BY ROYAL LETTERS PATENT.

THE THEORY AND PRACTICE OF BREWING ILLUSTRATED

BY

W. L. TIZARD.

FOURTH EDITION

Frederick Ponsonby.
Biggleswade January, 72

FOURTH EDITION.

THE

THEORY AND PRACTICE

OF

BREWING

ILLUSTRATED:

CONTAINING

THE CHEMISTRY, HISTORY, AND RIGHT APPLICATION OF
ALL BREWING INGREDIENTS AND PRODUCTS;

A FULL EXPOSITION OF THE NEWLY DISCOVERED PRINCIPLES OF CONVERSION
AND EXTRACTION IN THE MASH-TUN;

THE PHILOSOPHY OF CLIMATE, SEASON, AND SITE;

CRITIQUES ON THE *MODUS OPERANDI* OF FERMENTATION, AND
THE EFFECTUAL PREVENTION OF ACIDITY:

ALSO,

Many new Practical Observations

ON BREWING

LONDON AND DUBLIN PORTER, EAST INDIA PALE ALE,
EXPORT STOUT, &c. &c.

BY W. L. TIZARD,

PROFESSOR OF BREWING, AND BREWERS' ENGINEER,
12, MARK LANE, LONDON.

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AND ALL BOOKSELLERS.
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PREFACE

TO THE

FIRST EDITION.

THE Preface to a book, like the blue wort of a spent mash, is last drawn but least valuable, and commonly of doubtful service; or in plain technicality, instead of being the broaching of the subject, it constitutes the bunging up. In the present instance, the Author having stirred his oars to attemperate his few prefatory remarks into the body of his introductory chapter, has here little prospectively to add; and must therefore content himself with two or three retrospective observations, which rise upon him as a fob, to complete the ordinary anomaly of a pro-epilogue to his brewing *drama*.

As his volume is of the magnitude by some considered bulky, though he trusts that he has not drawn a greater length than his grist required; and as he has imbibed the notion that a Book without an Index resembles a Vat-room without a Registry, he has added an appendage of that nature, as the concentrated essence of his work, and as a more comprehensive outline of its primary compounds than his Table of Contents can consistently supply.

As scarcely ever yet, since Van Helmont discovered fermentation, or Faust first exercised the art of printing, has a book been "got up" without containing some of that indigestible husk or undigested amylin denominated "*errata;*" and as he is bound to confess, that with all the vigilance which himself, his amanuensis, and his printers, have individually and conjointly been enabled to command, certain blunders have unaccountably crept in, or in some of the instances have not crept out, he can here take seasonable opportunity to convert necessity into virtue, making the former his mucilage, the latter his saccharum, and the corrections the gelatin of his depuration. Upon these, he is persuaded, his readers will oblige him by brewing a little of that wonted patience and clemency which they are accustomed to extend to other authors under circumstances similarly unattenuable.

The work has not been written with any idea of imitating popular style, or of competing for honour; for although it embraces a wide field of *novelty*, the principal aim has been to set forth utility and practicability, to illustrate old and new practice, as the purpose of its title implies, and to make all the newly discovered principles positively beneficial to the whole community. Many of the subjects which he has noticed, have already been treated upon by very able pens; but then, the demonstrations have been theoretical rather than practical, and therefore inconclusive; and besides, it is here as with other branches of the useful arts and sciences, that the errors of each generation must submit to correction by future experience; old theories being better understood, old practices modified, and both improved and more beneficially applied; while others have been introduced, in accordance with the dictates of advancing science and the progress of knowledge tempered with wisdom. The Author having therefore freely commented upon the productions of his predecessors generally, must leave his readers to judge of himself as they find him; for how far he has remedied the defects and extravagances of which he finds occasion to complain in others, must be left for their wisdom to decide in that manly way which befits the intelligence of a judicious community. He can assuredly assert that, though obliged to several for prompt and candid answers to his correspondence in point, he has not put himself under obligation which he is ashamed to acknowledge or unworthy to receive, and so far he has studiously endeavoured to avoid the sin of ingratitude: here he would do wrong not to notice the kindness of his Birmingham friend, who is the author of a "Philological Grammar," and from the commencement of his undertaking assisted him to the close of the compilation; and whose mathematical attainments have been highly appreciable.

A desire to do critical justice without causticity, has also been a great object with him, in prosecuting which, he has taken the greatest freedom with the most responsible authorities, dealing with little matters in a small way; but in this bold attempt to grapple with giants, he may perhaps be found to have failed, though not through any deficiency in that literary skill and gist which distinguish the scholar from the smatterer, so much as through want of participation in the feelings of others; but by the consequences, with the following explanation, he is willing to abide, being aware, however, that animadversions upon a work professedly technical, are not within the range of some men's province, notwithstanding their pretensions.

So far as he has been enabled to judge of the publications brought out on the subject of Brewing, they, in general, who have written theoretically, without a competent practical knowledge, have as often been designedly led astray by the mis-statements of the practical men whom they have consulted, as by their personal ignorance of the art and practice. Another class of writers, possessing neither theory nor practice, have merely dressed up the opinions of others in their own verbiage, or have garbled them by a twisted misunderstanding or misinterpretation of their true import; and too frequently they have adopted the precise words of others, without deigning to acknowledge the obligation or the fact; so that from one or other of these causes, the brewery has derived no great deal of benefit from books; though

> "Each might his several province well command,
> Would all but stoop to what they understand."

On the other hand, the few works that have emanated from practitioners, are deficient of scientific theories and popular deductions, or the most valuable parts of their evident knowledge have been studiously withheld from the publications, and consequently from the public, and made obtainable only by private communication; so that in either case, something of ignorance or imposition, presumption or finesse, exists and betrays itself:—but, there are *a few* exceptions.

Lastly, among the writers of brewing treatises must be enumerated a class who overrate the value of their ideas and scientific pretensions, and who delight to soar above their less fortunate brethren, by demanding a price as the value of their understanding, such as none but persons in affluence can afford to give: here is a deficiency of philanthropy or an excess of avarice in the individual, which distinguishes him from the race of authors, much in the way that a pagan nabob would single himself out from a herd of common Christians.

To which of these classes the present Author belongs, he is not aware: perhaps not to any of them, because his wish has been to leave nothing unproved which the sacrifice of time, or capital, or health, or favour, could bring to bear; and this must be the veritable apology for his prolixity. He has occasionally indulged in a brief poetical flight of other men's fancy, and has backed it by his own; but he has given it merely as a cheering ray in the midst of a wet subject, where it has seemed to require a pause by way of relief; like a pinch of snuff, or a gust of fresh air to a traveller in a desert.

Having, too, *en passant,* described the properties, and clearly and fully explained the nature, of each of his inventions, and having so minutely detailed the most important views entertained by others in both the practical and the scientific world; little more can be expected from him than to lay down his pen and reflect; but he has yet a trifle to add. The idea of a new book, especially if a large one, though very startling to a reluctant schoolboy, is not so to the man who has been schooled to read and meditate, teach and be taught. As regards brewing, nothing but the absolute renunciation of malt and hops can, in the ideas of some whose capacity is narrow, require further interference in authorship; for they have, say they, as many "brewing books" as will fill a wheelbarrow; and what is a book to them but a book? He flatters himself, nevertheless, that he has accommodated that class of bibliopolists, by showing to them the real possibility and practicability of dispensing with malt, hops, and barm,—all three;—and has only to refer them to pages 28, 203, and 356; for though malting is an useful preparatory process, it does not follow by any means, that such process is a *sine quâ non*. Look, for instance, at Ham's system of brewing from potatoes, and of employing the pauper children in the workhouses to grate and prepare the fecula, (Ham, pp. 74-6,) an idea which, by the way, the writer presumes, must be exceedingly grateful to the sensitive and lively feelings of Her Majesty's Poor Law Commissioners.

In showing what is practicable as one thing, and what is profitable as another, he has been seriously anxious to recommend such alterations as are useful, whether the inventions be his own or not; for as science advances, new interest in literary and mechanical productions is constantly excited and perpetuated; and perhaps it is this fact, aided, probably, by a little curiosity, that must account for the rapid sale of the present work, rather than any real and intrinsic merit which it possesses. Thus encouraged, however, he makes his preparations for a *second edition*, and while he thanks his present subscribers, he hopes and imagines, with some little confidence, that if the work does not exactly merit their approbation in every respect, it will not produce disappointment or dissatisfaction in the mind of any of them.

PREFACE

TO THE

SECOND EDITION.

Subsequently to the appearance of his former edition, the Author has been accused of having introduced technicalities and chemistry into his work, and he considers the charge to be somewhat oddly preferred; for, with regard to the former section of it, he is at a loss to conceive how a technical undertaking can satisfy, when deprived of its technical diction; for it must naturally resemble beer from which the alcohol has been abstracted, the one being thereby rendered too stale for the reader, the other too insipid for the drinker, and both altogether lifeless and dull.

Again is the promised volume of the magnitude by many thought bulky; for though it contains less of quotation, and many of the minor and less practical observations contained in his maiden production are here omitted, much new, curious, and valuable matter will be found herein, which an appeal to his Index, as an analysis of facts and observations, will fully testify; and it must be evident that many of the subjects cannot be curtailed without spoliation; and with respect to compilement, the writer trusts that the ample scope which he has afforded to the merits of others in displaying the novelties of their several inventions, where in coincidence with his own views, will exonerate him from the grievous tax of concealed plagiarism on the sinister hand, and from the galling burden of self-conceit and egotistical gratulation on the other, and in some measure atone for the protracted appearance of his pages. Indeed, some small items enumerated in his prospectus have, on more maturely weighing them, been purposely omitted, among which, in particular, is "bottling;" a subject too devoid of art or interest to deserve any peculiar attention. Compensation for these trivial omissions is amply made in the new matter which is inserted gratuitously, and without prior notice.

With regard to chemistry, which some pronounce to be "too scientific for practical men," the Author must beg to dissent in his explicit opinion from any doctrine so vaguely inconsistent. In all spheres and stations of life individuals may be encountered, the ability of whose thought and action is not competent to qualify them for the post they are intended to occupy, some of whom bask as securely in the connivance of interested friendship and undue patronage, as others will thrive through the indifference or ignorance of their principals; and to such as these does science appear as criminal as its attainment is formidable.

Many operative brewers, some of them in a few of the largest town establishments, even now ridicule and despise the idea of chemistry being in any way connected with the art of brewing. Such instances of misapplication in men's services are but melancholy subterfuges, inasmuch as they act injuriously and unjustly on a better class, by excluding them from offices for which their superior talent exclusively befits them; and besides, this reckless mode of appropriation perpetuates vain bigotry and an enormous waste of property, all of which the enlightened and cultivated mind would studiously avoid; and thus the progress of the useful arts is impeded, and their promoters are ungenerously maligned by a dark spirit which knows not the limited range of its own chaotic capacity. Better far would it be for business, were such obstructors returned to the wash-house, or transferred to some other more congenial vocation, than be allowed to deceive and injure their employers and the public, and continue to misrepresent and deride their superiors, merely because "their capacity is too limited to understand one-half" of that which is addressed to them for their own good.

Surely brewers ought not to be less intellectual than farmers. Let those who are self-sufficient enough to scorn the idea of the necessity of chemical improvement run through a few modern books, subscribe to a periodical or two, attend a series of lectures on agriculture, read the farmers' newspapers, peruse the "Journal," &c., visit their public halls and reading-rooms, inspect their newly invented machines and implements, their improved and scientifically arranged homesteads, well-tilled lands, and luxuriant crops; and if then their own convictions do not cause them to blush, they must really be unaccountable creatures. Let such reflect that the time has long since arrived when it is necessary that mere manures should be analysed, and their components minutely advertised, to enable the husbandman to purchase according to his especial purposes; for nothing but his newly acquired and inestimable knowledge could ensure the right application of any particular compost, to suit it to the nature of the soil and of the seed to be sown within it. That person must be most obdurately deficient in judgment who cannot, after such free enquiry, pronounce science to be a progressive vehicle, and that, too, the most powerful ever introduced to civilization. The universal and important application of chemistry must ere long force itself upon the convicted minds of the people, and, through their instrumentality, upon the attention of government, till within the course of a very few generations this branch of the sciences will, with others, be cultivated as generally by all classes as writing and arithmetic now are; indeed, a youth's education is not at present considered complete without some smattering of the art.

The precarious state of the Author's health, and the expediency of personally superintending the erection of his patent machinery in various places, have caused some little delay in the bringing out of this edition; but he imagines that the appearance of his smaller work, the "Voice from the Mash-tun," in the commencement of the past summer, relieved the anxiety of some of his friends respecting the success of that important feature of his solicitude, and obtained for him the patience of others, for which he hereby thanks them; and he hopes that this plain statement of circumstances, unavoidably true, will appease any apprehension of their censure which he may have entertained. On other topics to which his original preface referred, he will now be silent. As an author, he is fairly before the world ; and as an inventor, he knows the range to which his principles have been carried into action ; but in neither capacity has he any desire to be bombastic. If his apparatus are accurate and their results steady, and if he continues to be honoured by the testimonials of first-rate men in his profession, the issue will be sufficient within itself to supersede the use of boasting on his own part. His object from the first and throughout, has been to make himself useful to society by means of new discoveries calculated to benefit the community at large, and to commit his errors in thought or practice to correction by future experience and improvement; being well assured, that as his theories become old, his practical operations will be modified by the wisdom and skill of others, and both will be bettered accordingly, as the progress of knowledge follows the dictates of expanding art, befitting the intelligence of a judicious world, brightened by gradual cultivation. With this prospect he has recommended such alterations as are useful, attainable, and profitable, whether his own or not, in order to posite a step in the staircase of literary advancement, to be repaired or reconstructed as new interests in scientific or mechanical productions become excited and perpetuated.

For the edification of young beginners, a copious Lexicon has been appended on derivative principles ; and the tables which were composed for the first edition have been carefully revised, most of them remodelled, and several new ones added, on the presumption that they are truly serviceable ; and the analyses and specific gravities of bodies, which are of the first consequence in practice, have been reconsidered and compared with the expressions deduced by the highest and most recent standard authorities, and adjusted accordingly. Saccharine juice, in particular, a substance long held in doubt and dispute, has claimed much of the Author's vigilant attention; and his conclusion has been deliberately formed, and can scarcely be deemed extravagant, when it is admitted that a cubic foot of sugar-loaf, which is not a perfectly compact solid, has been determined to weigh 1606 ounces; which countervails all arguments which would fix solid saccharum at any lower ratio; and surely it cannot be unreasonable, were more perfect proofs wanting, to allow an increase of 19 for complete densification. This being all that is requisite to be advanced in reference to particulars, he reposes his generalities, with some degree of confidence, in the hands of his impartial readers, thanking them for their attention, and his subscribers for their patronage and good opinion.

PREFACE

TO THE

THIRD EDITION.

NOTHING can be more gratifying to an author who seriously values his own reputation, than to be understood and appreciated, and to see his works pass through the market with a cheerful and steady sale; particularly when he is and ever has been determined to rely more on his own performances than upon high patronage and special privilege, and to seek his reward in the sound judgment of practical, discerning men: how greatly, then, must the writer of the present treatise value the estimation in which his former editions were held by a judicious portion of his professional brethren in town and country, amongst whom he has the satisfactory pleasure to enumerate a full third of the fraternity at large, many of them occupying comparative eminence in the trade, and enjoying deserved popularity in the ranks and paths of society! In short, the encouragement which he has experienced from time to time, has induced him, on each renewal of his occasion, to bring forth, as Oliver Goldsmith expresses it, his "best dish" for the edification of his admiring and obliging friends; for the plain deed of having sold his first impression of five hundred copies within six months from the dawn of publication, and his second edition, consisting of five hundred more, in the space of three years; besides finding a great number of his third five hundred bespoke before the day of its maturity has arrived, enables him to look back upon his undertaking with a degree of mental pride and gratitude.

Thus situated, and contemplating upon a demand which advances with considerably more celerity than in the preceding instances, he cannot in justice apply any other than his best skill and judgment to render the work as serviceable as his utmost ability can accomplish.

The Author would, therefore, as some token of his desire to impart a degree of toleration to his labours, have his readers to perceive, that in each republication he has not confined himself to a mere revisal of his former sentiments, or to a hurried recapitulation of his thoughts, for the purpose of giving a new spur to a subject which had exhausted his energies in the original compilement of its matter, as is much too commonly the practice of book-makers, who are ambitious to build their fame upon the number of nominal editions which they can palm into public view. Such a course would be quite inconsistent with the doctrine of *perfect mashes*, *thorough transmutations*, and *entire gyles*, which he has sought to establish on the abolition of inimical *sparges* and *returns*, and the supplantation of that tendency to acidity and staleness to which the working-up of old goods must decidedly contribute. Hence, in the preparation of his second imprint, upwards of two hundred pages of the first were removed, and more than three hundred pages of new matter were introduced; inasmuch as experience had brought many things into his view which, in his first essay, he had neither contemplated nor conceived; and, assuredly, an ample notice of modern improvements must at all times afford a greater degree of interest than the repetition of quotations from the opinions of predecessors, however wisely and eloquently they may have emanated.

Upon the same principle the present edition has likewise been devised and arranged, though with somewhat fewer innovations, yet with a greater measure of concentration, and a fuller consolidation of ideas. He has, therefore, expunged some copious references to the ingenious productions of others, which he formerly gave for *their* benefit, in total disregard of any personal advantage to himself, but, on the contrary, at considerable expense in the promulgation of that which did not individually concern him.

Exercising, then, his own reason, and relying on long experience and perseverance as bases of superior knowledge, he trusts that the volume now produced will be found to contain much additional information that may be willingly received and usefully employed. He has substituted some new matter of considerable consequence to himself and others, and especially to those who do not object to be guided by his arguments, and by the facts which he adduces: these, in the main, are such as necessarily and naturally arise to a person who is constantly accumulating a knowledge of his subject, through a daily increased connexion, and a watchful solicitude over the object in pursuit. The whole work has been most carefully revised and corrected, both by the Author and by other competent parties under his instruction, with as much vigilance as time would permit; his time and mind being now almost perpetually engaged in practical business, either in his manufactory at home, or in superintending the erection and operation of new Steam Plants in various parts of the United Kingdom.

