting the primary cause of alcoholic weakness, rather than the drugs for concealing it which were such a focus of 'purity' agitation.[661]

As a result, gravity determination in beer samples became one of the Laboratory's chief functions. Many samples were found to be understrength, and brewers inevitably disputed the Excise chemists' methods. The question was referred to a committee comprised of three authorities, representing different facets of the 'respectable' face of chemistry: Thomas Graham, Professor of Chemistry at University College London; Theophilus Redwood, one of the Pharmaceutical Society's founders and Professor in

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[659] Stieb 1966: 82, 143-9

[660] Hammond and Egan 1992: 5-6, 11-22

[661] Hammond and Egan 1992: 49-53

its school; and August Wilhelm Hofmann, Director of the Royal College of Chemistry, a former Liebig pupil engaged in training pharmaceutical and industrial chemists in laboratory methods.[662] This committee broadly vindicated the Excise, and its slightly revised methods formed the basis of a new Act in 1856. From this point forward, brewers began to train their own staff in the Laboratory's methods and installed their own analytical equipment. Samples registering understrength declined sharply thereafter: the brewers were effectively policing themselves.[663]

Meanwhile anti-adulterationist agitation, stirred by the *Lancet*'s "Analytical Sanitary Commission" (consisting principally of Hassall's microscopic researches)[664] resulted in the Adulteration Act of 1860. This permitted, but did not require, the appointment of analysts with a public function to detect adulteration, and was not widely regarded as a success;[665] a further Act of 1872 was in theory more stringent, but highlighted the lack of any institutional support for analysis or firm definition of its aims. In 1874, in the wake of another parliamentary investigation, the Society of Public Analysts (SPA) was formed. Whereas analysts had at first come primarily from medical backgrounds,[666] the teaching programmes of the Pharmaceutical Society brought increasing numbers of pharmacists into the field, and the founding president of the SPA was Theophilus Redwood, the pharmaceutical professor who had contributed to the alcohol determination report. The Society worked quickly to establish definitions for adulteration and mixtures, heavily influencing the framing of the 1875 Sale of Food and Drugs Act, which made the appointment of analysts compulsory for the first time, and in 1876 founded its own journal, *The Analyst*.[667]

The later nineteenth century, then, was characterised by an ever-growing appeal to chemical authority, promoted by the legislature and by professional bodies, whose roles became increasingly interlinked. Early friction between the SPA and the Laboratory of the Government Chemist, centring on the limited chemical training of

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[662] Background on Hofmann: *DSB*. Hammond and Egan's reference to 'Alexander Hoffman' [*sic*] is seemingly a literal.

[663] Hammond and Egan 1992: 39-40, 53-4

[664] For which see Smith 2001.

[665] Stieb 1966: 127-8

[666] Stieb 1966: 160

[667] For the early history of the Society from its own institutional standpoint, see Dyer and Mitchell 1932, esp 1-8.

the latter body's staff, was settled in 1894 when Edward Thorpe, Professor of Chemistry at the Royal College of Science and a former public analyst, was appointed to the directorship of the Laboratory.[668] The institution of the public analyst fuelled the rise of chemistry in the food and drinks trade: many producers hired analysts as consultants as a precursor to obtaining analysts of their own. Otto Hehner, for example, who had worked alongside Hassall, provided services to private firms from 1877 whilst serving as a public analyst, an active member of the SPA, and a regular *Analyst* contributor.[669]

5.5.3 The changing definition of adulteration

While chemistry became a respectable, and ultimately an authoritative discipline, its proponents never lost their antagonism to the 'purity' position which had proved so popular among the public: the ongoing project of analysing foodstuffs into their constituent chemical parts precluded any straightforward division between 'natural' and 'unnatural' ingredients, and the question of whether the materials were dangerous to health increasingly became the only basis for judgment. We have already met this position, in the brewing case, in the 1830s work of William Black, who criticises the application of laws which were, he assumes, framed primarily to inhibit the sale of "deleterious ingredients," in the case of "*harmless*" additives: if these were permitted, he believes, the use of toxic additives would decline. Black considers that all flavourings, unless poisonous, fall on the legitimate side of the divide, picturesquely citing the "very pleasant" aroma imparted by pineapple, raspberry or strawberry.[670] From the legitimation of sugar in the 1840s, the Excise itself moved to accept this position.