Adverting to this subject with all the sincerity he is capable of entertaining, he may perhaps be pardoned for having taken opportunity to remark, in common with other observers, that the rapid pace at which the progress of invention moves forward, and the manifold and important changes wrought in the various departments of our mechanical powers, whether adapted to internal commerce, or to foreign and divergent intercourse, are truly surprising to all who attentively meditate upon their wonderful effects; and in few branches of industrial art has the influence of modernization proceeded more spiritedly of late years than in the management of the Brewery, where the steam engine is busily sweeping into oblivion the manual exercise of the oar, and is fast superseding the horse-wheel of former exploit in engineering; and where steam, as a vehicle of caloric, has found employment, to the expulsion of the furnace, and the abandonment of the dome copper, and almost to the renunciation of coppers of all descriptions, until these utensils have become nearly as scarce in the order-book as the stage-waggons and post-coaches upon the public roads, which delighted our ancestors by the easy and expeditious mode of transit they afforded; so that costly purchases, expensive erections, money-eating repairs, and purse-exhausting labour, are much diminished in respectable establishments, through the all but universal sovereignty of the mighty giant Steam. Even if the Author's exertions had not at all assisted in effecting this revolution, as he is persuaded that they have, he might still safely congratulate his patrons on the suppression of a grievous evil, whether his share in the compensation had been liberal or circumscribed, and equal to their generosity or not. At all events, be his auspices stimulative or restrictive, he enjoys the credit of having worked hard and well with due independence, earnest zeal, and a consciousness of having acted right in his endeavour to found a new circle of practice in a very important profession, upon principles that are now recognized by the reflective and studious portion of its members. In so doing, he does not hesitate to acknowledge the sacrifice of a comfortable fortune, together with many years of deep anxiety and laborious toil; and if his reward has been less productive in a pecuniary sense than a combination of circumstances once led him to anticipate, any disappointment which he may think himself entitled to feel is considerably mitigated in the heartfelt assurance that he has fearlessly and stedfastly performed the duty of his vocation, and has received the encomia and approbation of intelligent and well-informed men of all classes and professions, possessing a capacity to estimate literature and science according to their merits and imperfections.

PREFACE

TO THE

FOURTH EDITION.

In presenting to the public a new edition of this work, the Author, for the information of those who may now become acquainted with it for the first time, appends hereto the Prefaces which accompanied its three former editions.

He has only to add that the present edition has been carefully revised and corrected, under the guidance of maturer judgment, and that it embodies the results of much additional experience. It has been pruned of some exuberant leaves and branches, for which have been substituted a few engraftings of novel character, which add to its originality, and are evidences of its progressive spirit.

An invaluable addition has recently been made to the brewing plant. Lengthened investigations, and a long series of experiments, on the part of the Author, have resulted in the invention of a philosophical process, which,—by means of the simplest contrivance imaginable, namely, the floating skimmer, or "Octuple" apparatus, a description of which is given at page 412,—unites all the advantages, and avoids or remedies all the defects of all the usual methods of fermenting and cleansing. To the description of this process, and also to the new "BREWERS' REPERTORY," which is appended to this volume, the Author earnestly directs the reader's attention.

Youthful members of the brewing community are sometimes disappointed by finding that original treatises, like the present, do not give particular directions respecting every process and stage of the production of all kinds of malt beverage. Experienced men, however, know that so much depends upon taste, construction of plant, natural and local peculiarities, and other considerations of equal importance, that it would be impossible to frame any correct rule of the kind alluded to which would hold good in all cases, and which would not be more likely to mislead than to assist. The truth of this remark is illustrated throughout the following work, and especially at pages 131, 273, 480, and 511. In the present case, moreover, to have attempted to give such rules would have been foreign to the Author's design, and out of accordance with the title of his work.

This treatise originated in the invention of the steam brewing plant, particularly that part of it known as the "MASHING ATTEMPERATOR," of the merits of which machine the most satisfactory proof possible is afforded by the fact that pale-ale brewers repeat their orders for it, and prefer it before all other machines, in consequence of its fulfilling all the inventor ascribed to it, *without discolouring the worts, or endangering their soundness*, calamitous results which are inevitable when *stationary steam-pipes*, whether placed inside or outside the mash-tun, are used, and when the delicately nurturing worts are alternately heated and cooled, jumbled about, and pumped from place to place, during their saccharine conversion.

Each successive edition has announced some other novelty, either in mechanical invention or manipulation, but though all those have won the complete approval, alike of the best practical brewers and the highest theoretical authorities, none of them are of greater value than the cleansing apparatus, called the "OCTUPLE," to which the reader's attention has been directed, and the addition of a description of which constitutes the special peculiarity of this, the Fourth, edition of "THE THEORY AND PRACTICE OF BREWING ILLUSTRATED."

CONTENTS.

CHAPTER		PAGES
I.	Introduction	1—22
II.	Ingredients	23—58
III.	Malting	59—102
IV.	Water	103—128
V.	Mashing	129—169
VI.	Sparging	170—178
VII.	Saccharometry	179—209
VIII.	Hops	210—242
IX.	Boiling	243—268
X.	Cooling	269—284
XI.	Refrigeration	285—310
XII.	Ferments	311—340
XIII.	Rapid Fermentation	341—356
XIV.	Gentle Fermentation	357—369
XV.	Fermenting places	370—389
XVI.	Alcohol	390—416
XVII.	Porter	417—448
XVIII.	Exports	449—462
XIX.	Storing	463—483
XX.	Racking	484—498
	Appendix	499—503

THE

THEORY AND PRACTICE

OF

BREWING.

CHAPTER I.

INTRODUCTION — PRACTICAL BENEFITS — OLD NOTIONS — HISTORY OF BREWING — CURIOUS CUSTOMS — DERIVATIONS AND CRITICAL REMARKS — DISCOVERY OF DIASTASE — SCHEMES AND FAILURES — REMEDY SUGGESTED.

Solon, the Athenian lawgiver, who was one of the seven sages or wise men of Greece, taught his disciples the prudent maxim, "Know thyself;" and truly wise are they who know how to adopt his *dictum*, and adapt it to their own individual circumstances; for, as Periander, another of those venerable seers, says, "With industry, nothing is impossible." With these impressions stamped upon the imagination, we may also bear in mind the words of our own countryman, the immortal and philosophical Locke, who observes, in his Essay on the Human Understanding, that though "no man is under necessity to know every thing, yet, they that have particular callings ought to understand them." Sentiments of this nature deserve the utmost regard; and hence it is that the author and compiler of this treatise, excited by a desire to pursue a task enjoined by the inspiring manifestation of courageous zeal, and having his mind stamped with deep impressions, received within the course of twenty-five years, during which he has been practically and extensively occupied in the superintendence of Breweries, has studiously endeavoured to possess himself of adequate ability to fulfil his engagements, and to impart practical and rational information to others. How far his efforts have been successful, the following pages are intended to show, especially to such as may be disposed to doubt the reality of that share of public approbation which already has arisen from his exertions.

Her Majesty having granted him her Royal Letters Patent, for the introduction of his several inventions to facilitate and improve the Art of Brewing; he calls the attention of society, and especially of Ale and Porter Brewers, Distillers, and Vinegar Makers, to the various instruments that he has invented and successfully introduced, and that constitute, in the opinion of those who work them, a series of machines, implements, and utensils, of the greatest possible benefit to THE TRADE; and he sees the necessity of upholding his Patent-right by protecting all who favour him with their orders; and of detailing, for general instruction and public satisfaction, the principles that he has acted upon in accomplishing the means by which each respective portion of his apparatus completes the purpose that he has had in view while attending to its especial department in the establishment. Many sleeping partners and young practical brewers, may require necessary information to a certain extent; and the opinions of more experienced men following the "copper side," backed by the doctrines of chemists of standard celebrity in the scientific world, may be of real service to others, whilst they are acceptable to him as corroborative evidence of the utility of his system, now completely reduced to practice through the completeness of the mechanism which sustains it. For his own part, the testimonials which he has attached to his former editions, added to his own knowledge of the quantity and quality of extract produced by his own machinery under his own eye, and by others who employ it, completely convince him of its extraordinary powers; and no other guarantee is wanting firmly to determine his own mind to continue and extend the principles that he has wrought out.

Still all demonstration is useless, unless it be powerful enough to displace hastily-formed prejudices, or to remove from the conviction the effects of former and weaker evidence. The remark has been made, that practice without theory is like music without notes; and it is the discord and confusion of ideas that is now sought to be rectified in the Brewery: consequently the task, however arduous, *must*, and the author flatters himself that it *does*, accord with correct principles, which require to be kept in harmonious order.

Although his apparatus and its effect are open to inspection and inquiry, wherever erected, and though he might content himself by reference to the several establishments where it is at work, for a clear comprehension of its merits, (and such a short course might, in a pecuniary sense, afford immediate and ample satisfaction to some inquirers,) yet, in a state of society like the present, when philosophy and trading enterprise travel rapidly round and through the land, and when the demand for scientific aid is loud and peremptory throughout every branch of the arts and manufactures, the act of withholding theoretical and useful information from a thirsty world, would be as criminal as the publication in darker days was dangerous; and were the exposition of the wonderful merits of the lately detected substance called DIASTASE the sole motive for the present author's intrusion on a reading and thinking community; that alone, as a means to an important end, would lead him to the task of fully and fairly developing its properties to the Brewer, whose trade, as a science, is but in its infancy, though there were Brewers in Solon's day, 2400 years before the present critical generation sprang into activity.

Many are forward enough to observe, and perhaps to contend, that the ideas of persons who have written on this old subject cannot be new; and the doctrine is good as far as it goes; but new men have novel notions —perhaps not altogether founded on any that have had prior circulation. Another well-received opinion, because anciently held as a good dogma, was, that though all things may change, nothing is new; which is equivalent to saying, that a man never wears a new coat. A few brief questions will settle the absurdity. Is the patent Hot Masher new? Can the invention for which it was granted be otherwise than new? Are its purposes unchanged from old practice? Is Diastase a new discovery? Is a lymphine fermentation in wort an old theory, or any portion of one? Is the transmutation of mucilage into beneficial and pure saccharine matter new? Is the conversion of starch, hordein, and hops, by steam, and the salvation of the essential oils, new? Is the *desideratum* of a constant temperature new in practice? Is an additional saving of 5, 10, or 15 *per cent.* new? These are points for examination and reflection, notwithstanding the saying which has existed from time immemorial, that "any old woman can brew;" which is no argument to the purpose; for so could the Armenian matrons, in their little way, before Socrates was born.

Still, however, dames can brew; though when we meet with thousands (not to say millions) of barrels of beer quite unfit for drinking, we do not thence conclude that every old woman is fit to brew, and much less that the generality of such women can brew perfectly, or at all advantageously.

Few old women are chemists; fewer chemists are brewers; and fewer still are the brewers who, by attention to chemical transformations and chemical constituents, have been able to increase the quantity of the useful extract from malt, and to reject the errors, both in theory and in practice, that eventually reduce the labour of the old-woman brewer to futility and loss.

Gr. Οἶνος (Oinos), Lat. *vinum*, Eng. *wine*, and Κρίθινος (Krithinos), *hordearius*, barleyan, from the root Κρίθη (Krithee), *hordeum*, barley, are the two words used by Zenophon, who died B.C. 359. Dr. Thomson, who refers to the Euterpe of Herodotus, c. 77, for the above account of the Egyptians, adds, that, "in the time of Tacitus, whose treatise on the manners of the Germans (*de Moribus Germanorum*, c. 23) was written about the end of the first century of the Christian era, beer was the common drink of the Germans. Pliny (Nat. Hist. lib. xxii. c. 25) mentions beer as employed in Spain, under the names of *cœlia* and *ceria*, and in Gaul under the name of *cerevisia*." He then proceeds to explain, that "almost every species of corn has been used for the manufacture of beer. In Europe it is usually made from *barley;* in India, from rice; in the interior of Africa (according to Mungo Park), from the seeds of the *holcus spicatus*" [spiked or bearded wall-hardy.]

Some of these observations are borne out by other authors of antiquity; and the *cerevisia* of Pliny evidently takes its name from *Ceres*, the goddess of corn, —lexicographers doubting whether it ought not to be written *cererisia.* Plautus more minutely calls it *cerealis liquor;* that is, liquor used at the "*harvest home*, or solemn feasts in honour of that goddess;" and both he and Columella, a famous writer on agriculture, who flourished in the reign of Claudius, and consequently whose work is coeval with the invasion of Britain by that emperor, called this liquor *zythum*, which, if we trace it to its Greek origin, is there written Ζύθος (Zythos), and is interpreted by Schrevelius thus: "*Potus ex hordeo cerevisia:*" DRINK FROM BARLEY; and he works out the derivation from Ζύμη (Zumee), *a ferment*, which again descends from Ζέω (Zeo), to *seethe* or boil, and hence also our word *sea.*

BARLEY.—That barley, the *hordeum vulgare* cultivated in Britain, was known to the Romans, is evident from Virgil, who uses it plurally, *hordea*, as we do the word *oats;* and Pliny tells of the *hordearii gladiatores*, a kind of fencers, whose sustenance was *barley.* Authors again write, that when the Romans were in Britain, they found there a species of *wine* made from this kind of corn, by the aborigines called *baer*, which in excellence of flavour and quality surpassed all the wines of Rome. Hence, though they possibly mistake Britain for Germany, the English word *beer*, and its ferment, *barm*, with an oriental termination; but the latter part of the word bar-*ley* relates to the field in which it grows, rather than to the corn, and is purely Anglo-Saxon; and certainly Cæsar found little of the *cerevisia* here; for he says (Bel. Gal. iv. 14), "Interiores plerique frumenta non serunt, sed lacte et carne vivunt." (*The more inward for the most part do not sow corn, but live on milk and flesh.*) Whatever, therefore, the Roman soldiers found, was necessarily in small space, and with due deference to them in the sense of taste, was perhaps as nectareous as that which modern topers term "dipup," "bastard vinegar," or "whistle-belly," of which, they say, he who has the most has the worst share; for though it might have been "*potus coctus*" (cooked or boiled drink), and bears, as such, the flavour of antiquity, it had nothing in its nature partaking of modern brewing principles, or that emanated from such, however fine and choicely *bouqueted.* Custom is not always easily accounted for. The Britons drank mead till the introduction of agriculture by the Romans, and many are the encomia passed upon it in the songs of their bards; but the Roman farmers undoubtedly found the soil suitable to the growth of barley, on comparing it with the lands of Gaul and Germany, which they had visited in their progress. A record of brewing in the fifth century says, that the grain was then steeped in water, made to germinate, and was afterwards dried and ground; after which it was *infused* in a certain quantity of water, and then fermented, when it became a pleasant, warming, strengthening, and intoxicating liquor; and that it was commonly made from barley, though sometimes from wheat, oats, or millet. This is all that we know of the Romano-British brewery. Leaving, therefore, the Roman arts and the Roman glory to take their spread over a conquered country, as civilization matured and good faith became mutual and common, we come to the days of the Saxons and Danes, who butchered and caroused here during the space of 617 years, or from 449 to 1066.

ALE.—The learned Camden, in the Derbyshire of his Britannia, says that *Ale* is from the Danish word *oela*, not, as Ruellius derives it, from *Alica*. "The Britons," he adds, "called it *cwrw*, for which we have in Dioscorides the corruption *curmi*, a liquor made of barley. This, our barley wine, which Julian the Apostate smartly calls in an epigram Πυρογενῆ καὶ Βρόμον οὐ Βρόμιον, q. d. corn made of wheat and oats, not the liquor of Bacchus. It is the ancient and peculiar liquor of the English and Britons, and at the same time the most wholesome."

In a work entitled "Domestic Life in England," we read, that when the Saxons inhabited these regions, they drank mead and *ælle* as their common beverage, using wine only as a medicine or a luxury. From this word *ælle* Dr. Johnson derives the more modern *ale*, which is still pronounced *yell* or *yal* in the northern counties, where many relics of Saxon manners, customs, and language remain; but *ælle* signifies *universal*, whence *all;* and ale seems to have been held in general request among that people. Ina, who was king of Wessex from 689, names the beverage *ælle* in his laws, which restrict the use of it; and by a law laid down by King Edgar the Pacific, who died in 975, the huscarles and guests were limited to half a pint at each draught, and tankards were made to hold two quarts each, having pegs fixed one above another at proper distances, dividing the measure into eight equal portions, and certain punishment was inflicted on any one who drank beyond his peg; but when the surface had subsided to the centre of it, he handed the vessel to his next companion. When the Danes had possession of the country, they were most immoderate sots; and when a Saxon and a Dane drank out of the same bowl, each was *pledged* not to stab the other while drinking. This ale was fermented like their mead, differing from it only in being extracted from mongrel malt instead of honey-comb, and tinctured with herbs. In their revels they entertained harpers, gleemen, jugglers, and tumblers, who also frequented guest-houses and *ale-shops*, in which women were the brewers; and even till as recently as the reign of Edward III., if a man attempted to bake, brew, or dye, he was considered an innovator. Chester ale seems to have been in great repute; for the Danes decreed, that any inhabitant of that city, brewing bad *ale*, should be placed in a ducking-chair and plunged into a pool of muddy water, or should forfeit four shillings. In the time of Edward the Confessor, mead sold at 16*d*., spiced ale at 8*d*., and *common* ale at 4*d*. the gallon; but we are not told what kind of spice they used.

Brew.—Most of our domestic words are derived from the Anglo-Saxon language, and particularly such as contain a *w*, that nation having introduced this letter into the island, though, according to Johnson, the word *brew* is of Dutch origin, and signifies to *cook;* and we find that with the ancient Romans a Brewer was designated *cerevisia coctor*, or *cooker of beer*. That eminent chemist, Dr. Thomson, says, in his section on Vinous Fermentation, that "under this name is comprehended every species of fermentation which terminates in the formation of an intoxicating liquid. Now these liquids, though numerous, may be comprehended under two general heads, namely, those which are obtained from the *decoctions of seeds*, and those which are obtained from the *juices of plants*. The liquids of the first class are denominated *beer* or *wash;* those of the second *wine*." Here are two more brewing words, each beginning with *w;* and a third is *wort*.

Mash.—As to *wash*, which the Saxons would write *wæsh*, or perhaps *wæsc*, its general termination, *ash*, implies something loose, as *mash*, *lash*, *smash*, *crash*, *sash*, *fish*, (*fisc*,) *desk*, to *ask*, and the *ash*-tree, which grew detached from the group of the forest. *Mash*, which

Johnson takes from the Dutch *masche*, has something extensive implied in its initial letter, and so have *marshes*, *marches*, and the *meshes* of a net; and a *mash*, whether of culinary vegetable roots or of malt, is synonymous with a comprehensive *mass* or *mess;* and the mode of *cooking* such a mass by *soak* or semi-distillation, which is a way of nursing it into solution or digestibility, is *brewing* it, whether performed in a mash-tun, a tea-pot, a vegetable steamer, or if it be a collection of soluble vapour concocted in a cloud on the mind. Such is the plain meaning of the words *mash* and *brew*, with which most good housewives are practically acquainted in one way or other.