The distinction between toxic and merely fraudulent adulterations was further highlighted in 1874, with another Select Committee concluding that only the latter was widespread.[671] The larger food manufacturers, like the brewers, formed a concerted lobby represented by resident parliamentarians: of primary influence in the 1870s were

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[668] Dyer and Mitchell 1932: 14-18

[669] Horrocks 1994: 136

[670] Black 1835: 75-7. Italics original

[671] Stieb 1966: 126-7

Jeremiah Colman[672] and Sir Henry Peek, whose family names are to this day associated with, respectively, mustard and biscuits. These great, household-name producers, like the brewers, presented themselves as above suspicion, sometimes even placing advertisements in *The Analyst* to stress their credentials.[673] None, however, spoke in support of a 'purity' position. In the 1875 Sale of Food and Drugs Act which followed the Committee report, mixed or "compound" substances, provided they were appropriately declared, received explicit protection, and attempts to install requirements for 'purity of substance' failed conclusively when Colman and Joseph Fry convinced the legislature that prosecutions filed against them on account of their 'mustard' and 'cocoa' containing other ingredients were ridiculous.[674] The manufacturers succeeded in problematising the concepts of 'pure' and 'adulterated' foodstuffs to the extent that the word 'adulteration' itself appears nowhere in the Act.[675]

Propelled by these various influences, the brewing industry moved towards an understanding which would have been startling at the beginning of the nineteenth century, yet was more or less general by its close: the use of non-deleterious additives in beer, it was established, was *not adulteration*. This position was legally cemented by the 1880 "Free Mash-Tun" Act, taxing the brewers on the original gravity of the finished product, without reference to the raw materials.[676] From this point, virtually *any* non-deleterious substance was permitted: unmalted grain, malts of cereals beside barley, colouring, synthetic glucose and malto-dextrin preparations for body, gum-based headings, and countless others. The change led to the introduction of a new terminological usage: the newly 'legitimate' malt supplements were not adulterants but *adjuncts*.

The principal suppliers for the more innovative additives were, as ever, chemists: but they now displayed their wares more openly and pointed to qualifications, patents established and analytical expertise. In the 1880s, for example, the Manchester chemist Nathaniel Bradley offered a hop supplement "[t]o save one-third of the Hops,

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[672] In later years, Colman's developed a particularly strong programme of research into the chemistry of its core product. [Horrocks 1994: 140]

[673] Phillips and French 1998; Horrocks 1994: 143 n 8

[674] Stieb 1966: 134; Phillips and French 1998: 354-5

[675] Stieb 1966: 126

[676] Burnett 1999: 123; and cf Section 3.4.2

and supplement the Hops used with valuable keeping properties", "Frothing Powder" to raise a head, "Permanent Hardening" to give water the salt profile of Burton's, and material "for protecting the Wort from acidity, and for producing a Beer of greater delicacy of flavour and colour, even from inferior Malt." Bradley advertised himself as "Analyst to the Manchester Brewing Association," and could be contacted by the telegraphic address "Analyses, Manchester."[677] The brewers, then, still relied on a separate manufacture carried on industrially by non-brewing chemists, and promoted on a retail basis, just as had been case with the brewers' druggists: yet the practice was now carried on in total legislative security.

5.6 Conclusion

Both chemists and brewers had developed specialist interpretations which led them to exclude considerations of malt-and-hops 'purity': brewing practice, as we have seen, was heavily dictated by a vacillatory Excise policy over permissible ingredients, whereas chemical analysis revealed common elements in the constitution of 'traditional' and 'sophisticated' materials. The 1880 Act represents the triumph of what was by now an integrated brewery-chemical perspective: the legislature and the Board of Excise were arguably in a stronger position to change brewery practice than were the brewers themselves, since they were not accountable to the public and their conservative tastes. Accordingly, for a time, the use of adjuncts was presented as a consequence of the law, as in the 1911 *Britannica* entry stating that, "in view of the keenness of modern competition, it is not to be wondered at that the brewer should resort to every *legitimate* means at his disposal to keep down costs."[678]

Yet the purity position, despite its simplicity and the immediate appeal which had ensured its survival in literature aimed at a general audience, was now revealed to have little effective power. In the 1880s and 90s a series of attempts were made to enact a Pure Beer Bill, which would have excluded most adjuncts (though the legitimacy of sugar appears to have been accepted by this point): these were chiefly motivated by farming interests, threatened by the legitimation of cheap imported grain, and were in