Malt and Wort.—These words also are Anglo-Saxon. *Malt* signifies any thing *malled*, being a mere curtailment of the word, as *wort* is of *worked*, and scores are like them. In the old herbals, descriptive of plants that were brewed into medicinal *drinks*,—which word *drink* is also Saxon, importing the act of imbibing, as well as the matter *sucked* in; and which kinds of drink were much used anterior to the introduction of hops and malted barley,—we read of ragwort, spearwort, spleenwort, and crosswort, all so called from the shape or position of their leaves; and of mugwort, figwort, and moneywort, from the structure of their seed-vessels; while pilewort has its title from the resemblance of its roots; bloodwort from the colour of its leaves; and some have their names from the effects they produce, as sopewort, pepperwort, butterwort, and sneezewort; but more from the efficacy ascribed to them in curing various diseases or infirmities of the human frame, as lungwort, liverwort, rupturewort, barrenwort, birthwort, motherwort, goutwort, bladderwort, stammerwort, throatwort, and woundwort; and some were pre-eminently dedicated to their titular saints, as St. John's, St. James's, St. Peter's, all in consequence of the virtues they were said to possess when put to *work* within the human or other animal body; and surely *staggerwort* must have been as potent as any.

To proceed to the history of the wort prepared by the brewer to *work* in the fermenting vat, and those "decoctions of seeds" by which it is produced: the Saxons and Danes were no great improvers, and consequently we may infer that the art continued with them much in the same rude Britico-Armenian state in which they found it, especially as the Normans did not stumble over any brewhouses or malthouses when they compiled the "Dom Boc" or register, though where they met with a *molin* (or miln) they valued and booked it; nor were the English likely to exert themselves while under the Norman subjugation, which lasted till the signing of Magna Charta in 1208. In fact, the Normans reduced the Danish gluttonous habit of four heavy gormandisings a day, to two abstemious meals; but it is recorded of a certain bishop of Ely, in the reign of Henry I., that his table was replenished daily with "all sorts of beasts that roam in the land, of fishes that swim in the water, and of birds that fly in the air," and with beverages of French wine, spiced mead, mulberry hypocras, pigmait, claret, morat, cider, perry, and *ale;* and we also learn that in the days of Henry II., whose two meal-hours were nine in the morning and five in the evening, his richer subjects regaled on wine and mead, but the poorer class drank cider and *ale.* In the reign of Henry III. the price of ale was regulated by that of corn and wine, and the women who brewed it sold it at a penny a gallon in the cities, and at the rate of three or four gallons for a penny in rural places.

Beer.—Louvres.—Whether some alteration took place about this period in the mode of brewing, or whether malting was commenced upon a new and enlarged plan, it may be difficult to say; but many novelties were now introduced from abroad, and the wings of commerce began to expand. A brewhouse or malthouse ventilating blind is called a *louvre*, which is a Norman word, and consequently not of recent introduction, but seems to have come with the influx of improvements, though the brewers may have borrowed it from the tanneries. The old British word *beer* was also revived in this or the following reign, and seems to have superseded the ale of Saxon, Danish, and Norman make; for in the 17th of Edward I., *anno* 1289, amongst the charges for a man of rank travelling from Oxford to Canterbury with a retinue of six attendants, are sixpence for *beer* and a halfpenny for apples, whence we may presume that they had "lamb's-wool" for supper, and that the master was an ecclesiastic. On the following day, which was Sunday, is a charge of 12*d.* for *beer* "for my lord at Westminster, when he held a breakfast there for knights, *clerks*, and esquires," besides "two gallons of *beer* for the boys, 2*d.*" Edward III., after passing a severe law to restrain eating and drinking, gave an entertainment of thirty courses, called dinner, at nine in the morning, the fragments of which fed 1000 poor people. We have no account of the drink consumed; but after dinner they had confections of cloves, cinnamon, grains of paradise, ginger, &c., for dessert, which shows the kind of condiments to which the spicers and adulterators of those ages had recourse.

Under Richard II., malt liquor was drunk at breakfast-time; and that king, in 1389, gave a housewarming to 10,000 guests in his new hall at Westminster, which he had rebuilt, and where he kept Christmas, the breakfast consisting of boiled beef, sprats, herrings, brawn, bread and butter, mustard, malmsey, wine, and *beer*;

and this kind of fare then became common among the gentry, the monasteries grew into great note for their superior brewing, as did the colleges after them, and men had become brewers, having taken pattern from King Richard's 2000 cooks. In 1421, one William Payne, of the Swan, in Threadneedle-street, London, refused to send a barrel to Henry V., then in France; and report says, that in the following year the celebrated Whittington, who had been lord mayor in the last year of Richard's reign, 1398, informed against the Brewers' Company for selling their *ale* too dear, and had them fined 20*l.* by the lord mayor then in office. From this time aleconners were appointed to inspect the measures; and two years afterwards, being the second of Henry VI., the company had grown to sufficient consequence to be incorporated. In the reign of Edward IV., at the installation of Archbishop Neville in the province of York, among other extravagances enumerated, were 300 tuns of ale; and Edward himself gave breakfasts of bread, salt fish, and *ale*, to his nobility, at seven in the morning, dined at ten, and sat three hours, with a side table appropriated expressly to wine and ale, which were handed to the guests in goblets of pewter, wood, or horn; supper was served at four; and at nine, lords and ladies had *liveries*, or collations, with a gallon of *beer*, and a quart of warm spiced wine to each; and there appears to have been a difference between the *ale* with which they broke fast, and the *beer* on which they supped.

Brayley, in his "Londiniana," vol. iv., informs us, that in the churchwardens' accounts of Allhallows Staining, in London, in which Ironmongers' Hall stands, is the following entry, made in 1494: "Payd for a kylcherkyn of good ale, wyche was drunkyn in the Irynmongars' Hall, all charg's born, 12*s.* 2*d.*" It must have been *truly* good; for the same author has also discovered a bill of fare for fifty people of the Salters' Company, dated 1506, and preserved as a record in the waiting-room of their hall, in which one of the items is, "1 kilderkin of ale, 2*s.* 3*d.*"

The great earl of Northumberland, in the time of Henries VII. and VIII., who had a family of 200 persons, allowed each of them a quart of *beer* and another of wine to breakfast every morning at six, and another of each to dinner at ten. Meat, drink, and fire, were then calculated to cost 2½*d. per* head daily; and malt was sold at 4*s.* the quarter, which brewed two hogsheads.

Breweries.—No deal of sagacity is requisite to perceive that these establishments sprang up, though not of such magnitude as at present, when men began to take the trouble of brewing off the hands of the women; for if there had not been a number of breweries in 1422, Whittington had not turned informer against the company. In the fifteenth of Henry VIII., alderman George Monoux was elected mayor of London, and fined 1000*l.* for "neglecting to appear after being divers times called upon by letter and otherwise," and next year, "on his petition and bill of supplication alleging his great age and feebleness, and offering to give *a brewhouse adjoining to the bridge-house in Southwark* to the city, in consideration of being discharged from the office of alderman, had the decree against him revoked, and his request granted, on some special conditions." At least, therefore, "Barclay's" has existed more than 320 years, as the occurrence took place in 1524: the precise year in which the old distich tells us that

> "Turkeys, carp, *hops*, pickerel and *beer*,
> Came into England all in one year;"

that is, beer of a new sort, qualified with hops, which opens a new chapter in the chronicles of the Brewhouse.

Ale and beer, though in some places named synonymously, and in others indifferently, certainly never signified the same thing at the same time, though each may have changed character. *Ale* was the stronger of the two before this change of bitter, as it now is, in some places, though not in the same sense. It was then a strong extract fermented without hops; but *beer* was a revived word, as before noticed, appropriated exclusively to liquor obtained through the application of the hop. In and around London, at the present day, "beer" signifies porter, and "ale" is the paler production of the brewery, as exemplified in the light bitter article brewed for foreign consumption. In the southern and western parts of the kingdom, and in other country districts, "beer" is strong old ale, and "ale" is a weaker, fresher, or milder beverage. About Manchester, *ale*, distinguished from porter, is termed *beer*, and the stronger the more so; whereas in some parts farther northward and eastward, *ale* is brewed from malt, and *beer* from treacle; so that the thirsty traveller must conform the language of his desire to the district in which he chances to alight.

Lance, in his "Hop Farmer," published in 1838, has the following explanatory document from a curious old book by Reynolde Scot, dated 1578 (20th Eliz.): "The hoppes shall be wholesome for the body, and pleasanter of verdure or taste than such as be disorderly handled. You cannot make above viii or ix gallons of indifferent ale out of one bushel of mault, yet you may, with the assistance of hoppe, draw xviii or xx gallons of very good beere; neither is the hoppe more profitable to enlarge the quantity of your drinke, than necessary to prolong the continuance thereof; for if your ale may endure a fortnight, your beere, through the benefit of the hoppe, shall continue a moneth; and what grace it yieldeth to the taste, all men may judge that have sense in their mouthes; and if the controversie be betwixt beere and ale, which of them two shall we place in preheminence, it sufficeth for the glorie and commendation of the beere, that here in our own countreye ale giveth place unto it; and that most of our countrymen doe abhorre and abandon ale as lothsome drincke; in other nations beere is of great estimacion; and of strayngers entertayned as their most choyce and delicate drinke; without hoppe it wanteth its chiefe grace and best verdur."

In the grand carnival, when Robert Dudley entertained the queen at Kenilworth Castle in 1575, the *ale* there consumed was 365 hogsheads, the value of which at that day, according to Holingshed, was five gallons for a shilling; and in 1586, when the queen of Scots was confined within Tutbury Castle, the conspirator Babbington, of Dethick, contrived to convey letters to her through a chink in the wall, the messenger being a brewer who supplied the house with *ale*. At that time Derby, whence the brewer probably came, had acquired a celebrity for its provincial produce which its neighbour Burton retains. Brayley notices it as a favourite beverage in the metropolis; for Sir Lionel Rash, in Greene's pleasant comedy of "Tu quoque," says, "I have sent my daughter this morning as far as Pimlico for a draught of Derby *ale*, that it may fetch a colour into her cheeks:" a proof that this hilarous beverage was accounted medicinal.

This, then, is the history of the brewery through embryo into life: all the rest has been growth. The mash, the hop, the working, &c., as general subjects, will be found more fully handled in their appropriate chapters; but here, be it observed, that if a bushel of malt would produce twenty gallons of good sound beer, or *ale* as it is now called, as early as the sixteenth century, and would keep a month on tap, it is much more than can be said of most ales that are brewed in the nineteenth; so that the brewer's art has not made great progress since the former period, notwithstanding all the books that have been written concerning it, and all the contrivances, whether inventive or alterative, that have been introduced to amend the process, though many are excellent in their way. The Elizabethan economists had in view flavour, quantity, quality, and preservation; and with these united, that *summum bonum* of industry's desires—profit. If, therefore, brewing were as simple and unprecarious as some are willing to imagine, the author has a shelter for his essay in the wing of the great Herschel, who, in his discourse on the study of natural philosophy, says: "To the natural philosopher there is no natural object unimportant or trifling: from the least of nature's works we may learn the greatest lesson." Thus it is with the brewer: his taps, his rolls, his heats, his yeast, his fermentations, his every thing, demand the nicest care; and even the misplacing of a bung or a vent-plug may involve him in serious consequences; and the sustentation of the action of diastase in a state of solution, is an art within itself that never yet engaged the attention of the old women of philosophy: it is the discovery of the French and German men of science, at whose schools none of our countrywomen, and few of our men, have matriculated.

The mere mixing and stirring of malt with heated water, without regarding the true principles of the art, may be called mashing; and this may suffice with many who brew, though it may lead them into hot water uncoolable. But the intelligent brewer takes into consideration the colour of his malt, its former situations in the field and the rick or barn; where possible, the quality of the land on which it grew, the mode of malting it, and other particulars; and having considered the relative value of his samples, he has regard to the strength, flavour, and general qualities of the potable extract to be made, and the locality of its subsequent destination; he also watches, with particular care and anxiety, the temperature of his solvent liquors, and the chemical change which is to take place in the organs of the bruised or broken grain when in contact with hot water. The many varieties of colour and constitution in malt liquors demand from the brewer an equal diversity of varieties in the mashing heats; and the most skilful in his profession is frequently, through the temperature of the atmosphere alone, and often from other causes, prevented from mashing at the exact heats, which, from experience, he knows to be proper. His daily observations, and consequent gradually enlarged knowledge, most probably point out to him the paramount utility of the mash-tun thermometer, by which he ascertains the period when the lowered heat of the goods compels him to "set tap;" and he knows that the smallest mashes require the greatest limitation of time; yet, great as all his advantages may be, they are susceptible of very great increase, which to him is a consideration highly important; for another circumstance, which ever exists in connexion with the first part of the process, and over which he has no more controul than his most ignorant workman, is his inability to increase, maintain, decrease or vary at pleasure, the heat of the whole mash: a power which it is the first object of the author to give, by means of his invention.

The great difficulty, hitherto insurmountable, experienced in endeavouring to obtain all the most valuable contents of the mash-tun, and those only, has led to many schemes and experiments, most of which have utterly failed; and the rest are so far blended with anterior practice in their nature and working, and have proved so inadequate to the purposes sought, that the establishment of a more satisfactory system has long been anxiously and earnestly desired. A recapitulation of the disadvantages that are felt and seen by men of business, would be a positive waste of words: in truth, so dissatisfied are brewers with the peculiarities of each other, that not one of the methods yet projected has been thought worthy of general adoption; and the writer knows from his own practice, and from active correspondence in many parts of Great Britain, her colonies, Germany, and the United States of America, that the least objectionable plans hitherto adopted are, from the cause that has been named, so unsatisfactory in their results, that nothing short of a new *principium* is required in order to perfect the processes of mashing and fermentation.

The Germans are so sensible of the importance of a hot mash, or the dangers of one that is the least too cold, that they dip the first mash out of the tun, and place it in a copper; and when it is heated to their satisfaction, they transfer the whole mass to the mash-tun again, and finish the process of extraction nearly as it is done with us; but, notwithstanding the immense labour attendant upon this dilatory and slovenly process, they consider it far preferable to the ordinary English chance method.

Though the desirableness of preserving the heat of the mash is universally admitted, very few have had recourse to the only plausible arrangements that have presented themselves to their notice for that purpose; one of which consists in a double mash-tun, so constructed that the inner vessel or tub, containing the goods, may be surrounded with hot water or steam, contained within the cavity of the outer. This experiment has failed, because, if the heating medium were applied hot enough to affect the bulk of the mash, the outer parts of the goods would be overheated; and if the parts lying near the side were of the requisite heat, the gradual diminution of temperature from side to centre, would keep the latter too cold; and the existence of either too much or too little heat, will cause a comparative neutrality, instead of a converting action, among the most valuable principles of the grain, and will produce irreparable injuries in other respects.

Another plan which has been tried, and found unsuccessful, is the *admission* of steam through perforated pipes or valves, or its *circulation* through a continued series of pipes, *beneath the false bottom* of the mash-tun. This arrangement, though at first sight more feasible than the preceding, is still open to the same objection, namely, the extreme difficulty, indeed the absolute impossibility, of equally and readily diffusing the increased temperature of the goods nearest the bottom, through the mass, the most efficient mashing-machine being inadequate to the great task.

An instance of the danger of such experiments took place, not long since, at a large distillery near London, where a foreigner had been allowed, under pretence of effecting a great end by a little ingenuity, to introduce naked steam. The goods set, and the brewer was obliged to draw the little wort he could get, off the surface of the mash; for such were the coagulation of the albumen, and the pasty consistence of the starch, that the liquid could not percolate. The loss was serious, and consequently the project was abandoned. The fact is now established, that wherever or however additional stationary heat is applied, the goods in contact become in part set, and the surface or interior of the mash is acetified.

But though the promoters in general of the highly-essential object have been unsuccessful in their attempts, the accomplishment of their wish has been frustrated, not so much by the difficulties presented to the attainment itself, as by the inadequacy or unscientific application of the means employed; for had the experimentalists considered that caloric, in such a case, could only pass by transmission from particle to particle, and that all unmetallic fluids are bad conductors of heat, they would assuredly have preferred a contrivance such as that which is now, for the first time, before the public.

All bodies charged with surplus heat have a radiating and diffusive quality; therefore, they retain uniformity of temperature no longer than while they receive an uniform supply from other bodies in communication with them to replace the rays remitted to colder media, whether that supply be obtained from steam surrounding the sides of the vessel, or derived from submerged steam pipes. Now the present common system of mashing conveys the calorific principles, especially from the surface, much faster and much more freely than they are supplied from below, where the intensity of the heat is preserved by its greater density; and hence the comparative coldness and consequent sourness, so often and so easily perceived upon the long standing of the tap, notwithstanding such precautionary measures as a layer of dry malt strewn over the surface, and marked with a cross "to keep the witch out of the tub:" a superstition fit for the reign of James I., of demonological memory, and showing that in some places intellect has been halting. Curtains and covers, too, are frequently used, in reliance on their defensive or reflective virtues, though the heat will partially ascend through such coverings; so that the tun still remains in an unprotected state. Some surround the mash-tun with sawdust or other non-conducting substance; yet their difficulties exist as before, from their inability, as in the other instances, to controul the mashing heat.

The majority of common brewers are compelled to waste many quarters of malt annually; and the most economical and ingenious are the readiest to confess this general truth, knowing that they fail in their efforts to accomplish a perfect and sound extraction. This must ever necessarily be the case while they remain destitute of the means at the author's sole disposal; and they suffer incalculable loss from the imperfect mode of drainage, the extraction depending on the puny action of a variable stream of *water* (a plain word, which professional brethren will pardon, if occasionally used instead of *liquor*), trickling in its progress from place to place, visiting the inferior side, but not always the interior of the mash, and stealing its way through channels and cavities, between unbroken lumps, and without even entering the compressed masses that imprison large portions of the sweet. To prevent the loss arising from such irregularities and other occasional accidents, is one of the main objects of the improved apparatus.

The properties, uses, and advantages of these machines, upon which the action of the first part of brewing in a great measure depends, are explained herein; but, prior to this, the preparation of the necessary ingredients, and the rejection of noxious principles, must be considered as a preliminary and indispensable measure.

CHAPTER II.

INGREDIENTS.

EXAMINATION OF CONSTITUENTS—CHEMICAL ELEMENTS—NATURE OF SACCHARUM AND WORT—STARCH, GUM, MUCILAGE, GLUTEN, AND OIL—TUBERS, CORN, AND PULSE—FOOD AND PARTS OF PLANTS—DIVISION OF GLUTEN—APOTHEME AND OTHER MINOR PROPERTIES—USELESSNESS OF PULSE—CHARACTER OF ALBUMEN—WONDERS OF DIASTASE—NECESSITY OF MALTING.

THE Art of Brewing naturally divides itself into two branches or principal departments, which are,—1. Infusion, called *Mashing;* and, 2. Fermentation, more commonly termed *Working.* Preparatory to the first of these is the process of *Malting*, or reducing to a proper consistence by *Grinding* or Crushing; and to the second, the application and regulation of heat and flavour, by *Hopping*, *Boiling* or *Steaming*, and *Cooling;* and when the liquor has been fully brewed, it must be preserved by *Storing*, which has sometimes its attendant stage of *Racking.* The mode of performing all these several operations in the most efficient manner, is the subject at large on which this work is designed to treat, and clearly, if possible, to elucidate. The brewer has to examine the principles upon which these depend, because the virtue of the staple commodity employed in the production of his wort is dependent upon them: he has, therefore, to ask—1st, What is the species of grain or other substance which is best adapted to the production of saccharine and other profitable matter? 2nd, How is the quality of the best samples to be distinguished? 3rd, What are the characteristics of the fittest materials? And, 4th, What is the best mode of preparing them for the purpose of infusion, decoction, or brewing? The question is not precisely to determine the greatest quantity of absolute alcohol, or intoxicating spirit, (though that is inseparable from the solution,) but how to obtain the best and most of that nutritious constituent of wort, the *saccharine matter*, from which, in combination with other constituents, the alcoholic beverage is produced; though the quantity of alcohol it contains be a fair test of its superiority, and its presence a criterion of its preservative quality.

That all nations, ancient and modern, where liquor extracted from corn without distillation has been known, have produced it from barley, and that a rude mode of previous preparation similar to that which we term malting was known as early as the reign of Cyrus, appears from the authorities named in the preceding chapter; but whether such process is the best that can be followed, becomes a question for investigation; because, if we can reject this commodity, and adopt a better, we can claim credit from posterity; and if we see that the old course cannot be altered, we can only do our utmost to amend it, knowing that we have an immovable basis whereon to operate.

This leads to a review of the several kinds of corn, pulse, &c., usually consumed as food. Thomson has compiled from foreign journals perfect analyses of most kinds of grain, &c., ordinarily reared for the market, and has confirmed many of the results by experiments of his own. The following Table, collected from his works, and reduced to the centimal standard, purposely for this treatise, will show at one view, the constituents of which each is compounded. It may be necessary to premise, that lentiles are the *ervum lens*, vetch, or tare; and that mais is "the seed of the *zea mais*, or Indian corn, a native of America, but now reared in Italy and other southern nations of Europe. It was cultivated and much used in Peru before the conquest of that country by the Spaniards. They even knew the method of fermenting it, and of producing from it an intoxicating liquid, to which they gave the name of *chicea*." (Thomson's Org. Chem. p. 883.) The gluten of mais is termed *zein* by Professor Gorham, in the Journal of Science, XI. 205. All the rest must be familiar to the common reader. The albumen found by Einhof in barley contained phosphate of lime. Vogel removed the husk from his oats, and afterwards analysed the meal; his sugar contains some "bitter extract," and his albumen is described as "a grey substance *like* albumen." This "bitter extract" resembles the "extract and bitter principle" found by Cadet in coffee, which consists of tannin with oxygen abundantly absorbed, and is more clearly explained under its proper head. The one per cent. extractive found by Prout in barley and malt is not a bitter, but is called by him "yellow resin." Convenience does not require separate columns for these.

NATURE OF CONSTITUENTS.	SUBSTANCES ANALYSED.															
	Potatoes.	Rye Meal.	Wheat, French.	Wheat, Odessa.	Oats, Ripe.	Rice, Carolina.	Rice, Piedmont.	Mais.	Pea and Pod.	Ripe Peas.	Lentiles.	Field Beans.	Kidney Beans.	Barley, Green.	Barley, Ripe.	Barley Malt.
Saccharum or Sugar ...	....	3.27	4.71	8.02	5.45	0.29	0.05	0.90	4.58	2.11	....	....	....	5.55	5	15
Starch	15.00	61.09	71.13	59.25	38.94	85.07	83.80	88.63	1.38	32.94	32.81	34.17	35.93	14.59	32	56
Gums	....	....	3.31	5.35	1.65	0.71	0.10	2.28	....	....	5.99	4.61	....	....	....	....
Mucilage	4.00	11.09	....	....	....	....	....	....	....	6.49	....	....	19.38	....	4	15
Gluten	....	9.48	10.90	13.27	....	....	....	5.76	1.82	....	....	....	....	1.77	3	1
Bitter and Extractive ..	....	....	....	....	....	....	....	1.09	0.65	....	....	3.54	3.41	2.60	1	1
Oil	....	....	....	....	1.32	0.13	0.25	0.32	....	....	....	....	....	....	....	....
Husk	....	6.38	....	1.75	34.00	4.80	4.80	....	10.42	21.88	18.75	10.05	7.50	16.60	....	....
Volatile or Hordein Matter	....	....	....	....	....	....	....	....	78.13	14.06	3.12	15.62	....	52.12	....	....
Fibre	7.00	....	....	....	....	....	....	0.95	....	....	....	15.88	11.06	....	55	12
Earthy Phosphates	....	....	....	....	....	0.13	0.40	....	0.11	0.28	0.57	0.98	....	....	....	....
Albumen	1.40	3.27	....	....	2.84	....	....	....	0.91	1.72	1.15	0.81	1.36	0.45	....	....
Animo-vegetable	....	....	....	....	....	3.60	3.60	....	....	14.56	37.32	10.86	20.80	....	....	....
Water..............	71.10	....	9.95	11.00	15.80	5.00	7.00	....	....	....	....	....	....	....	....	....
Loss	1.50	5.42	....	1.36	....	0.27	....	0.07	2.00	5.96	0.29	3.48	0.56	6.32	....	....
Total......	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
By whom Analysed.	Einhof ...	Einhof ...	Vauquelin	Vauquelin	Vogel......	Braconnot	Braconnot	Bizio	Einhof ...	Einhof ...	Einhof ...	Einhof ...	Einhof ...	Einhof ...	Prout	Prout ......

To readers unversed in chemistry, it may be useful to premise that this Table exhibits, as nearly as analysis has approximated, and with sufficient accuracy for the present investigation of constituents, all those *proximate principles* of the substances under consideration, which in chemical language are termed their *primary compounds*, as saccharum, starch, &c., each of which has its own function in forming and supporting the structure of the seed, root, or other body referred to; and each primary compound is resoluble into the *ultimate elements* denominated *not* "fire, air, earth, and water," as the four elements of ancient philosophy, but

(O.) *Oxygen:* the fiery or acid basis (from Οξυς [Oxys], sharp, acid, nimble, acute, swift; and Γενναω [Gennao], to generate or produce).

(C.) *Carbon:* the earthy or coaly (from the Latin *carbo*, a burning or common coal; but the Greek is Ανθραξ [Anthrax]).

(H.) *Hydrogen:* the watery or humid (from Ὑδωρ [Hydor], water; and the same generative term as before); and

(Az.) *Nitrogen:* the airy or nitrous (from Νιτρον [Nitron], nitre, *saltpetre* or petrified salt; and as before). This element is also called *Azote*, from Αζω [Azo], to be dry; to suck in.

These elements, by combining together in an endless variety of ways, form all the complicated substances discoverable in the universe, be they animal, vegetable, mineral, or gaseous; and, according to certain philosophers, the primary compounds most important to the vegetable economy are *sugar*, *gluten*, *farina*, *mucilage*, and *oil*, each possessing very different properties from the rest, as regards the production of nutriment. The Table extends to other principles, equally proximate as constituents of the vegetable substances examined; and we have now to show how far they individually affect the constitution of wort by sharing in its composition; the final object being the discovery of the proportion necessary to sustain the ultimate elements on the most advantageous terms; since on them, however blended in the compounds, the constitution radically depends. The Saxons, as appears above, gave to this extract the name of wort; first, because it requires *working* in the mash; and, secondly, because it *works* itself into spirituosity by fermentation; and, if we are really good brewers, we shall pass it safely through both processes, leaving it with characteristic virtue at subsequent command.

Thomson's definition of the wort derived from barley-malt is, that it consists in the mealy parts of the grist being held in solution by the water employed: so it does; but he also says, that it *appears* to consist of *four* substances so held, which he calls *saccharine juice*, *starch*, *mucilage*, and *gluten*, combined with *tannin;* and of these, the brewer knows that in good worts saccharum is the principal constituent that demands his care to preserve it. Experience soon teaches him to know it by the sweet odour of his wort, by its luscious taste, and, where his process is properly conducted, by its perfect transparency; but, after all, what is it? How and where obtained? How best preserved? How far, and in what manner does it combine with the other ingredients which assist in the solution, transmutation, and purification of the beverage?

1. Saccharum.—This substance, called by Paul Egineta *sal Indicus*, or Indian salt, being, as he says, like common salt in colour and concreteness, but like honey in taste and flavour, appears to be similar to the juice with which the Armenians, as above noticed, impregnated their malt-liquor to strengthen it; and to that which

Theophrastus, who died B.C. 288, described as *the other honey which is in the reed;* though, with respect to colour, the saccharum from British malt is brown, darkening gradually when it is heated, becoming brittle and glazed. It was little known in Europe before the Christian era; but was noticed about the middle of the first century by Dioscorides the physician and Pliny the naturalist; the former of whom informs us, that *saccharum is a certain kind of concrete honey from India and Arabia Felix, found in reeds, like salt in its concretion, and is broken like salt when subjected to the teeth;* and the latter says, that *Arabia brings saccharum, but India is more praised;* it is *honey collected in reeds, clear like gum, fragile to the teeth, as much in size as a filbert-nut, and is very extensively used in medicine.* Lucan, a contemporary poet, who died in 65, has the following verse in praise of it:

"Quique *bibunt* tenerâ dulces ab arundine succos."

That is, Whoever *drink* the sweet juice from the tender reed. But it stands as a confirmed opinion, that these Arabians and Indians within the Ganges, were not growers, but mere *mercatores* trading with the Romans; and that they were supplied with this, as with other precious spices, by the exporters from Bengal and Siam, who had first brought the plant from China. From the medicinal properties of this "*gummi modò candidum*" exuberance, or Eastern *sugar-candy*, and the patronage bestowed on it by the faculty of those days, Piso relates that it became scarce and high-priced, which induced those Arabs and Inner Indians, from the description given of its growth by those with whom they traded, to search for it at home; and they had the good luck, not many centuries back, to pick up the indigenous *Mambu*, from the knots of which, after some four years' growth, a *white*, spongy, light juice exuded, in which they found a sweet taste so like that of the saccharum, that they soon became able to compete with the foreigners in their own markets, by introducing it as what they called their *Sacchar Mambu* or *Tabaxir;* and the Arabians also found a species of dog's-bane, or Apocin, which they called *Alhassar* or *Alhuzzar*, from which they abstracted a third kind of saccharum, which they titled *Alhasser Zuccar*, whence, by corruption, our word *Sugar*. Thus were three species known, independently of that obtained from malt, which three are severally called the *Zuccar arundineum*, or Indian salt; the *Zuccar Mambu*, or Persian *Tabaxir*, and the Arabian *Zuccar Alhasser*.

Hence sugar and saccharum are synonymous terms, applied to almost equivalent matter, except that one is fluid and the other dry and crystal, and are *food* and medicine for the nourishment of man; and two remarkable coincidences may be observed in relation to them: one is, that the sugar-cane contains about equal portions of sugar and molasses; while the barleycorns, when malted, yield like quantities of sugar and mucilage; and the other is, that just when malting began to be practised as an English trade, the inhabitants of southern Europe turned their attention to the cane; for in 1250, Marco Paulo, a nobleman of Venice, travelled to Bengal in search of it, and planted it in Arabia, whence it passed into Nubia, Egypt, and Ethiopia, and subsequently into Morocco, Sicily, and the Atlantic islands, where it was fostered, till, in 1520, St. Thomas alone had sixty manufactories, producing annually 150,000 arobes, each thirty-one avoirdupois pounds, or nearly 2076 tons. Liquid or uncrystallisable sugar was first pointed out in Spain by Proust, who has shown its habitation in a variety of fruits and vegetable juices.

It was found in carrots by Margraff, and is a principle in liquorice, distinguished from every other species of sugar by being incapable of forming crystals like those of the sugar of commerce, so that it can only appear in a liquid state. According to experiments made by the Duc de Bullion, the juice of grapes yielded from 30 to 40 *per cent.* of this saccharum; and Proust asserts, on the strength of his experiments, that the raw sugar from grapes, when sufficiently diluted with water, ferments, and is converted into wine. Now it appears from the above Table, that of the substances investigated, none but corn-seeds and peas contain this saccharine matter without conversion; but that mais has more than 88 *per cent.* of starch, and nearly 1 *per cent.* of hordein, which latter is a distinct farinaceous substance, similar to one whose particular province is seen to be barley, but that rice has not in it any portion of matter resembling this hordein; also that the sugar is decreased by the ripening of the seeds, while their starch is very materially enlarged; whereas the malting of barley trebles its sugar, and almost doubles its starch, which is vastly important; for as saccharum is the first essential of wort, its conversion and preservation are of paramount consideration.

Sugars differ in constitution; for the ultimate elements of cane sugar are O. 50·63, C. 42·47, and H. 6·9, according to Gay Lussac and Thenard; but starch sugar is O. 55·87, C. 37·29, and H. 6·84, as given by Saussure; and sugar of malt by Proust is O. 56·71, C. 36·2, H. 7·09.

2. Starch.—The presence of this substance, apparently the most abundant constituent of ripe grain, is readily detected by iodine, which produces a blue colour; or by dropping an infusion of nutgalls into the wort, when a precipitate will appear, which, at the heat

of 120°, will chiefly re-dissolve, leaving only a little of the combined gluten and tannin unaffected. Starch was well known to the ancients, as Pliny informs us in the seventh chapter of his eighteenth book, that the inhabitants of Chio first discovered the mode of procuring it. Saussure ascertained that 100 parts of starch, when converted into sugar, became 110·14 parts; and concluded, hence, that starch sugar was a mere compound of starch and water in the solid state; and Kirchoff, a Russian chemist, found that starch might be converted into a juice possessing precisely the properties of sugar of grapes, by mixing it with water four times its weight, and sulphuric acid about a hundredth part; after which he boiled the mixture thirty-six hours, supplying fresh water as fast as the old evaporated. It has also been found that sugar so obtained melts at the temperature of boiling water, and spontaneously undergoes the vinous fermentation when dissolved in water and sufficiently diluted.

It seems from the discoveries of Raspail and Guerin Varry, chemists of great eminence, that when starch is examined under a microscope, it is found to consist in a number of rounded grains, of somewhat variable shape; that these lodge in cells in the particular plant that produces them; and that their magnitude enlarges as the plant grows and ripens, which circumstance accounts for their paucity in green corn, as shown by our Table.

Potatoes.—These contain 15 *per cent.* of starch, 7 of fibre partaking of its nature, and 4 of mucilage, with a superabundance of water, and rather less than 1½ of *albumen*,—a substance noticed near the end of this chapter. The fæcula or starch of the potato, differently as the two terms are commonly considered, is no other than a *gum*, divided into minute portions, each of which is a globule inclosed in a shell of tissue; and chemists have discovered that the latter only is coloured blue by iodine. Add an alkali, and it becomes soluble; add an acid, and it converts it into sugar like that of grapes. Gum is considered to be the chief nutrient principle of vegetation, disposed freely among the constituents of plants, and constantly in action; but starch is stored up in such a manner that the water of vegetation does not easily solve it; and this, as well observed by Du Candolle, agrees very well with the office assigned to it in the vegetable economy, of forming a reservoir of nutritious matter to be consumed, at particular periods, in supporting the plant. In corn and buckwheat the storehouse is with the albumen of the seed, but in most other plants it is elsewhere; as in the potato, for instance, it descends into the root as the plant becomes mature. At page 100 of the "Society's Treatise on Botany" (Nat. Phil. vol. iv.), the editor observes, that in all these cases, the starch is either capable of supplying food to the young plant, or it may be supposed to be provided for the sustenance of man; but that the former is the more immediate destination, is probable from its continuing to increase during the latter part of the year, when the plant is preparing a fresh supply, reaching its *maximum* when it has ceased to grow, remaining stationary in winter, and rapidly diminishing with the growth of the young shoots in spring. This is exemplified in a French work on agriculture, which shows that 100 lbs. of potatoes contained the following quantities of starch at different stages:—

	lbs.		lbs.		lbs.
In August ..	12	In October	17	In April	13¾
In September	14½	In March	17	In May	10

Potatoes, in their raw state, do not contain any gluten; at least, Proust could not find it, nor does our compiled analysis show that Einhof was more successful; and moreover, they are also destitute of saccharine matter; and Liebig observes, that if they grow where they are not supplied with earth, as in a cellar, for example, a true alkali called solanin, of very poisonous nature, is engendered in the sprouts that shoot towards the light. Yet potatoes will convert into a species of malt, and may be deprived of their generative function; since it is well known that whole cargoes brought from Ireland, and overheated in the passage, have entirely failed as seed. And they possess other principles in common with grain; for Thomson, after reciting Einhof's experiments on potato starch, in the residuum of which he discovered albumen and mucilage, says that the juice which may be separated from them when boiled is sweet-tasted; consequently, it is saccharific. He tells us that the meal is insoluble in boiling water, though potato starch forms a transparent solution with it; and accounts for the difference by supposing, quite rationally, that the albumen, fibrous matter, and starch, combine by boiling, and form an insoluble compound.

The direct conclusion, therefore, is, that though potatoes differ essentially from wheat and barley in containing no gluten, yet the detection of *mucous sugar* and gum by Peschier, which sugar is the basis of wort, demonstrates that potatoes thus prepared are capable of undergoing the vinous fermentation.

Sir Humphrey Davy argues that an acre of potatoes will produce 4031 lbs. of starch, gluten, and sugar, which will yield 2200 lbs. of brewing extract; while he believes that wheat contains no more than 1289, barley than 1242, nor oats than 990 lbs. of the compound, respectively yielding but 900 lbs., 750 lbs., and 629 lbs. of the extract; and as starch is chemically allowed to be the parent of sugar, and as the fæcula of potato is readily converted into starch, Ham strongly recommends it to the brewer's attention, and prefers the farina and sugar of potato to the ordinary kind for all culinary purposes, except that of making bread, the lightness of which he ascribes to tenacity in the gluten of wheat; and from the feature of his treatise, it seems that the introduction of potato brewing, and potato conversion at large, has been one of the chief objects of his publication. Certainly much contraband sugar has been made from the potato-root, and from beet, as some extensive seizures have, within a few years back, been made by our excise; and though the analysis of the root does not show that it is glutinous, but starchy and mucilaginous, still the sugar, which the starch is made to yield, may be converted into an alcoholic beverage by solution and the application of barm, containing albuminous gluten as an ingredient. This beverage may not be imperishable, neither has the art of man provided such; and then the author before us truly says, that unfortunately, through the stringency of our excise laws, the purposes to which such an extract is applicable are in a great measure prohibited; and this settles the brewer's doubts, if he has any, as far as potato beverage can concern him.