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[677] Reproduced in Patton 1989: 74

[678] *Encyclopaedia Britannica*, 11th edn (1911) s v "Brewing." Italics mine. For the legitimation of sugar in particular, see Chaston Chapman 1912: 19

any case unsuccessful.[679] Deleterious drugs, banned separately in beer under the Inland Revenue Act of 1885, continued to attract significant public concern until the First World War, fuelled by crises such as the Manchester arsenic epidemic of 1901 — in fact an instance of contamination rather than deliberate adulteration — which allowed a renewed Pure Beer Bill to attain a second reading, the furthest the measure ever progressed, being defeated after brewery assurances of improved safeguards.[680] The idea that most additives were adulterative, fraudulent or unacceptable, however, quietly disappeared from public discourse.

Twentieth-century bodies created to represent the interests of consumers against the policies of the major brewers and legislature — the Society for the Preservation of Beers from the Wood, founded in 1963, and the more activist Campaign for Real Ale (CAMRA), originated in 1971 — have focused more on the production and dispense of the product than its constitution, and stress taste and diversity rather than 'purity' considerations. Whereas CAMRA does object to, for instance, high levels of rice as compared to barley malt in brewing grists, the objection is presented entirely on flavour grounds: few present-day campaigners would seriously contend that the use of adjuncts is adulterative.

The legitimation of additives, reciprocally, promoted the union of chemistry and brewing. From the 1890s, the employment of one or more chemists was becoming the norm in any large brewery, as it was in food and drink production as a whole.[681] The breweries, Excise, universities and professional bodies now had a shared interest in a common image of the chemist as expert authority applying techniques of disinterested analysis. It is worth contrasting this newly-consolidated approach with that of Friedrich Accum in the *Treatise on Adulterations*. Despite his status as an instrument-maker and professional analyst, Accum was chiefly concerned to produce a *popular* work, detailing tests the reader could perform at home: this perhaps explains the omission of several laboratory techniques, such as refractometry, introduced by William Hyde Wollaston in an 1802 *Philosophical Transactions* paper which refers

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[679] Baker 1905: 166; Clarke 1998: 66-7. The legislatively autonomous Isle of Man is unusual in having introduced in 1874 a Pure Beer Act, still in operation.

[680] Gourvish and Wilson 1995: 296 n 90. The incident forms the subject of a current PhD thesis investigation by Matthew Copping, University of Kent.

[681] The food manufacture case, including subsequent developments to 1939, is well summarised in Horrocks 1994.

specifically to the detection of adulterations.[682] It is possible that the emphasis on presenting the easily-accessible in Accum's work, as much as his dishonourable exile, contributed to the eclipse of his reputation as a chemical innovator in the later nineteenth century.

The new analysts, by contrast, presented the application of the most complex and laboratory-bound techniques as a point in their favour, emphasising their authority: the appeal for the legitimacy of brewing chemistry, by the end of the nineteenth century, rested not on openness or accessibility, but on the extent to which practices, understandings and results were shared with such reputable bodies as the Society of Public Analysts and Laboratory of the Government Chemist. Examination of brewing manuals from the later nineteenth century reveals that the 'scientific' approach was no longer the project of a small and partisan group within the brewery, but increasingly a necessity: advanced laboratory techniques of precision gravimetry and polarimetric sugar resolution were covered, and bodies such as London's City and Guilds Institute for the Advancement of Technical Education instituted examinations in brewery theory which were sat both by "Revenue Officers and others" involved in the policing of the brewery, and by trainee brewers themselves.[683] Ultimately, then, in the post-1830 brewery, as Everett Mendelsohn remarks of the wider technological context, "the specialist in science became the normal man."[684]

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[682] Stieb 1966: 60

[683] See in particular Hooper 1885 [quotation: iii] and Baker 1905: 140-2. For the rise of scientific education in brewery training, see Reinarz 2003: 42-7.

[684] Quoted in Inkster 1991: 94

Conclusion

To conclude, we must return to the underlying questions posed in my introduction. Each is presented once more below, and answered with reference to the analytical themes and case studies presented in the body of the thesis.

What does it mean for a discipline to be made 'scientific'? In the brewing case, several important factors seem to be relevant: the standardisation of products; the application of a quantitative approach; the importation of technologies (chiefly instruments) from other disciplines; and the changing self-image of brewers. What importance did the brewers themselves attach to these factors, and how were they interrelated?

A survey of those writers from a brewery background who professed themselves to be "scientific," or proponents of "science,"[685] reveals that their understanding of the term principally carried connotations of *certainty*. A 'scientific' brewer was one who had positive information of the state of his malt grist, or mash, or fermenting wort, and how to manage it if it varied. The chief value of this certainty, according to these brewers' own accounts, was the possibility of replication, imposing a local *standard* on such attributes as mashing heat and strength, and so giving a consistent product. By contrast, the 'unscientific' practitioner, lacking this certain knowledge, was doomed to endure set mashes, poor worts, foxing, ropiness, cloudiness, acetic fermentation and a myriad other obstacles; the point was not that these disasters would generally occur, but that they would strike intermittently in a way the old-style brewer, however experienced, could never comprehend, not being party to the knowledge which the new techniques presented.

This conception of the 'scientific' can be seen to proceed from the old sense of 'science' as 'knowledge' or 'privileged skill,' which current historians of science, with their focus on the avoidance of present-centred analysis, are so careful to preserve. Initially, then, the proponents of what George Adolphus Wigney termed the "New

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[685] Richardson 1788; Hayman 1812; *Young Brewer's Monitor* 1824; Morrice 1827; Black 1835; Wigney 1835

System"[686] were not necessarily 'scientific' in the sense of embracing the speculative and experimental disciplines which ultimately became known as the branches of science. Brewing itself, as the titles of most publications make clear, had the status of an *art*: a skilled process employing technologies founded on practical principles rather than natural-philosophical enquiry.

Some brewers, of course, did embrace philosophical principles: Michael Combrune, most notably, involved himself with the project of chemical philosophy, and sought to legitimate thermometry on exclusively chemical-theoretical grounds. However, as we saw in Chapter 2, by 1800 most common brewers had embraced the thermometer *without* the chemical underpinning Combrune had provided for it. Its 'scientific' utility, in their eyes, was not revolutionary but merely a superior means of locally standardising wort heats, compared to the mixture of boiling and cold water which it seems to have replaced: certainly, not all techniques of standardisation rely on instruments. We may conjecture that the method of mixtures was itself viewed, by some, as more 'scientific' than the subsiding steam criterion — which, in turn, was on William Ellis' account an improvement over the "Hour-glass" approach.[687]

But this is not to suggest that the thermometer and other instruments could have been introduced without a growing common context between natural philosophers and a section of the brewery: the existence of "hybrid people" (in Sungook Hong's phrase) such as Combrune and John Richardson was a precondition, not a consequence, of the introduction of thermometry and saccharometry.[688] Those brewers who first applied philosophical instruments had to think like experimental philosophers, and, in one sense, not like brewers: that is to say, in the event of disagreement between their disembodied instruments and the sensory evidence of experience, *they had to trust the former*. This would be more likely with younger practitioners,[689] whose experience was more limited — hence, we may suspect, James Baverstock's dispute with his

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[686] Wigney 1835: 252-6. The pagination is eccentric, with "Old System" and "New System" being dealt with on facing pages bearing identical numbers.

[687] See Section 2.2.1

[688] Hong 1999: 300-1

[689] I have not established Michael Combrune's dates, but he was seemingly alive to publish the New Edition of *Theory and Practice* in 1804, some sixty-three years after he professed to have begun thermometric experimentation.

father over the thermometer[690] — and occurred as these brewers, acquiring some of the literacy and leisure of gentlemen, were exposed to the treatises and lecture demonstrations supporting the instruments, and as natural philosophers such as Peter Shaw, for their part, moved to spell out the commercial applications of their work.

In the period to 1830, by and large, this natural-philosophical context was necessary *only* among the pioneers: as soon as the thermometer, for instance, was commonplace among the brewers, the need for a strong external justification disappeared. Our brief survey of events to the end of the nineteenth century, however, shows that brewing ultimately became a thoroughly 'scientific' business, in the modern sense of having assimilated the authorities, notations, publication procedures and techniques of assessment (of both samples and students) of professional science.[691] The applicability of two senses of the term 'scientific' in different periods is by no means a coincidence: modern 'science,' and the 'scientists' who practise it, came into being as those who privileged and saw a productive role for what was then regarded as natural-philosophical knowledge set up institutions and professional bodies to promote it. These developments took place outside the scope of the present thesis, but further study might reveal how new 'boundary objects,' such as the spatial conventions of the analytical laboratory shared by university and brewery chemists, ultimately made scientific credentials a requisite for *all* commercial brewers.