But though the matter called *solanin*, *solanina*, or essence of night-shade, of which genus the potato is the species *tuberosa*, has been shown to be poisonous; and though Dr. Thomson advises extreme caution in the use of the shoots after germination has begun; yet with fæcula, more particularly if in good season and keeping, it is otherwise; for Ham's potato sugar, which is quite hard and beautifully white, is preferred to the best refined sugars of commerce by makers of wine who have tried it in private houses, from the accredited assertion that it does not readily become acid, owing, no doubt, to the absence of gluten within it, which, if resident, would attract oxygen and present it to the alcohol, converting it into acetic acid.

He tells us that the whole French nation is alive to the superiority of potato sugar; but, admitting the impolicy of parliamentary dictation to the manufacturer of any staple article of necessary consumption, inasmuch as it manacles ingenuity, menaces industry, and prohibits fair and free competition, thereby upholding monopoly, the retarder of knowledge, and the crippler of economy; still, inequitable as setting off restriction against principle may be, his mode of handling this tuber is objectionable from the tenor of his own language, where he informs us that the brewers and distillers of France sweeten their flour by a process which it would be foreign to his purpose to describe. Why so, if it works a beneficial conversion? The more we learn, the wiser we ought to become: but another block obstructs our way; for at present it is, as he says of oats, "Too inferior to bear a duty of 2*s.* 6*d.* *per* bushel," even in fæcula; and to that decision we are legally bound to submit, whether we give the experiment a private trial or not, so long as the restrictive duty remains upon the produce of the soil to damp the energies of enterprise. The duty is 2*s.* 8½*d.*

Saussure, Gay Lussac, and analysts of a later date, give the elements of several kinds of starch thus:—

Potato:	O. 49·076,	C. 44·25,	H. 6·674.	—100.
Wheat:	O. 49·04,	C. 44·26,	H. 6·70.	—100.
Rye:	O. 49·20,	C. 44·16,	H. 6·64.	—100.

Gum is analogous to starch, as albumen is to gluten; it is the *amidin* or liquid yolk which fills the vesicular pustules already noticed, which latter chemists distinguish by the term *amylin*. In an analysis of the starch of potato by Guerin Varry, he gives the proportion thus:—Amidin, 38·13; amylin, 59·75; and an external tegumentary amylin, 2·12 *per cent.* Gum itself is in specific gravity from 1310 to 1430, and has no smell. Proust's analysis of wheat starch, after 20 hours' exposure at the boiling heat, and 6 more at above 300°, became O. 49·78, C. 44, and H. 6·22 *per cent.*, differing but little from the above.

According to our Table, gum abides most particularly in coffee; to some extent in wheat, beans, and lentiles; more sparingly in mais and oats; and triflingly in rice; but *is not found in barley or malt*, rye, peas, kidney beans, or potatoes; but as potatoes and barley-meal have been found to abound in starch, where it originates, the gum generally collected in this Table must differ from the amidin or egg of starch, in some particulars. Thomson affirms that alcohol separates starch in part from its decoction, but that gum is insoluble in alcohol; and that if alcohol be poured into *mucilage*, the "*gum*," from the greater affinity of water to alcohol than to it, immediately precipitates in white, soft, opaque flakes, which will not solve in ether or in oils. But gums are various, according to the substances that produce them; and different kinds are obtained by different and even contrary processes; and we need not hunt for gum arabic, gum senegal, or gum guaiacum, in proof of it; besides which, some chemists seem to stumble between gum and mucilage, which are not by any means the same; and it will be found well for the brewer not to confound the distinction: his gum is the *amidin* of starch, before noticed.

Starch gum and sugar readily unite when both are dissolved in water, and by gentle evaporation a solid substance is obtained, which, like the Indian salt of the ancients, is uncrystallisable and perfectly transparent.

This gum is nutritious, though alone it cannot support animal life; and in its composition it approximates, as well may be imagined, to that of starch itself, its elements being composed of O. 50·84, C. 42·23, and H. 6·93, according to Gay Lussac and Thenard; of O. 51·2, C. 42·2, H. 6·6, as given by Goebel; and of O. 51·31, C. 41·91, and H. 6·78, as by Berzelius; which trifling difference might easily arise from diversity in the quality of the starch; they are also almost identical with the results severally obtained by the same philosophers from their experiments on raw sugar; and as sugar contains neither earth nor alkali, no more does this kind of gum.

An article called British gum is thus described in the Magazine of Science, vol. i. p. 32:—"A gummy substance, obtained by heating starch until it obtains a slightly brown colour, which it will do at a temperature of between 600° and 700°. It is soluble in boiling water, but not in cold; and if a few drops of tincture of iodine be added to the solution when cold, a purple colour is produced, and not a blue, which the unburnt starch would have produced; showing that, during the roasting, a chemical change has been effected. A gummy substance analogous to this is obtained by the addition of strong sulphuric acid to paper or woody fibre, such as sawdust; and then saturating the acid with chalk, this gum is left." Similar to this obdurate substance, therefore, must be the gum of roasted coffee or of porter-malt, which is rendered strongly adhesive by heat, but is deprived of its saccharine consistency and its liquescency. Starch, therefore, is clearly convertible either into a liquid saccharum of a nourishing nature, or will set into an inconvertible and tenacious gum; and it is the brewer's province to promote the one, and to prevent the other.

3. Mucilage is that which, according to Thomson,

precipitates in flakes as a gum, when wort is dropped into alcohol, and which he finds to be more considerable in the last-drawn worts than in the earlier and stronger. Hermbstadt distinguishes mucilage from gum thus: The former is opaque, the latter transparent and glutinous; the former does not feel glutinous, but slippery, and cannot be drawn out into threads, whereas the solution of gum can be so drawn out. The following has been given as a mode of separating the one from the other: Reduce the mixture to a dry mass; dissolve it in the smallest quantity of water in which it can be done; drop into the solution, time after time, diluted sulphuric acid: this will coagulate the mucilage, but the gum will remain dissolved; and when the coagulation has ceased, if the mixture remain awhile at rest, the mucilage will precipitate and become a jelly. Mucilage is therefore a substance wholly distinct from gum, rather than the product of some new combination and transition, being co-existent with it; and Einhof must have been conscious of the dissimilarity when he found the one in field beans and vetches, and the other in ripe rye and barley, peas, kidney beans, and potatoes; and we shall presently see that it has not the same function, but can occupy a separate habitude. Indeed, it is thus otherwise described:—"Next to gluten, in the property of affording nourishment, is *farina*. This is found most copiously in wheat, and it forms a considerable portion of the nutritive parts of various kinds of pulse and tubers. Most fruits contain a basis of mucilage or farina, which is combined with sugar or with oil. Sugar is among the most highly nutritive of all the vegetable products, and oil seems capable of being converted almost wholly into nutrient matter." (Treatise on Animal Physiology, Nat. Phil. p. 47.) Mucilage is therefore not a food within itself, possessed of intrinsic virtues, but merely holds the nutrimental part of food consistently together, and is susceptible of disengagement by common solvent means; resembling in these particulars the *amylin* or *shell* of starch. Hence we must regard with caution any expressions which treat mucilage and gum synonymously. Thomson says that there are many kinds of seeds, as linseed, for instance, which, on being macerated with water, make it become thick and adhesive, *converting it* into what is called mucilage; and that the solution of *arabin*, the principal constituent of *gum* arabic, used by calico printers to thicken their colours and mordants, and thereby to prevent their running, "is known by the name of *mucilage*." We might hence conclude that mucilage was the produce of a secondary admixture or transition from the state of starch; but the fact is, that these adhesive solutions contain gum as well as slime, and this is the admixture of which kidney beans contain more than four times as much as barley-meal, and of which the same chemist says that water dissolves *gum* in large quantities which are thick and adhesive; the solution, when spread thin, having the appearance of varnish, and readily attracting moisture and becoming glutinous; for though he says that it is "known by the name of mucilage," he admits that water washes it away; and that, when mucilage is evaporated from it, the gum is obtained unaltered.

No doubt, the elements vary in mucilage as in other substances, according to the nature of the body composing its basis. Marcet analyses mucilage at O. 53·09, C. 41·4, H. 5·51, and Guerin Varry gives for the mucilage of linseed, O. 52·78, C. 34·30, H. 5·65, Az. 7·27; but it may be presumed that the quantity of nitrogen which thus distinguishes mucilage from sugar, starch, or gum, is an accession chiefly at the expense of the carbon, which, though dependent on the character of the seed examined, pronounces it at once a separate substance.

4. Gluten.—Thomson asserts that the other ingredient in wort is the insoluble part of the precipitate thrown down by the gall test, and is a combination of *gluten* and *tannin*, and very inconsiderable in quantity. He pronounces gluten one of the most useful vegetable principles, and says that it is an essential constituent in wheat, because it renders the flour fit for forming bread. It is, in fact, a strong stimulant, whereas mucilage is languid and passive; and this stimulative power of gluten is particularly useful to the brewer in producing alcohol, by its excitement in the act of fermentation. It is a substance which he studies to eject, though he must first avail himself of its services. Beccaria, an Italian philosopher, who undertook to analyse wheat-flour in 1742, first discovered this substance thereby, and found it to be grey, tenacious, elastic, and ductile, capable of being stretched out to many times its natural length, like Hermbstadt's gum, to which it is allied. We see by our Table that it is doubled by the ripening of barley from a certain stage; that it abounds in wheat and rye, and that mais is tolerably prolific of a matter so essential, the value and use of which may be appreciated from the definitions every where given of it. The writer on Animal Physiology above quoted, speaking of vegetable materials, defines it to be the most nutritious of them all; its elements the most nearly resembling those of animal matter, and that it contains nitrogen in considerable quantity: an element which is absent from almost all the vegetable products; and observes, that it is found in the greatest proportion in wheat, which fact the Table tends to substantiate.

Hence, though vegetable gluten has been known now a full century, its true properties and principles have been but little studied as such; for if they had, G. Varry would have found less nitrogen in linseed mucilage. Dr. Liebig, in his "Chemistry in its application to Agriculture and Physiology," (chap. v. p. 70,) has this sensible passage: "We cannot suppose that a plant could attain maturity, even in the richest vegetable mould, without the presence of matter containing nitrogen, since we know that nitrogen exists in every part of the vegetable structure. The first and most important question to be solved, therefore, is, how and in what form does nature furnish nitrogen to vegetable albumen, and gluten to fruits and seeds?" This subject he proceeds to investigate at considerable length, and concludes that they are imbibed from the atmosphere, thus supporting Schrader's hypothesis on the natural food of plants. Thomson pronounces gluten a common ingredient in the structure of vegetables, but, as he says of albumen also, extremely various in quantity and appearance; and, accordingly, he thinks of the substances composing rye, that they must vary exceedingly in proportion, according to soil, climate, and age; let us, therefore, proceed to examine that seed in connexion with gluten.

Rye.—The gluten of rye and that of wheat differ, as most other things do, in many particulars, and that of barley from either of them. Wheat gluten is more tenacious than that of rye, and not so soluble. Rye gluten and water form a mass which contracts by boiling. The saccharum of rye, when freed from its attendant gluten by dilution, digestion, and evaporation, though sweet, has a harsh taste, and has become soluble in water, alcohol, or ether, and is propense to turn immediately sour; which harshness, added to the reality that the meal contains 11 *per cent.* in mucilage, and only 3¼ of this inferior saccharum, added to the tediousness of obtaining the latter, and the certainty that rye-bread, however sweet, speedily acetefies, quite unfits this species of corn for the brewer's use.

Rye, having gluten for its support, would have less disadvantage, notwithstanding, if it could be properly malted; but to this the thinness and weakness of its husk constitute an insuperable objection; for as soon as its farina is made to expand, through the absorption of moisture in the steep, and germination begins to ensue, the cuticle breaks asunder, and the rising plumula, having no stay to control it, creeps through the fracture and grows externally, which is commonly termed "malting the wrong way;" hence, being unprotected, it is easily broken off in turning, by which breach not only is its further growth prevented, but the mutilated grain becomes mouldy and putrid, as we shall find to be the case with over-thrashed barley.

Wheat.—Let us now treat of gluten in its relationship to the *triticum hibernum*, or winter-wheat, described by chemists as by far the most nutritious kind of corn; for here, again, our interest may be affected to a great extent. Thomson found it composed chiefly of starch and gluten, of which starch was the more prominent, with small portions of saccharum and bitter, to which Fourcroy and Vauquelin add mucilage. The specimen from Odessa in the Table above, is taken at the average between hard and soft grain; but the analysis of the hard is, starch 56·5, gluten 14·55, sugar 8·48, gum 4·90, bran 2·30, water 12·00, loss 1·27; total 100. But the flour used by Paris bakers, as analysed by Vauquelin, gave starch 72·8, gluten 10·2, sugar 4·2, gum 2·8, water 10; total, 100: an inferior kind yielding less starch and more gum and water, with 2 *per cent.* of bran; and it must be noted, that here, as in the Table above, the gluten is not purely such, but "a mixture of gluten and albumen;" and the fact is, that chemists now divide gluten into four distinct substances: *albumen*, *mucin*, *emulsin*, and *glutin*. The elements of wheat-gluten are thus given by Jones: O. (with sulphates and phosphates) 23·56, C. 53·83, H. 7·02, N. (az.) 15·59.

Nine bushels of wheat, ten of rye, and nineteen of oats, have, on trial, been found equal to thirteen of barley, and to produce equal quantities of beer of the same strength; if, therefore, they were equally eligible and available, their several market prices would determine the relative advantage or disadvantage of brewing from each, the disproportion being chiefly consequent upon the bulkiness and compactness of the kernels of the more productive sorts, and on the thinness of their cuticular covering. The author has behind him the experience of the seasons succeeding the harvests of 1834 and 1835, when wheat sold at 36*s.* to 40*s.* *per* quarter, and barley, being scarce, was considerably higher. Large quantities of the former were then malted, and made good ale, when properly attenuated, if the wheat had been very carefully treated in the manufacture; but it is best to malt it mixed with barley, the roots of which will protect it, and regulate its temperature; for as its plumula bursts forth through its tender coat of bran more abruptly than even in rye, it is in great danger of decapitation if rudely handled; and it requires to be mixed in the mash with some huskier or chaffier substance, because it contains so much farina in proportion to its cuticle, that it would otherwise set into a paste, from which the extract could not be obtained without difficulty and danger. Nothing is so good to mix with it as barley-malt, well crushed; and it is better not to crush the wheaten malt too fine, for it contains too much starch, and too much gluten with it, to suit the purpose of solution; and hence the facility with which it runs into acetous fermentation, and the reason at once why the produce will not keep so well as the wort from ordinary malt; though the author ventures to assure himself, that by the new process of conversion and extraction in the mash-tun, further aided by the improved mode of fermentation which he prescribes, all the superlative gluten would be removed, much of the starch would transmute into saccharum, and consequent advantage could be taken of the superiority of wheat over barley under such favourable circumstances of price.

5. Bitter and Extractive.—When Dr. Thomson found his gluten combined with tannin, he must have experimented upon the wort of particularly high-dried malt, as we find no such principle existing among our tabular constituents; but he has discovered, that when coffee is *roasted*, tannin is formed or increased within it by the action of heat; and we may suppose the same of roasted malt or corn. Paissè, who has analysed the raw berry with great care, describes this, not as tannin, but as a peculiar acid, called by Chenevix *caffeic-acid*, and by Cadet *caffein*,—which, they say, though it reddens vegetable blues, is not entitled to be called an acid: it becomes a *colouring matter*, by the action of heat. The bitter principle which gives to certain substances a dye, and in some instances an offensive taste, may, for the sake of chemical euphony, be termed *amarin;* but it evidently differs in quality and character, according to the nature of its maternal plant, and sometimes is named accordingly; as *quassite*, from quassia; *brionite*, from white briony, by country people called mandrake; *berberite*, from barberry; *lupinite*, from lupines; and *lupuline*, from hops; though a very different species is extracted from wolf's-bane. If each plant had not its peculiarity, nature would have no need

for distribution of genera into species, nor would language have need for a corresponding adaptation of epithets; and the words here applied to their extractive principles are a mere Latinising of the essence to the botanical classification of the substance. They are of no use to the brewer, but, like the bundle of evils in Pandora's box, they have each one single item of albumen lying at the bottom.

Similar to amarin is extractive, which is defined to be a principle existing in bark, with a strong taste, containing an acid liquid, and being insoluble either in alcohol or in ether, but soluble in alcohol when containing water, and then it will also solve by evaporation; but the term seems to have been generally applied to the remnant of a solution when every thing was gone which distillation or evaporation could carry off. Fourcroy and Vauquelin describe it as a substance at first soluble in water, but insoluble after exposure to the air, through having absorbed oxygen there; but Saussure controverts their argument, and says that instead of imbibing oxygen, it gives out hydrogen to it, converting it into water. Berzelius is of the same opinion, and distinguishes it as a brown substance from other *extracts* used among apothecaries, by the term *apotheme*. Its general character is, that it solves with difficulty, and imparts deep coloration to the water or alcohol in which it separates. It seems from our Table to be contained in peas, beans, and mais, but not in any other ripe corn, and therefore does not further concern the present inquiry, as we shall find that these are not brewing materials.

6. Oil is every where a sign of richness, as mucilage is of poverty. Thomson's description of vegetable oils is very clear and comprehensive, where he divides them into *fixed* and *volatile*. Fixed oil, he says, is found no

where but in the seeds, and is almost entirely confined to such as have two cotyledons, as linseed, almonds, beech-nut, poppy, rape, &c., and the volatile in every part of the plant except the cotyledons of the seeds, where, in his idea, they *never* occur.

Now cotyledon is a Greek term, from κοτύλη, a *cave* or *hollow*, particularly applied in the parent language to the hip-joint, but botanically to that part of a seed in which are posited the organs that renew the species. In native English, the interior of this cotyledon is called a *kernel*, which latter word is no more than a diminutive of *corn*, though more commonly applied to nuts and the like, but by maltsters very properly to barley and malt. Every *graminous* plant (from *gramen*, grass or grain), is *mono*-cotyledonous, or has its kernel in *one* piece; whereas pulse, such as peas, beans, or vetches, are *bi*-cotyledons, or are split into two parts; whence it would appear that the fixed "fat" oils found by Braconnot in rice, by Bizio in mais, and by Vogel in oats, were exceptions to natural principle, as are similar oils extracted from rape, mustard, and almonds; but Fourcroy and Vauquelin have found such an oil also in barley, which they say is like coagulated olive-oil, but darker, resembling butter, burning like lamp-oil, and will form soap when combined with an alkali. (Mus. de Hist. Nat. 38, p. 8.) Thomson remarks, that this barley-oil has escaped Einhof's notice, though he has obtained it in his own experiments, by the same process as the French chemists. This subject, and that of resin, will be found discussed more fully in the next chapter, under the head, "Constitution of Malt."