What was the nature of the 'unscientific' brewing tradition castigated by reformers? What was lost in the transition to the new methods? Given that these methods were often presented as allowing an established product to be produced more reliably, how is it possible that such products were sometimes changed fundamentally in the process?

Pre-thermometric, pre-saccharometric brewing was — as Otto Sibum indicates — a highly localised art, based on tacit principles of the kind described by Polanyi, and resistant to textual communication; the brewer's senses played a central role, serving as the final authority to interpret and direct developments in the process. The innovation of new measurement devices, and the associated "theoretical technologies"

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[690] See Section 2.5.2

[691] See Section 5.5.3 and 5.6

of numerical tables and written records,[692] created new and non-localised authorities with the potential to displace the individual brewer from this privileged position. This is illustrated most vividly with respect to the transfer of processes: we may contrast the centrality of craft operatives around the mid-eighteenth century, when the industrial spy John Holker was obliged to bring not only tools and samples from England to France, but skilled workers to perform the necessary operations,[693] with a brewery incident of 1833, when the young and "forward-looking" brewers Gabriel Sedlmayer and Anton Dreher — later installed as pioneers in the brewing cultures of Bavaria and Vienna respectively — visited a series of English and Scottish breweries and engaged in effective thermometric and saccharometric espionage, using hollowed-out canes to take surreptitious wort samples.[694]

This position is well-established. What is novel in my conclusions from the thermometric and saccharometric cases, however, is the extent to which new methods could proliferate only if they were *not* presented as displacing the brewer from his central controlling authority. The thermometer, as noted above, first found acceptance as a localised tool, subordinated to the prior experience of the brewer; the saccharometer was marketed by Richardson as increasing the individual brewer's control over his product, at the expense of the maltster, consumer or Exciseman; the apparently intrinsic attributes of universal communicability were nullified, in the commercial environment, by blind scales and falsified records. Given the extent to which innovatory adaptation was seemingly bound to favour the conservation of established practice, it may well be wondered how products or behaviours changed at all.

The answer lies in the realisation that the rhetoric of the 'scientific' brewers systematically conflated two modes of standardisation: that which is *internal* to the individual brewer's domain, which may be applied in a conservative fashion; and *external* standardisation, applied across multiple localities, whereby some practices must inevitably change. The case of an ale-brewer using the thermometer and saccharometer to output reliably consistent beer in an established style represents the former mode; the general shift to pale malts on saccharometric grounds, and the

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[692] Sibum 1998b: 30 uses this phrase, drawn from Andrew Warwick, with reference to the tables of John Levesque.

[693] Harris 1998: 47-78

[694] Teich 1993

consequent legitimation of colour, is probably the archetypal case of the latter. The conflation is exhibited particularly strongly in the work of Richardson, who wrote explicitly that the saccharometer should be applied to safeguard the individual brewer's existing practice, but in the same work asserted that his saccharometric pronouncement against brown malt should be applied generally.[695] It was quite possible, then, for brewers to be swayed by the apparent prospect of enhanced control which new technologies represented, only to become participants, under pressure of economic arguments or the re-acclimatisation of consumer tastes, in tremendous shifts in general practice.

We must be wary, finally, of the assumption that the objection to 'unscientific' methods became general. During the long period of adulteration controversy, advocates of the purity position outlined in Section 5.2.3 often sang the praises of 'traditional' ale, as exemplified by William Cobbett's paean to home brewing in *Cottage Economy*:[696] the 'sophistications' which aroused suspicion could include unfamiliar practices alongside unfamiliar ingredients. The 'scientific' brewers, of course, scorned this perception as a romantic delusion, asserting that home brewers produced good beer only by chance and high expenditure, whereas the new methods, properly applied, would produce reliable beer in a cost-efficient fashion that benefited producers and consumers alike.[697] The equation of tradition with probity, however, certainly survived the period under review; it is, indeed, still with us, and ironically informs the marketing activities of some of the largest, most heavily industrialised beer-producing concerns.

Who were the agents of quantification, standardisation and the promotion of the 'scientific' context? Were these developments largely internal to the brewing community, or were they transferred into the brewery by outsiders with other agendas?

On a superficial reading, it may appear that the thermometric and saccharometric endeavour in brewing was enacted almost exclusively by the brewers themselves, notwithstanding the Excise introduction of similar measures into the distillery from the early eighteenth century: Richardson, as we have seen, was careful to divorce his

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[695] Richardson 1788: 176, 161

[696] See Section 5.2.3

[697] Richardson 1788: vi

gravimetry from the controversial spirits context, whereas innovations such as the blind thermometer demonstrate the autonomous and non-'philosophical' character of some brewery instrumentation. The developments discussed in Chapters 4 and 5, however, suggest a role for the Excise beyond its ability to impose acts of mensuration. Tax, as characterised by Ashworth, is a tool which can be used not only to redistribute capital, but to alter public tastes by shifting the balance between 'staples' and 'luxuries,' and even to redefine the categories by which commodities are conceptualised.[698]

We see this at several points in the beer story. The ever-rising duty, since at least 1760 (the year of the 'Poundage' letter), has always been presented by brewers as promoting and legitimating technical change: this had its most notable effect in the shift to paler extracts, which was directly consolidated through the legislative sanction of beer-colouring, under the monopoly patents granted to Wood and Wheeler, and policed by the Excise itself.[699] The legislature's intermittent retreats from malt-and-hops purity before 1830 chimed with that section of the 'scientific' interest who considered the desired characteristics of beer as reducible to elements, which could be engineered through the use of appropriate additives: when this position took hold permanently, after 1847, it was through the growing common context of analytical chemists and Excise embodied by the Laboratory of the Government Chemist.[700]

We should also note that a multiplicity of agendas existed within the brewery itself, and even in the work of individuals. Richardson, for instance, was probably quite genuine in his professed aim to improve the lot of brewers in general: at the same time, it is important to note that his proprietary scheme was constructed primarily in his own interest: by recommending the saccharometer he sought to create a market for its supply which he himself could control.

How does the conspicuous industrialisation of London's porter breweries relate to developments in the quantification and standardisation of products? Were techniques based on 'science' prerequisite for the establishment of large-scale production, or did industrialisation precede and promote the adoption of the new methods?

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[698] Ashworth 2003: 6

[699] See Sections 4.4.2 and 4.4.3

This question relates chiefly to the themes of my fourth chapter. The huge growth of the urban porter breweries, and their resulting conceptual distinctness, certainly predated the introduction of thermometry and other techniques imported from natural philosophy (being, already, established by 1760): it may be regarded as an instance of independent technical development, vindicating the thesis that technology is not merely the application of scientific theory. As noted above, on the other hand, *standardisation* does not require instrumentation to be enacted. Given the exceptional concentration of drinking establishments in the metropolis, the ability to maintain a reliable product was particularly important to the porter brewers, and standardisation was probably key to the development of porter from the outset.

We see this in the very nature of porter: a dark beer, strongly flavoured by smoky malts and a high hop rate, its most minor variations would not be as perceptible as those in ale. Furthermore, it was often composed (whether at the brewery or in the publican's cellar) by the mixture of 'mild' and 'stale' forms: we have already noted the adjustment of the proportions of each, in response to variations in their quality, to create a uniform 'palate.'[701] We should also note the characteristic porter-brewery operation of 'marrying' beers. This involved the mixing of stale beer which had been returned as sour with some which was much younger and milder: the operation, however, was not perceived as a simple blending to dilute the sourness, the younger beer being instead considered revivify the older, which partook of its nature. Success, writes William Black in 1840, "can only be accomplished by those who have been accustomed to such management": this was an area of tacit skill into which the established 'scientific' modes had not penetrated even by the mid-nineteenth century.[702] Porter, then, was (or was considered) peculiarly susceptible of being brought to a standard state.

Natural-philosophical techniques and apparatus, in fact, *were* duly incorporated as they became available, facilitating ever-greater expansion (as in the case of the systematic use of pipe thermometers at Whitbread's plant.)[703] Yet in this respect they were no different to such diverse resources as new malts, steam engines, increased capital

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[700] See Section 5.5.2; and cf Ashworth 2003: 10-11, 307-315

[701] Boyle [1800]: 14; cf Section 4.3.2

[702] Black 1840: 132-5

[703] See Section 2.6

holdings or the architect of Barclay Perkins' suspension bridge: those major brewers who were committed to and capable of expansion exploited whatever opportunities presented themselves. The major porter brewers, then, were not uncommonly 'scientific': the famous names of London's 'Big Eleven' are not to be found among the authors of brewery manuals or chemical papers. Indeed, as Mathias points out, the properties of porter were such that it did *not*, in contrast to ale, require philosophically-derived processes such as attemperation to be brewed in bulk, this being one factor in its earlier growth. Accordingly, when a particular association of chemical and analytical methods with large-scale production did arise, after 1830, its locality was not London but Burton.