7. Husk.—Having now proceeded to observe upon the most important primary compounds, as enumerated after the Table, we see that in the collection of seeds, some few constituents remain to be disposed of: these

are, husk or fibre, volatile and fibrous matter, phosphates, animo-vegetable matter, and albumen. The husk in ripe peas exceeds one-fifth of the whole bulk, and is wholly unprofitable; but in the ripening of barley it is reduced from $16\frac{1}{2}$ to $6\frac{1}{2}$ *per cent.*, the analyst qualifying it by observing that it is not merely husk, but contains starch and gluten. But the most prominent seed in the article of husk, as it is also of fat oil, is that considerable production and "staff of life" of our more northern and hilly provinces:

Oats.—The husk of this seed, amounting to one-third of its whole constituency, is known to be a thick, glossy, outward shell, as hard and compact as reeds, or the strongest wheat-straw, and inclosing an inner membrane or parenchyma of great nutritious virtue, which again covers the cotyledon. The quantity of starch is still more considerable than the husk, but Thomson admits the difficulty of freeing this starch from "another substance with which it is united," without acquainting us with the nature of that substance; so that its properties can only be inferred by consulting the Table; though in his account of Scotch *sowans* or *flummery*, he gives an interesting account of the parenchyma and its virtue; but, like rye, it is apt to "become sour." The interposition of this middle film, the smallness of the kernel compared with the husk, and the tardiness which its obduracy inflicts upon the germ, combine to render the malting of the oat a disadvantageous speculation, particularly when the *duty* is considered, whatever may be the value of the interior substance. It is true that in the North it is usually cultivated for human food; but as a malt it is so proverbial, that a person of dilatory habits is likened to it.

Rice.—Vauquelin, who published an analysis of this grain, which may be seen in the 12th book of the

Annals of Philosophy, did not find any saccharine matter in it, but "a little liquid gum and some sulphur" instead; though Braconnot, as we see, detected a trifle; but it neither contains gluten nor albumen; therefore it is not a proper brewing ingredient, but is nearly the same as sago, which is classed by chemists as a "pure starch," and sets into a jelly at a low temperature; and, instead of yielding a limpid fluid, absorbs the liquids presented to it, and stiffens with them into a solid mass, which hardens as it cools.

Mais.—Respecting this foreign production, a few words may serve. An analysis of the dried grain is given by Gorham thus: starch 84·6; zein or gluten 3·3; albumen, distinct from gluten, 2·7; gum 1·9; sugar 1·6; unaccounted for 5·9. Here may be all the requisites for brewing the *chicea* of the Peruvians, but none of the extractive named by Bizio, which drew into threads while warm, but became brittle when cool, with amaradulcet taste and the smell of honey; whence it seems that analysts differ in their views of the finer matters. The zein of Gorham did not afford any nitrogen, and was therefore inert; but the albumen was more considerable than we find it in any other corn except rye. Bizio also gives one *per cent.* not of fibre, but *zimome* or *amidin*, besides the undissolved starch; whence it appears that he took his analysis when the starch had begun to burst, and consequently, as shall be shown, when diastase was at work. This zein is yellow, viscous, and ductile, like the resin of barley, and is also without taste or smell, so that it more nearly resembles gum; but it is useless to us, and the quantity of starch in this seed is prodigious, and may be discarded for the same cause as rice.

8. Volatile Matter, from *volo*, to fly, is that which is easily carried away by evaporation or otherwise.

This matter appears to be five times as plentiful in the unripe plant as in the seed, which is shown in the instances of barley and peas, amounting in the early stage of the former to more than half, and in the latter to four-fifths of the whole, but reduces by ripening to 10 *per cent.* in the pea. Barley has, therefore, a preferable substantiality in this respect, as well as in glutinous food, which is doubled as it becomes mature, whereas in the growth of the pea it entirely wastes away; besides, the saccharine matter which is not materially diminished by the maturing of the grain, is reduced one-half in the pulse by the same process; all which things militate against the pulse and for the grain; and though the saccharum or immature juice of the barley is reduced in quantity, or rather is gone, it is replaced by a superior quality. Einhof, as it will be seen, found that the pod of the pea contained more volatile matter and starch, in proportion to its bulk, than when pod and pea were taken together, but less gluten and vegetable fibre, and only half the albumen.

Peas.—Einhof also noticed, that the sweet juice of young peas might be obtained by slight pressure; that when a quantity was exposed to the air, a thin skin gathered upon the surface, and afterwards fell to the bottom in white flakes; and that it gradually and spontaneously fermented and became sour; the residue, composed of the coats of the peas, and a white, fibrous, and tasteless matter, dissolved in hot water like starch, resembling it in some measure, but agreeing in its properties with the fibrous matter of potatoes. None of these phenomena occurred in the treatment of the ripened pulse or grain, though the water in which the green barley had been macerated deposited some flakes of albumen when boiled. In all these respects, therefore, barley is superior to peas; and though many, not excepting persons connected with the excise, harbour an idea that a few peas thrown into a couch of malting-barley will vegetate with it, and improve the brilliancy of the article made from it,—the idea of the apple-pie made all of quinces will show its erroneousness, as a brewing of unadulterated pea-malt would at once demonstrate; for it would, in the first instance, have to pay one-third more duty, and ultimately not more than five *per cent.* of the whole pea would incorporate with the wort. The experiment of sprinkling peas upon the couch is not usually done to a greater amount than one *per cent.*; and the idea that one-twentieth of that, or a two-thousandth in the magnitude of the mass, could have any sensible apparent effect, either clarifically or aromatically, is truly preposterous, unless it were all diastase, or analogous to it. In short, to explode the absurdity, the writer must admit that he was once prevailed upon by a person with whom he acted, and who had heard much of the sparkling beauty thereby produced, to try this experiment; and, accordingly, he procured six quarters of peas, which he malted and brewed with barley in various proportions, and watched the wort and the ale very closely, but did not perceive any alteration for the better, which was precisely the result which he had predicted to arise from a speculation so uncommonly out of course.

9. Fibrous Matter.—That before us was extracted from peas by Einhof, who published his experiments in the sixth volume of Gehlen's Journal. He says that it is much like gluten, but differs from it, and from all other vegetable constituents; that it is adhesive, will form paste, is perfectly insipid and inodorous, and insoluble in water, whether cold or not, and begins to putrefy when commingled with it. This, from its de-

scription, appears to be a mass of unformed mucilage and gluten, into which the husks seem partially convertible, and differs from that other fibrous matter found in rice by Braconnot, which consisted in a parenchyma (the integumentary amylin), not unlike that of oats, mentioned above, being knit together, filled with small bubbles, and was tender and succulent.

Lentiles and Beans.—These seem also to contain a quantity of fibre, starchy or otherwise, amounting on the average to not less than a fifth of the whole, the field-beans having the most, and the kidney-beans the least. They have plenty of what seems to be albumen, but no saccharum, or any real azotic gluten to produce it, and kidney-beans abound in mucilage; and all of them, as well as peas, and particularly lentiles, have too much of the substance called animo-vegetable to be preserved from putrefaction during any length of time, when once solved into their disorganised elements. Vauquelin and Correa de Serra found tannin in the skins of beans, and again in their animo-vegetable substance, and the only remarkable property which the former has found on a more minute series of experiments on a black species of kidney-bean from the Isle of France, appears to be "a black substance containing azote:" indeed, all these pulse darken the water in which they are boiled. The flour of lentiles, when digested in alcohol, gives to the latter a bitter acrid taste, and turns it green; and when distilled, and mixed with water, it acquires a disagreeable smell. Though it is said to approach gluten in its properties, it has been proved by Einhof to differ from it in several particulars, as it soon putrefies when mixed with water, and gives out the smell of ammonia. Playfair has reduced beans, and given the elements thus: C. 38·24, H. 5·84, Nitro-O. 38·10, Ashes 3·71, Water 14·11 *per cent.*

10. Phosphates.—In European rice we find thrice the quantity of these that is contained in the same sort of corn if brought from the Carolinas, ripe British barley affording something like a medium between them, but the unripe yielding none that is perceptible. Ripe peas seem to contain between two and three times as much as green pods, and beans more than thrice as much as peas. In some of the other cases they have been overlooked, or are included in the loss. The author once felt disposed to describe these curious salts, "formed by phosphoric acid," as Henry has it, rather particularly, and to show how plants draw them from the soil, as sustenance, till the seeds eventually imbibe and feed upon them; but as they are chiefly neutral, and the presence and quantity of each is dependent on the composition of the native soil, nothing needs here be said of them, more than that Liebig, the prince of agricultural chemists, declares, that the seeds of corn *could not be formed* without the phosphate of magnesia; and that the alkalines, as well as those of magnesia and lime, are necessary for the production of all graminous plants.

11. Albumen.—This substance has been named above (p. 44) as one of four derivatives from gluten, and as being thrice as copious in ripe barley as in unripe. Link, who is followed by Thomson, says that albumen and gluten resemble each other too closely to be considered distinctly; though the latter, in his more recent work, says, "it is unlikely that the constitution of the albumen, mucin, and glutin, should be exactly the same:" thus may men live and learn, while others unlearn what they have once known. The author, in exercising his own judgment with some degree of freedom, has learned to think, with Liebig, that the critical repetition of another's experiments, or of his sentiments,

must be viewed as a criticism upon his opinions. "If the result of the criticism be merely negative, and do not suggest more correct ideas in the place of those which it is intended to refute, it should be disregarded." Though Thomson's conviction has induced him to shift his opinion, and though he says, after all, that "little confidence can be put in M. Marcet's analysis," still he gives it without a better of his own; and perhaps that chemist thought the difference too trifling to notice; therefore let us take the following:

Gluten by Boussingault.			per cent.	Albumen by Marcet.			per cent.
O.	3 atoms	= 3·000	.. 25·	O.	2½ atoms	= 2·5	.. 20·95
H.	7	= 0·875	.. 7·292	H.	7½	= 0·9375	.. 7·85
C.	8½	= 6·375	.. 53·125	C.	9	= 6·75	.. 56·55
Az.	1	= 1·750	.. 14·583	Az.	1	= 1·75	.. 14·65
	19½	12·	100·		20	11·9375	100·

Which is a considerable difference in substances so nearly allied that they lately could not "be considered as distinct principles." The above, it is true, are the gluten and albumen of wheat; and though Einhof saw that they existed in rye and barley, and complained of the difficulty of separating them, they evidently do not vary far from these, though the gluten may differ in character. The analysis of animal *albumen* given in Thomson's "System" is O. 23·87, H. 7·54, C. 52·88, Az. 15·71, or nearly as the *gluten* of Boussingault. Another analysis of the albumen of wheat has O. with sulph. and phosph. 21·84, C. 55·01, H. 7·23, Az. 15·92; and Thomson again says, that no simple substance has yet been found in the animal kingdom which does not likewise exist in vegetables. This is particularly demonstrable in albumen, which has important engagements to fulfil, distinct from any other kind of matter: in fact, it is in both kingdoms the *primum mobile*, enveloped in a substance peculiarly its matrix, and having an innate germ, appropriate to its own office and necessity. It is, in short, one of those "other substances besides starch, sugar, and gum," which Liebig says, "*must* be present in a plant, if these are to take part in the development of the germ, leaves, and first radical fibres."

In like comparison, also, gluten or *emulsin* may be considered as the milk or nutrient matter of seeds; saccharum as their blood, or the vehicular supporter of their life and motion; woody fibrin their bones; starchy fibrin their intestinal organs; mucilage their flesh or perishable substance; volatile matter their sudorific or other excrescent essence; starch their solvent sinews and tendons; oil their fat; amarin, extractive, animo-vegetable, phosphates, &c., their digestive food and alien matter; and husk and parenchyma their skin, membranes, and glands.

Albumen at 160° coagulates into a white solid mass, of a consistency dependent on the time that the heat has been applied, and in some measure, likewise, on its own quality; and the mass thus formed has exactly the same weight which it had in its fluid state. The coagulated albumen is insoluble, though when cold it solves in water; and this proneness to coagulate, through irresistibility of the power of heat, is a characteristic of the substance that distinguishes it from all others. Such is albumen, which the brewer is enjoined to bear particularly in mind when he examines the contents of his copper and the treatment of his worts. It is one of those essential properties of seeds to which the hackneyed word "gum" was applied by chemists before its distinct nature became known.

12. Diastase.—Another inherent property of seeds, which may seasonably be considered in connexion with albumen, is diastase (from διίστημι, to put at a dis-

tance; compounded of ἵστημι, to stand, and διὰ, between: a word signifying separation or disunion; being that principle which causes, according to another interpretation of the word, "breach of friendship" among the farinaceous constituents of the mash). Liebig, to whom we owe a debt of gratitude for the introduction of it, has laid down the following important principles:

1. *That the conversion of starch into sugar* during the germination of grain, is ascribed to a vegetable principle called diastase, which is generated during the action of commencing germination; but this mode of transformation can only be effected by gluten, although it requires a longer time. 2. That seeds which have germinated always contain much more diastase than is necessary for the conversion of their starch into sugar; five parts by weight of starch being converted into sugar by one part of malted barley; and he declares that this excess of diastase cannot be regarded as accidental; because, like the starch, it aids in the formation of the first organs of the young plant, and disappears with the sugar. 3. That diastase contains nitrogen, and furnishes the elements of vegetable albumen. 4. That the solution of diastase, whether it be pure or contain sugar, separates amidin from all starchy substances that contain it; and when heated to 150° or 167° with flour or starch, its extraordinary potency detaches the envelopes from the amidin, with which it then enters into combination, and causes it to form a solution in water, while the amylin separates, either falling to the bottom or floating on the surface. Such is the energy of the diastase, when thus engaged, that *one part* of it is sufficient to render soluble the interior portion of *two thousand parts* of starch, and to convert them into sugar. Yet, with all its

energy, it does not convert the obdurate shell called *gum* into sugar, or act upon common sugar, or upon barm, neither is that necessary. This to the brewer is the key-stone of his art, and its truth is well grounded on French experiments, repeated in England: in fact, it was in consequence of this property of separating the two constituents of starch from each other, that MM. Payen and Persoz gave it the name of DIASTASE.

Our celebrated professor has again determined, that sugar, gum, and starch are not food for plants; but that carbonic acid, water, and ammonia feed them when fully developed, the former serving, when accompanied by an azotised substance, to sustain the embryo, until its first organs of nutrition are unfolded; and that the quantity of gluten, vegetable albumen, and mucilage, will augment when the plants are supplied with an excess of food containing nitrogen.

Diastase is submissive when not excited, but resolute when forced into action. Though not soluble in alcohol, it is soluble in water and alcohol diluted. The aqueous solution has neither alkaline nor acid quality, and little taste; and when left to itself, it will fret into acidity, the more rapidly the higher its temperature. It is not precipitated by diacetate of lead, but is obtained solid, white, and amorphous, in the following manner:

Macerate ground or crushed malt in water for some time, then press it; filter the liquid which flows out, and heat it to 158°. This will suffice to coagulate and separate the principal portion of an azotised substance existing in the liquid. Filter the liquid again, and mix with it alcohol till the diastase is thrown down, leaving the sugar, the colouring matter, and the rest of the azotised substance, in solution; and, in order to obtain the diastase pure, dissolve it twice more in water, and precipitate by alcohol as before; the azotised substance then is albumen, and we have the substances separately.

Diastase dwells in the seeds of malted barley, oats, and wheat, but not in the roots or stems of potatoes, except in the tubercles near the eyes, where it associates with an azotised substance as above, soluble, like itself, in water, but not in alcohol; but differing with it by not coagulating in water at a temperature from 169° to 177°, in *not* acting on starch, in being precipitated from its solutions by diacetate of lead, and in being eliminated by alcohol before the diastase precipitates.

As the different kinds of corn and the tubercles of the potato do *not* contain diastase *before* they have germinated, this shows the necessity of malting, without which no diastatic action can consequently arise; and because the value of diastase is super-eminent, a knowledge of the subject will be found available when we come to examine and describe the process of mashing, where will also be found some account of resin, another operative substance not contained in the Table above.

CHAPTER III.

MALTING.

BARLEY—TESTS OF SAMPLES—MOULD—THRASHING MACHINES—PURIFYING AND STEEPING—STEEP-WATER—COUCHING AND FLOORING—DRYING—SPRINKLING AND ANTI-SPRINKLING—KILNS IN VARIETY—KINDS OF MALT—POOLE'S AND WHEELER'S PATENTS—CONSTITUTION OF MALT—TEST—MILLS AND ROLLS.

HAVING in the preceding chapter disposed of all kinds of corn and kernel except barley, and of their constituents severally, we come at length to the remaining corn, and to the properties which distinguish it in the malting process; not that they are peculiar to the seed, but because they perform their functions with peculiar aptitude; and these, by nature, lead to the consideration of another part of our subject, namely, *the qualities of samples.*

Barley is the *hordeum* of the ancients. When the philosophers Fourcroy and Vauquelin triturated the unripe seed with water, it deposited a white powder, possessing the properties of starch; the water passed transparent through a filter, leaving a slimy substance behind it, that possessed the properties of gluten; and when the solution was boiled, it deposited flakes of albumen; the liquid was then reduced to a syrup by evaporation, and this residue being treated with alcohol, and the solution distilled with water, the alcohol being subsequently distilled to remove some remaining gluten which went with it, a syrup was left with a sweet taste: thus was the saccharum of the barley obtained. In the treatment of the meal of ripe corn, they also found the water depositing a white powder, which soon became acid, the acetous water itself reddening an infusion of litmus. This water held a large quantity of matter in solution, consisting of albuminous gluten, mucilage, saccharum, and a proportion of the phosphate of lime and the nitrate of soda.

In its maturity, the farina of barley contains a yellow powder, which looks like fine sawdust, and feels granular to the touch: this is the substance which in our Table above is inserted as "fibre," but which is called *hordein* by Proust, who discovered that the malting process converted it into starch, which is a point of the most considerable consequence, as the meal contains from 54 to 56 *per cent.* of it. Marcet has examined it in both states, and found its composition to be as here given:

Hordein of Barley.		Starch of Malt.	
Oxygen *per cent.*	47·6	Oxygen *per cent.*	51·8
Carbon	44·2	Carbon	41·6
Hydrogen	6·4	Hydrogen	6·6
Nitrogen	1·8	(No Nitrogen observed)	
	100·		100·

These numbers have led Thomson to treat the subject according to the doctrine of atoms; and thence to conclude that hordein loses one atom of carbon out of twelve by malting, and that the nitrogen of the meal is not inherent, but is imbibed by admixture with common air, and, if so, it is again alienated by malting. It appears from this example, and from the specimens at page 26, that malt-starch contains some 2½ *per cent.* less carbon than that of raw grain or potato; and that its oxygen is more by 4 *per cent.*, the hordein nearly coinciding with the starch of the raw substances, except that it holds some nitrogen in lieu of a portion of the oxygen held by the others; Marcet's starch of malt coming within a half *per cent.* of Berzelius's *gum*, as given at page 38 above, in each of its elements.