Was the shift to 'scientific' practice an inevitable, self-propelling mechanism once initiated? Or was it rather contingent on certain conditions which happened to persist in the period under review? If the latter position holds, can we hold any particular external factors responsible?

We have already noted one account of technological change which is to some degree 'self-propelling.'[704] This is Thomas Hughes' account of large systems possessing *momentum* or *inertia*, defined as a tendency for change — or the absence of change — to persist, on account of such factors as the commitment of operatives within the system to maintaining their standing, or the need for a large production facility to maintain high outputs in order to remain cost-effective.[705] We might characterise the growth of porter vat sizes around 1790, or the nineteenth-century shift to jet-blackness in porter, as inertial in this sense, due in the first case to personal competition (one-upmanship) among the brewers, and in the second by the peculiar circumstance that the increase of darkness, motivated by its status as an established signature of 'traditional' brewing, proceeded ultimately to a level unknown to 'tradition.' Certainly, something like Hughesian inertia was at work in the persistence of the porter brewers' output levels. Having once developed plant and distribution systems on a vast scale, they were forced to maintain tremendous outputs or else be destroyed by their fixed costs, as in fact happened in the case of the Golden Lane brewery.[706]

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[704] See Section 1.5

[705] Hughes 1987: 76

[706] See Section 4.2.2

The move to 'scientific' practice — the embrace of the instruments and quantificatory agendas of those who first applied metrics to the tun — *can* to some extent be accounted for on such an inertial account: a brewer, for instance, might begin to apply the thermometer because his neighbour did so, through motives either of competition or of maintaining credibility. But — paralleling the industrialisation case discussed above — in this respect they were no different from practices with no basis in natural philosophy. 'Scientific' status by itself, as we have seen from the 'traditional' brewers' reactions, and from the attempts of projectors such as Richardson to pre-empt them, did not make the utility of practices or instruments self-evident, nor their acceptance inevitable. Hughes, we must note, is careful to point out that inertia is not equivalent to *autonomy*.

The acceptance or rejection of a technology (like the success or failure of a porter brewery, both equally possible outcomes) is due to a huge range of contingencies: the innovator's rhetorical skills, the brewing community's economic fortunes, the legislative status of brewery materials, the rate of Excise duty and the system of Excise policing; the reputation of those with whom the brewers associate in the minds of the drinking public, and countless further factors. I hope that, in the present thesis, I have demonstrated the importance of this web of interconnecting influences, and the untenability of assuming a monolithic 'science' intrinsically destined to sweep aside whatever is 'unscientific.'

It might be objected that this aim has not been truly achieved, owing to the thesis' limited temporal coverage: the emergence of a common context of professional science uniting brewers and analysts after 1830, the argument might go, was a phenomenon qualitatively different from, and far more powerful than, the limited and largely internal co-option of philosophical instruments and measuring techniques in my period, and hence *might* have been a genuinely inevitable development. It is my hope that further research, whether by myself or by others, will extend the approach I have laid down here into the post-1830 period, providing more comprehensive insights into the complex relationship between 'brewery science' and the 'art of brewing.'

Glossary of brewing terms

abroad clerk	senior brewery staff member, responsible for making the round of supplied pubs to collect payments and supervise general management
abroad cooper	brewery worker, also sent around the pubs, usually responsible mainly for care of the product, including the supervision of fining. Largely distinct from the sense of 'cooper' as a cask maker
ale	historically, the term has held numerous distinct meanings; here, it is used in opposition to 'porter', implying a pale unaged beer with a relatively low hop rate, likely to be strong and to originate outside London
attenuation	the thinning-out of a wort during the fermentation process, as the sugars are converted to alcohol; quantified as the difference between the original and final gravities
back	brewery vessel, such as the jack-back or under-back
barrel	in brewing parlance, specifically a cask of 36 gallons' capacity (on the old ale measure, 32 gallons)
beer	often distinguished from 'ale' in primary literature as an alcoholically weaker product with a high hop rate; often brown and hence, in London, sometimes synonymous with 'porter.' For the sake of convenience, however, outside quotations this thesis follows the modern usage of 'beer' as a generic term for fermented malt liquors
brewing victualler	publican ('licensed victualler') who brews his or her own beer, for consumption on the premises
bright	clear and transparent; used of beer following the initial fermentation, when yeast and other materials have dropped out of suspension, usually indicating that it is ready to drink
butt	cask of three barrels' (108 gallons, beer measure) capacity, normally used for maturation in the cellar