Precisely in the same quantities are the elements of starch of malt given by Brande; and Thomson's account of hordein, in which he presumes to correct Marcet by the atomal system, is, according to the scale, $O.^{10}$ (10 atoms) = 10, the atom being unity; $C.^{12}$ (12 atoms) = 9, each ·75 or $\frac{3}{4}$; and $H.^{10}$ = 1·25, each ·125 or $\frac{1}{8}$; total, 20·25.

Then, as 20·25	: 100	:: 10	:	49·38 O.	The Elements *per cent.*
*	: *	:: 9	:	44·44 C.	
*	: *	:: 1·25	:	6·18 H.	
		20·25	:	100	

But if we must examine the starch by the same test, we must quarter the atoms, and say, $O.^{10\frac{1}{2}}$, $C.^{11\frac{1}{4}}$, $H.^{10\frac{3}{4}}$, which give, O. *per cent.* 51·77, C. 41·60, H. 6·63, which is as near as can be approximated without absolute decimation of the atoms; and shows, that though malting the hordein has converted it into starch, it has not made an atom difference in any of the elements, but has added half an atom, such as they were, to the whole, and that to the oxygen, the carbon having lost what the hydrogen has gained. But, as the process makes great changes in the other constituents also, it may be as well to notice the system at large.

Malting.—To dissert on this expansive subject fully, might occupy much space; therefore, a few brief but necessary remarks shall suffice, merely embracing the principles and features of the most approved systems, in strict accordance with the doctrine of economy, as dictated by close observation during the extensive experience of many years that the author has prepared his own malt, and improved his practice by intercourse with others.

As the constitutions, energies, and vital functions of grain differ, more or less, according to the diversities of soil, climate, seed, season, and husbandry in harvesting, stacking, and thrashing, so is it necessary that the skill and experience of the maltster should be equal to the important task of selecting those samples of corn only, which produce, by proper management, the richest and most uniform malts; he ought also to be unrestricted by arbitrary laws, and have full liberty to vary his practice in its manufacture, as the quality of his grain and attendant circumstances require, that his produce may at all times be as perfect as the nature of the grain, and his improvements from experience in working it, can possibly render.

The grain of barley, as shown in the Table, consists of sugar, starch, mucilage, gluten, a large quantity of hordein, and a hundredth part of a substance not bitter, but of a resinous character, which principles include some little oil and earthy matter. From these, in due proportion and combination, the plumula or acrospire, the radicle or rootlet, and the desirable saccharine matter, as well as the diastase that produces it, are formed by a healthy germination. When the grain is moist, it swells, decomposes, and evolves heat; the radicle is the most susceptible of these changes, as it soon expands, and conveys food from the moist exterior of the grain in contact with the wet, and probably from the atmosphere also, to the base of the plumula, through the inherent ducts of the cotyledon. While germinating healthily, the grain begins to emit an agreeable fruity aroma, if it have been kept sweet till put to steep, and the steep-liquor have been duly changed. The acrospire also swells, and gradually lengthens under the husk, and in a few days the end of the farinaceous matter, whence the root emanates, becomes friable and sweet. This progression of the germinating and saccharising principle continues, under favouring circumstances, until the cohesion of the particles is so thoroughly disturbed that they have become as meal, when, to complete the process, to prevent waste by excessive vegetation, and to preserve the sweet for timely use, the moisture of the grain is evaporated on a kiln: it now becomes what is called malt, and only requires freeing of its dried roots to render it fit for the brewer.

Such, in brief, is malting; yet, as in every undertaking, a variation in the means adopted in its manipulation, during any part of the process, causes a difference in the product; and never more so than by the two opposite and general practices pursued by the advocates of the sprinkling and non-sprinkling plans, although both parties claim the superiority, as rivals ever will.

Selection of Barley.—The barley most suitable for being converted into malt, grows on large hedgeless tracts of light calcareous land; and crops excellent in quality, also grow on rich loamy soil; but much likewise depends upon the seed, which will impair after a few sowings on the same land. The best has a bright, clean, thin, wrinkled husk, closely adhering to a plump, round, well-fed kernel, which, when broken, appears white, chalky, and sweet, with a germ full, and of a pale yellow colour. On the contrary, barleys that grow on cold, moist, aluminous soils, have a thin kernel and thick coarse hide, are colder in their nature, and make malt very much inferior in flavour, and from 10 to 15, and sometimes as much as 25 *per cent.* less prolific in quantity of extract. The farina of many of these inferior barleys is of a yellowish colour, and breaks hard and flinty, whence they are avoided as much as possible by the wary, as the very best pay no more duty, and in many cases not so much, which is a consideration of many shillings *per* quarter in pristine and ultimate value to the brewer who makes his own malt, the value of the additional extract often doubling the additional price paid for the raw grain.

Sugar-planters cut their canes before they have flowered, because they say that the nourishment which feeds the blossoms, lessens the sweetness of the juice; and as corn is known to ripen twelve days after it leaves the sickle, and as a certain quantity of native moisture contributes to the contraction of the sweet principle when seasoning, many experienced agriculturists, rather than run the risk of having their barley shed or its ears broken off in the field, make a point of cutting it before it is quite ripe; but experience will soon convince an attentive observer, that the ends of the malt made from barley thus husbanded, incline to be steely, which is not so with the corn cut in its proud maturity.

Barley is not in a proper condition for malting, until it has sweated and seasoned in the stack or mow, two months at least. Artificial sweating on the kiln has sometimes been made an expedient, with tolerable success, but is not so effective in dispelling the benumbing cause that prevents the grain from absorbing a sufficiency of pure water when in the cistern, as by a gradual decay and partial appropriation and dissipation of the superfluous and morbid moisture when in the stack. Sweated barley loses from a 30th to a 15th of its bulk, but generally recovers it again in the cistern.

The cautious maltster also directs his attention to any inequality of colour or size that may be in the samples presented to him, which act of care enables him to detect and avoid such mixtures as he knows will not grow evenly under the same circumstances, since it would be as impossible for a variety of barleys, or for the same barley differently housed and seasoned, to make an uniform malt, as to train human beings under the influence of a contrariety of circumstances, and opposite sentiments and dispositions, to a concurrent system of thought and action.

The thin coat of barley, and especially that of the finer kinds, when stretched by the plumpness of the kernel, is closely attached to the farinaceous matter within, with which it is intimately connected by a spongy substance that valvularly feeds the interior from without, as from a series of syphons in mutual action, and is therefore better supplied with solvent principles in one condition than another, and consequently is readier for solution.

Levesque, in his Brewing Essays, remarks upon the great care necessary to be bestowed upon barley that has to be coasted to London in large quantities; after all which, if the voyage is prolonged by contrary winds, the whole cargo will spoil and become unfit for malting. This essayist has laid down an axiom, that if barley, when it has been thrashed out, lie damp or exposed, it will soon lose its freshness, and smell strong and disagreeable, which, as he says, must depreciate its value. Like the Irish potatoes named in the foregoing chapter, such barley will also heat when on board, and is injured similarly to such as is overheated in a stack; the germ end of the grain turns to a blackish red colour, which denotes that the germ is killed. Take the skin off the germ end of the corn so discoloured, and it will appear shrivelled; but when uninjured the germ is full; and if the skin be taken off, the interior will be found yellow, and will look like butter. Another writer on the same subject cannot believe that "ship barley" *ever* makes good malt, because he supposes that it is *always* a mixture of various sorts; but since the introduction of steam navigation, many excellent cargoes have arrived from abroad, by no means inferior to our best specimens at home. In February, 1850, barley brought from the Saale, a tributary river to the Elbe, was yielding from 93 to 95 lbs. *per* quarter of beautiful extract, under the influence of the Hot Masher, at the Nine Elms Brewery, Vauxhall, London. It is necessary to know that the germ of new stock is paler than that of old.

Another serious, and indeed vital injury, inflicted upon the sensitive germ and its mother seed, is through the use of the thrashing-machine, which unfits them for malting by bruising and severing them. Such injured grain is incapable of vegetation, but *not* of putrefaction, which is evident from its blue-grey and mouldy appearance, and from the offensive effluvium which it emits upon the floors. Corn cut into sections does not germinate at all, and that with broken husks very imperfectly and partially; and even then the acrospire and solvent farina escape through the fracture, and the whole interior turns yellow and putrescent, tasting like rotten fruit, long before it reaches the kiln. The mephitic gases that emanate from this spoliation, often impart a bad odour to the more perfect grain in contact; and besides the first cost and these evil consequences, the amount of excise duty is another weighty reason for avoiding the purchase of an article so expensive, and liable to such contamination, without producing one compensating quality. When the mould makes its appearance, the maltster is deterred from sprinkling, because moisture only aggravates the evil; yet, by this seemingly wise precaution he entails an injury on the healthy corns by denying them their natural sustenance, whereby the germinating process is retarded, and consequently the saccharine production is limited in amount. The author has known the corns cut into two or more pieces to the amount of 10 *per cent.*, and with their coats cracked or torn as many as 15 *per cent.*, through being partially beaten off by a badly constructed or deranged machine: the sight of such havoc is most conspicuous and deplorable, just at the time when the grain is going to kiln; for it is then that these maltreated cripples, swollen by putrefaction in shapeless mouldy masses, give the whole body a blue and unsightly appearance, and an unpleasant odour, like exhumed bodies of martyrs risen up to appal the assassins that sent them prematurely to their destiny. In drying and turning on the kiln, nearly the whole of the mould tumbles off like a blue powder, and falls through the bottom, and the remainder passes through the screen; but the dried putrid farina remains, and its effect in the mash-tun is to stop the pores of the mash, a great proportion of it dissolving, and thereby preventing the wort from coming off bright. It is worthy of remark, that so strong a tendency has such wort to commence fermentation, that no barm is required to excite it at pitching; indeed, upon consideration, we know that some portion of the wort, being, in this particular case, an azotised matter, is in a state of putrefaction which boiling does not totally annihilate; for it is of the same identical constitution, and in the same condition, as yeast itself, and, consequently, it acts in the same manner, and with the same effect upon the saccharine principles accompanying it during fermentation, but yet more energetically, probably from being more equally diffused and in closer connexion.

Worts invested with so much putridity have been known to attenuate from 26 lbs. (being common stout) down to 8 lbs. in the space of forty hours; and in the winter season, when the heat of the gyle did not exceed 61° at any time. Here the brewer's interest is in unison with that of the poor agricultural labourer; for the flail and steady honest manual labour of the poor man is far preferable, in a commercial and domestic view, to this rough misapplication of the non-compensating machine, which, in this instance at least, robs the defenceless man of the means of earning a few shillings through the severest and dullest part of the year, when the other avenues to employment are closed against him.

Steeping.—This is generally done in a slovenly and unscientific manner, one uniform time being observed, whether the grain requires more or less. Both maltster and brewer would profit, if all the grain used were carefully screened before steeping; because the thin light corn pays duty, becomes exhausted in malting, and fills the measure without imparting one-fourth enough of saccharum to pay its cost. Some maltsters run their barley over a short screen, placed between the store or garner and the cistern; but the screening which it thus receives is very impotent. The most expeditious and effective barley and malt screens now used, are cylindrical in form, and revolve by hand or other power, at an angle of inclination of about 30°. Running the water into the cistern first, rousing and slowly washing the grain in, and skimming off the bruised, cut, and light husky corn, with the chaff and dirt that may accidentally accompany it, is also advisable; and to do this with ease, one edge of the cistern might be made lower than the others, to allow the water and swimmings to flow away over that edge, to fall on a fine grating, while the grain is being roused into the cistern.

The quantity of liquor imbibed by the barley when in steep, greatly influences the future quality of the malt, and depends upon the time that the grain is allowed to remain in the cistern, the temperature of the steeping-liquor, and the quality and condition of the grain. The bolder and heavier kinds of barley are seldom steeped long enough, and, in fact, every maltster throughout the country drains his cisterns from twelve to twenty hours too soon, especially in very cold weather, and when he uses river-water, or any other that has been exposed to the atmosphere.

The temperature of the steep-water does not occupy the attention of the inconsiderate maltster, since all that he requires is liquidity; yet it must be evident that grain will absorb a much greater quantity of water from a well, which is usually at 52° or 53°, than of river-water ranging from 33° to 40° in winter, the same length of time being allowed for steeping in each instance; and, upon the same principle, less well-water than river-water will be imbibed when the latter is raised by atmospheric changes to 66°, and means should be at hand for regulating the temperature accordingly; and the grain should not be removed from the steep-water so long as its nature requires further imbibition.

The future sweetness of the malt is materially promoted by frequent changes of liquor, though the officers object to more renewals than one, which certainly is insufficient in mild weather; but it is better to replenish once than not at all.

The legislature directs that all grain shall be steeped forty hours, or "so many hours longer as shall be found necessary." From forty-five to fifty hours is certainly quite long enough for the cold thin rubbish which ought not to be steeped at all; but the stouter and finer wettings require from sixty-four to seventy-two hours in the cistern, to saturate them sufficiently under ordinary circumstances. Attention to this particular is highly essential when it is desired to make a perfect and rich plump malt, regardless of a charge of five *per cent.* more duty which the additional swell will produce, but which in reality pays nothing extra, if measure of material and quantity of extract be considered, as shall shortly be shown; yet some maltsters who make for sale, being regardless of saccharine production, and wishing to pay as little duty as possible, purposely steep only for short periods, in order to prevent the enlargement of the kernel: it is needless to say that no sensible brewer would be guilty of such absurdity, or encourage such ultra-penurious practice in others.

COUCHING.—The grain, having steeped long enough to saturate its farina to the centre, is now drained and thrown into a frame called a couch, where it lies about twenty-six hours, during which time it swells a little higher, generates heat, and emits some carbonic acid gas, giving proofs that the process of germinous fermentation has commenced; and this is the chief purpose of couching. Here the excise obtains the greatest gauge, and fixes the duty, accounting the greatest "tell" the most correct charge. The average increase of bulk is little more than a fifth, and "the law presumes that the swell will amount to 18½ bushels for 81½ bushels before steeped;" but if the barley was bold and dry, the malting brewer would find it much to his advantage if the increase amounted to a fourth; that is, if 80 bushels gauged to 100 in the cistern; for it is of the utmost consequence that the grain carry with it a sufficiency of moisture to supply the operations of nature till the first sprinkling-day, which by law is the seventh; for by the 1st Vict., c. 49, sect. 7, "a maltster may sprinkle a floor of grain which has been kept in the cistern covered with water the full space of fifty hours, at the end of six days, or 144 hours."

If the sides and floor of the couch-frame were perforated, it would facilitate the change of air, and equalise its temperature throughout the body of the grain.

Flooring.—The barley, having been removed from the frame, is to be spread considerably thinner, that too much heat may not be generated, and that the rootlet may not be too speedily elongated. Malt-houses in general are badly lighted and ventilated. It is highly important that a current of air should pass freely over the floors during the whole process, the beneficial convenience depending more or less on its temperature, which care will regulate at all seasons. As much light as possible should also be admitted, though to the exclusion of the sun's direct rays. By means of these two improvements, the health, strength, and flavour of the malt will be greatly promoted.

The art and attention of the maltster are now demanded to regulate the temperature of his *pieces*, and influence the growth and form of the radicle; for which purpose a thermometer is sometimes useful, and particularly when the atmosphere is under 40°; but when above this, it is seldom of practical service, because the pieces cannot be cooled below 40° by either thickening or thinning, or yet by turning; and these are all the means of regulating the heat which the maltster has hitherto possessed, he having been all along a full century behind the brewer in mechanical contrivance and philosophical research, though he might easily have provided himself with *attemperators* suitable for the purpose. A new era, however, has now opened through the author's "Improvements in the Manufacture of

Malt," which has been briefly reviewed by Dr. Muspratt, an extract from which will close the present chapter.

As a thermometer may be of some occasional service, the author would next suggest that its frame be of metal rather than wood, as the latter is a bad conductor of heat, and the temperature of the frame influences the mercury so much that considerable time is required to examine the exact state of the pieces into which it is newly inserted. It should also be pointed at the bulb end, that it may the more easily pierce the grain. If possible, the young floors should not exceed the heat of 50°, and should be turned once in every four or five hours at the longest; bearing in mind that the lower the temperature, if not below 45°, the more gradual is the progress of both root and spire; the thicker, more numerous in fibres, and bushy will the root be; and the more general, natural, and uniform, the decomposition of the imbibed water and of the farina, by which it is especially appropriated. These are objects which the active and thoughtful maltster—for some such there are—regards with concern; though we must admit that he is sometimes foiled by circumstances over which he has had no previous control, such as the constitution of the corn, the state of the weather, and coercive laws.

Unless the floors are duly turned and kept cool, the smell of the moist grain will become unpleasant, and the radicle will consist only of a few long weak filaments, serpentinely entwining each other, and imparting but little nourishment to the acrospire. As these floors become older, they increase a few degrees in warmth, but should never be allowed to ascend above 56°, if possibly avoidable. The roots and spire now gather length and strength, and the kernel becomes white, mealy, and sweet; these indications continuing to show themselves with greater conspicuousness as long as the germination is progressive, and the grain sweet and healthy, which, however, seldom extends beyond the sixth day. At the termination of the restricted period, the corn is allowed to acquire a replenishment of one of its principal recreatives, *viz.* water, which must be greater or less, according to the previous dry or foggy condition of the atmosphere, the time it has been in the cistern, &c.; but it usually requires from one gallon to two upon each quarter. We know that it is the practice of those who water their floors as a principle, to use twice and even thrice this quantity at once; but this excess is objectionable, because some of the grain in the nether region of the piece receives too much water; and hence it is far preferable that a smaller quantity be applied at every turning, or at least at each alternate removal, or indeed as occasion may require, till the termination of the ninth or tenth day, when it may be discontinued; and about four or five days more will be quite sufficient thoroughly to saccharise the corn, and to consume and evaporate the chief part of the moisture; and it is then fit for the kiln. As it is deemed of the utmost importance that the germination be not allowed to flag between the couch and the kiln, and that it may receive the first effects of the fire of the latter while full of life, health, and sweetness, the custom of *withering* is here dispensed with as an absurdity.