cleansing	period of fermentation in which the yeast is worked out of the beer prior to casking; also sometimes, by extension, transfer of finished beer from fermentation vessels into casks
common brewer	brewer producing beer on a relatively large-scale basis, for supply to private consumers and those public houses which did not brew their own beer
copper	vessel for boiling, originally direct-fired and fashioned from copper
extract	fermentable materials in a wort, extracted from malt during the mashing process
entered property	brewery properties and utensils inspected and gauged by the officers of Excise, over which the Excise had jurisdiction
entire	beer 'brewed entire' is produced by mixing the successive mashings and fermenting them together, as distinct from the earlier custom of taking the first mash for strong beer and a subsequent mashing for a separate batch of small. 'Entire' or 'entire butt beer' is also a synonym for 'porter.'
final gravity	the gravity of the finished beer after fermentation
fox	taint affecting beer, generally understood to be the result of unclean utensils
goods	the grist once wetted in the mash-tun, or the soluble fermentables produced from it
grains	the spent grist left behind after the worts have been drawn off, commonly used as animal feed
gravity	the density of a liquid, usually as determined by a hydrostatic instrument
grist	the ground malt (and sometimes other materials) mashed to produce wort
gyle	individual brewing batch
gyle-tun	vessel in which the primary fermentation takes place

jack-back	strainer vessel in which the hops would be separated out of the wort after boiling
length	the volume of beer produced from a given mashing
liquor	refers, by brewery convention, to plain water as used for mashing; depending on context, can occasionally describe wort or finished beer
malt	dried partially-germinated grain, generally barley unless otherwise stated; the principal raw material of beer production
maltster, malt-factor	manufacturer of malt
mashing	the infusion of malt (and sometimes other materials) in hot water to produce wort
mash-tun	any large vessel used for mashing
mild	in eighteenth-century parlance, used of new, immature beer (opposing 'stale'.) 'Mild' beer was, in some instances, highly bitter and unpalatable owing to high hop rates. In the nineteenth century this was generally not the case, and 'mild' ultimately came to refer to beers which were low in hops
original gravity	the gravity of the cooled wort following the boiling stage, immediately prior to the start of the fermentation process; usually considered by saccharometrists to reflect the quantity of fermentable sugars present in the wort
porter	a dark beer, usually of low gravity, originally prepared from brown malt, typically aged in vats for weeks or months before sale, and particularly associated with the major common brewers of London
set	(of taps, stopcocks etc) turn on, set running
set mash	calamity resulting when the mashing liquor is too hot. The malt clots, assumes the consistency of paste, and retains most of the liquor, meaning that an inadequate (and usually cloudy) wort is drawn off

small beer	weak beer for everyday drinking, originally made from the final mash
stale	‘stale’ beer, usually porter, was that which had been matured for a time, producing a characteristic acidic tang sought after by many drinkers
tun	brewery vessel, usually large and coopered, such as a mash-tun. Also a standard cask size of six barrels (216 gallons)
twopenny	mutable term used for ale (as distinct from porter) styles: in some sources, appears to describe a strong pale ale; in others, a weaker and cheaper running ale for immediate consumption
under-back	vessel below the mash-tun, into which the wort is drained after mashing
victualler	publican; see also ‘brewing victualler’
wash	distillery term, roughly equivalent to the brewery ‘wort’
wort	unfermented beer; the solution of fermentables produced by the mashing procedure

Bibliography

Abbreviations used for standard sources

DNB Dictionary of National Biography

DSB Dictionary of Scientific Biography

ESTC English Short Title Catalogue

OED Oxford English Dictionary, second edition (1989)

PP Parliamentary Papers

VCH Victoria County Histories

Books, articles, thesis and manuscript material

A formal distinction between 'primary' and 'secondary' sources is made difficult by the number of sources — especially those published in the later nineteenth century — which may be cited on account either of their primary content, or of their interpretation of past events. For ease of reference I have therefore divided the texts at the turn of the twentieth century. Post-1901 reprints, republications and new translations of pre-1901 texts are presented in both lists.

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