As regards the criterion to be observed in the growth of the root and spire, the author knows, from oft-repeated experiments, that the former needs not exceed half an inch in length, that it is never too bushy or too strong, and that the latter cannot be too long while confined within the limits of the husk, though sufficiently not to shoot through upon the kiln; it is, however, important to observe that whenever the barley is so superior through its chalkiness, that it is literally half-malted before steeping, it is not necessary that the spires should reach the end of the corn by one-third, and in some cases one-half of its length. This kind of grain requires less than ordinary sprinkling.

The next operation is that of drying; but here we may properly stay to reply to the principal charges brought by maltsters who do not apply water to their floors, against those who are desirous to do it periodically.

Objection 1.—*Unwatered malt is from* 30 *to* 40 *lbs. per quarter heavier than that which is watered.* Reply.—Unsprinkled malt usually ranges *from four to ten lbs. per* quarter heavier than sprinkled, if the barleys were originally equal in quality and condition ; but weight is no criterion of the goodness of malt, though it may guide the buyer of barley. The non-sprinklers admit that where the vegetation of the grain has been imperfect, the product is faulty, and yet heavier than good, being partly malt and partly barley; which argues against their own theory of perfection. Little do they incline to think that the more oxygen the grain absorbs while germinating, the lighter the malt becomes; and yet they properly admit that the imbibition of this gas is necessary to the conversion of the farina into saccharum, though they unwittingly fall into the same error as Mr. Reynoldson, who was their chief opponent in 1808, in supposing that the increased weight of their grain is attributable to such acquisition ; which is absurd. The unsprinkled is heavier, not because it is more oxidised, and consequently sweeter, but from the opposite cause of deficiency in the appropriation of oxygen ; and hence its greater weight is only a proof of its less full conversion from barley to malt.

Objection 2.—*The root is the vehicle by which the* *oxygen of the atmosphere is conveyed to the interior; and the formation of saccharum is in proportion to the appropriation of that element by the farina.* Reply.—Admitting this principle, still the most skilful of all these advocates of starvation have not shown that the cotyledon, *when immersed in steep*, is furnished with air-vessels for the conveyance of this especial element from the aërial regions. Perhaps it will be safer to suppose, in the absence of better evidence, that the main source of the oxygen is decomposed water, particularly as this contains three times more of it than air; but be this either way, it does not militate against the sprinkling system, since we know that the starch of the grain is oxidised in a fifth of the time occupied in the *dry* process of oxidation.

Objection 3.—*When the floors are watered, the heat increases, and an equable heat cannot be preserved; which causes flinty malt.* Reply.—"Vain reasoning all, and false philosophy." This also appears to emanate from parties who judge theoretically, and without having ever paid practical attention to the subject. Every one knows that moisture increases the evaporation of caloric, and that in the East the same principle is applied in cooling wines and freezing liquors, as well as in surgery and the use of lotions. The truth is, that the generation of caloric is checked or removed under the sprinkling system, and that the pieces are many degrees cooler than the unsprinkled can possibly be: this some of the non-sprinklers know; for they grant that to promote the growth of the acrospire, they lay the grain a little deeper, and keep gradually increasing its thickness up to the kiln. It must then be clear that this deepening of the pieces is to preserve the moisture, and to increase the heat.

Objection 4.—*Some of the corns get so much moisture,* *that it causes the mould.* Reply.—The sprinkling is not intended to be done in so slovenly and prodigal a manner as to give any of the floor a surplus supply of liquor; yet, were this the case, it could *not* cause the mould, unless the grain had been previously injured, and then the mould could not be attributed to any particular system of procedure in the malt-house. Besides, the mould also originates in an extreme putrefaction of the gluten, which by contagion affects the albumen, mucilage, &c., a species of decay which cannot take place where a due provision of coolness, and the necessary fresh moisture for the preservation of vitality is observed. This may not always be done; but we must not condemn the system upon the error of the individual who negligently professes it.

Objection 5.—*The non-sprinkling plan is the most natural, clean, pure, and free from adventitious flavour.* Reply.—As the natural process of vegetation is subject to a constant supply of the elements congenial to its growth, the chief being a regular accession of fresh moisture, which is derived from the soil, rains, fogs, &c.; and as the anti-sprinklers purposely withhold such nourishment, and prevent a free circulation of atmospheric air by heaping their grain together, their opinion of a "natural process" is paradoxical; and besides, their roots are flaccid, brown, and enveloped in their excremental gases, which render the grain the reverse of clean and pure, and of being free from a sour and putrid flavour, which sort of flavour they necessarily mean by the word "adventitious."

Objection 6.—*A cautious and artful maltster may defraud the revenue of half the duty which he ought to pay, and yet incur very little risk of detection, provided he is indulged with watering the short wet corn on the floors.* Reply.—He cannot be guilty of vast fraud, if vigilantly watched by the officers; and if he could, that would not be a just cause for depriving the honest and most respectable of the more skilful portion of the malting world, of the best and most philosophical means of making good malt; and they constitute a majority: neither is it right to deprive the brewer and the vast ale-drinking community of the eminent advantages they ought to reap from the advancement of science in the production of an article, which derives from its employment a honey-like richness of extra-superior quality, naturally healthy and well made.

Objection 7.—*The vegetation of the sprinkled corn is forced, and is consequently pernicious.* Reply.—This charge is rather obscure; but if by "forced" is meant *expedited*, it is admitted; but expedition and force are two things, and it does not follow that either of them leads to pernicious results: on the contrary, enticing, so far as it fattens the malt by repeated applications of good, wholesome, and natural food, and only when the appetite demands it, cannot be pernicious: and reason, experience, and the saccharometer, prove the fallacy of the charge. But to force, by means of an accumulated amount of caloric, generated amidst mephitic gases, purposed starvation, and partial putrefaction, prolonged through five or six days more than are required by the other method, is *really* pernicious, because the efforts of nature are paralysed, and the local suspension begets flints and a gritty mealiness, besides a deficiency of both saccharum and flavour.

Objection 8.—*The watered barley throws a fresh root after sprinkling, and the old root is purposely beaten off in turning.* Reply.—The form and number of the fibres are points of solicitude with the observant maltster, but their length is not so much an object with him as their number, strength, and healthiness, on which their power in only conveying fresh supplies of food to the acrospire and kernel through fully extended and vigorous ducts, mainly depends; and although some of the roots may be beaten off in turning, it is never intentional, but merely accidental; and if fewer roots are lost by the non-sprinklers, it is because their pores have collapsed, become tougher and more fibre-like, and, of course, less capable of conveying the oxygen, of which they are so solicitous, from the atmosphere, in which it awaits their bidding.

OBJECTION 9.—*One of the evil results of sprinkling is a large strong root and spire, and therefore a needless exhaustion of the kernel.* REPLY.—This, to theorists, may appear plausible enough, yet it is also erroneous, and for these reasons:—Although the radicle and plumula are certainly stronger in the watered than in the unwatered specimens, yet their size does not arise from the solid of the kernel alone, but in a great measure from the decomposition and self-appropriation of such fluids as are occasionally presented to them through the watering-pan by the nursing maltman; and, moreover, such constituents of the grain as enter into the composition of the roots, consist chiefly of the least valuable and most objectionable parts, namely, the gluten and hordein, which they assist in reducing; these appear to be the cementing or cohesive principles of the barley, of which it is necessary to dispose to facilitate the preparation of the saccharum; and as these, including the albumen, are the most perishable parts of the corn, it follows that their removal by the root or otherwise, renders the malt more suitable for brewing ales in hot and precarious seasons, and, indeed, at any other time; the saccharised starch and other valuable matter being intended by nature to enter into the composition of the acrospire or future stalk as it proceeds, that it may constitute the germ of its own kind; yet, as the spire is never allowed to arrive at such age, strength, and condition, when in the maltster's hands, as would require those precious fundamental principles, or be in a fit state for their reception; any other appropriation in this respect, or any needless exhaustion of the kernel, cannot be fairly attributed to the more vigorous system engendered by sprinkling. In fact, a long or large root does not spring through the course of necessity, but is the casual consequence of an operation; for in some particular wettings of grain, a full formation of saccharum is evinced without any extension of the radicle, and in some instances the mere appearance of a rootlet is all that is put forth; and whether it be large or small, the spire and root subtract the elements of the starch and other solvent matter, in appropriate portions for the formation of sugar; and sugar can be made, though not so freely, without germinating the corn at all. Again, it is necessary to remember, that it is not until the spire breaks forth into light, that the kernel begins to liquefy to feed it: hence the precaution of all maltsters to stop the vegetation by drying, before such an accident occurs, some allowing the spire to extend two-thirds, some three-fourths, and others seven-eighths, up the back, according to custom, conviction, or notion.

Objection 10.—*Unsprinkled barley emits a vapour upon the kiln, which shows that it carries with it water enough from the cistern to malt it completely.* Reply.—This is no proof that the escaping vapour may not be so far exhausted, so contaminated, and so dissipated in the grain, that it has long been unfit for affording any further support to the germ, or for prolonging its vitality. The grain must be drier than it was before steeping, were it to emit no vapour upon the kiln.

Objection 11.—*Another object in sprinkling, is to increase the measure some ten per cent.* Reply.—The measure is certainly increased, but the accession of bulk to the maltster *is not half so much as ten per cent.:* it would be better if it were so, provided that the other advantage of above five *per cent.* increase in fermentable matter, which is insured by the sprinkling system, could at the same time be retained, to afford some compensation for the increase of duty available to the excise.

Objection 12.—*Watered malt yields from twenty to thirty per cent.* less *extract than unwatered.* Reply.—This is a wide, and undoubtedly a wilful, mistake, and may more properly be called a perversion. The author has repeatedly taken experiments during several years, in order to meet this assertion demonstratively; and the following is the average result, which establishes the superiority of the sprinkled corn over the unsprinkled, upon a ground that any other fair series of experiments will prove to be undeniable:—

Treatment.	Quarters steeped.	Measure when dried and screened.	Weight *per* bushel.	Quarters mashed.	Extract *per* quarter.
Sprinkled....	25	26·3	40¾	25	90·4
Unsprinkled .	25	25·6	41½	25	86·2

Showing, that though the additional increase in measure, or outcast, is not three *per cent.*, the additional extract from an equal quantity brewed is 4·2 upon 86·2, or 4·87 *per cent.* To the brewer who makes his own malt, the comparative value stands thus, supposing that his malt in each case stood him in 58*s.* *per* quarter; both malts having been screened once, and alike:

25 quarters of barley, unsprinkled, produced ..	86·2	lbs. *per* quarter.
And the total quantity of malt made in quarters and tenths, was	25·6	
86·2 × 25·2 =	2206·72	lbs. of extract.
25 quarters of the same, sprinkled, produced ..	90·4	lbs. *per* quarter.
Quantity of malt made in quarters and tenths ..	26·3	
90·4 × 26·3 =	2377·52	lbs. of extract.
Deduct the above	2206·72	
Increase in favour of sprinkling	170·8	lbs. at 8*d.* *per* lb.
Which reduces to	£5 13 10$\frac{1}{10}$	

Being an *additional* gain of nearly 8 *per cent.* upon the 1450 shillings expended; for $\frac{113\cdot86 \times 100}{1450} = 7\cdot85$, or £7 17*s.* upon each £100 of the outlay.

But the malting brewer's *real* profit in this instance, will appear in a more absolute light, if considered as follows:

	£	s.	d.
2377·52 lbs. of sprinkled malt at 8*d.* *per* lb. produce	79	5	0·16
25 quarters of barley bought, at 58*s.* cost	72	10	0
Gross profit	£6	15	0·16
But 2206·72 lbs. unsprinkled, at 8*d.* give only	73	11	1·76
Cost of barley, as before	72	10	0
Gross profit	£1	1	1·76
Difference of profits between the cases as above	£5	13	10·4

It will likewise be perceived that the increase in measure is $5\frac{1}{5}$ in the one instance, and only $\frac{4}{5}$ in the other, besides obtaining the preference in the market, as a reward for extract and flavour.

We may again observe that the difference in the measure is caused by the strongest roots of the watered corn not breaking off so near the end of the grain as those of the unwatered, and that the root end of the husk is also more extended, by being occupied by the stumps of thicker and stronger roots, so that the corns keep one another farther asunder in the measure; and this is a more correct way of accounting for a decrease of weight, than by supposing that it is occasioned by the exhaustion of the kernel by germination.

Kilns and Drying.—The limits of this publication prevent any lengthy observations on the structure, advantages, and disadvantages of the numerous kinds of kilns on which the drying part of the process is effected: it must suffice to suggest, that the drying-floor should be sufficiently capacious to accommodate a whole steeping at once, at a moderate depth of from twelve to sixteen inches. The floor may consist of hair-cloth, pierced iron, tiles, or wire; but the latter is preferable by far to any thing liable to choke up, and affords a readier access and more equal distribution of heat to the grain. It is also suitable for imparting any gradation of colour, from the palest to the brownest, though a little more attention to the fire may be necessary when drying pale malt upon the wire, than is demanded by the tiles. Cokes, anthracite coals, dry and green wood, and peat, are used for this purpose, according to locality, price, and the colour in request; that which dries off the greatest quantity at the smallest expense, without impairing the flavour of the malt, is the best. In some instances, hot-air tubes, leading from the furnace, fire-place, or hot-air chamber, and some two feet through the drying-floor, have been adopted, and found to answer the purpose remarkably well, in rarefying the moisture and air that hover on the surface of the grain, and thereby causing it to ascend directly through the corn, instead of the maltman having to turn the sweating and refrigerating corns to the bottom, again to cause the rarefaction and condensation of the moisture and vapour, in their passage from the wire through the cold surface. By this contrivance, besides a saving in fuel of from 10 to 15 *per cent.*, the flavour of the malt is preserved, through not being exposed so repeatedly, after the commencement of drying, to the vicissitudes of heat, cold, aridity, and humidity, and, consequently, by being subject to less evaporation of the aroma of the malt, which inevitably escapes with the vapour. A wire tube placed in each corner of the drying-room, descend-

G 2

ing through the floor of the kiln, and standing about eighteen inches above the grain, will be of similar utility.

When a steeping is dried off at two, three, or four times, the first kiln must either be malted too little, or the last grown too much, either of which casualties will present inequalities in the sample; and besides this, as much less time and more heat are thus engaged in drying each separate portion, there is a danger of refixing the gluten, and enveloping the partially converted hordein and starch together during the drying, or rather baking; and in this way, much hard, steely, and brittle malt may be accounted for.

A thermometer about two feet long, with a scale of some eight inches' range, the frame pointed at the bottom as before directed, and extending four or five inches below the bulb, is indispensable where uniformity is desired. Here this instrument may be used to considerable advantage, as the maltman may regulate his fire or his dampers according to the degree of heat required to pass through the grain during any period of the process.

Pale Malt.—The most profitable manner of drying pale malt, is to do a whole floor without hindrance, and slowly to occupy from two and a half to three days in the operation. During the first twenty hours the heat may be maintained at 80° to 84°. In the second twenty hours the heat may rise from 10° to 15°, and the heat not exceeding 90° at the end of the second day. During the last twenty hours, the heat may be allowed gradually to advance to 120° or so, and for malts less pale proportionably higher. Turning the grain on the kiln is rendered unnecessary by the current of hot air above alluded to.

Pale malt for India ale should be dried on kilns at least fourteen feet above the fire, in which case the air-chamber will be capacious and lofty. The furnace should be constructed so as to enable the workman to exercise the utmost control over the hot and cold currents for several hours without his attendance; and in all cases, some hot air should be made to pass direct from the furnace *over* the corn in upright tubes, or by independent side flues. It is better to unload the kiln without damping the fire or permitting the malt to cool; and this being done, to screen immediately and store away hot in a close dry room. Some experienced maltsters contend that it is preferable to trample off the root and store it away with the malt, because it fills up the interstices and excludes the air; while others, who make for sale, say that it acts more effectually if left on. The best way is to tread off the root, screen out about one-fourth of it, and throw it all over the malt, as a covering; but the salesman maltster had rather decline screening till his malt is sold, that it may remain light in an open store, and swell a little by the effect of the atmosphere playing through, which will also toughen the roots to prevent their breaking off close to the husk; but these considerations cannot serve the malting brewer, who calculates his profits by that unerring instrument the saccharometer, and to whom richness and aroma are so desirable and so valuable.

Brown Malt is made and dried in a similar manner to pale, excepting that before it is perfectly dried, a little water is sprinkled over it upon the kiln, to give flexibility to the husk; and the drying is finished by a brisk heat, derived from dried beech or other timber; and during this latter part of the process the grain is not above two inches thick, and is constantly being turned.

Another mode of high-drying has recently been adopted by the late Mr. Poole, of Camberwell New Road, who, in November, 1843, took out a patent for the merit of having combined rotatory motion in connexion with a cylinder, heated exteriorly by an oven or furnace, though he has laid no claim to the invention of the cylinder itself, which has long been used as a *roasting* apparatus; and it is clear that in this application of the principle it will either roast or merely dry, though he titles his scheme "improvements in *drying* malt." His mode of procedure specifies to put his malt into a cylinder of wire-cloth, placed within the iron one, in an oven or the flue of a furnace, the cylinder having arms by which it is fixed to a hollow shaft, made to revolve by hand or otherwise. The heated air then passes inwardly through the wire-cloth to the grain contained within it, which it permeates, and escapes out again through the hollow shaft, one end of which is prolonged outwardly from the oven, so that by the aid of a rack and pinion, the cylinder may be drawn from the oven at pleasure, as the state of its contents may require. The oven is closely fitted with doors, both at the place for withdrawing the cylinder, and also at the exit end at which the heated air and gases issue; and thus, when the cylinder is in action, no air, &c. can escape, except through the drying grain, and thence by the prescribed channel.

Blown Malt.—Another method of making brown malt, which is followed by most of the maltsters in and around the metropolis, is to lay the vegetated barley on a wire-kiln, in a tolerably moist condition, from half an inch to an inch thick only, and immediately to dry it off with blazing straw, where it can be had, or more usually with wood, where straw, whin, or fern is not procurable, keeping it constantly in turning by men with shovels, who, through the intensity of the heat and fumes, added to their labour, are nude with the exception of drawers and clogs. The grain thus expeditiously dried has the term *blown malt* applied to it, through having acquired an unnatural size from the sudden expansion of the husk, by the forcible rising of the farina and steam within.

Porter or Black Malt, commonly called Patent malt, from a patent granted for the invention and manufacture of it in 1817, to Daniel Wheeler, of the parish of St. George, Middlesex, is the legal colouring matter used in porter brewing, and is prepared by roasting inferior pale malt in cylinders, like coffee, at a heat of 360° to 400°. These cylinders, constructed of thin iron, are made to revolve over an enclosed furnace, till the malt within them acquires sufficient darkness of colour to answer the purpose intended. This preparation is by some thrown into the copper with boiling worts that are being brewed into ale, merely to extract its colouring matter, which is done without solving its farina; others mash it with their ordinary malt; and a third class put part into the mash-tun and part into the copper. Any kiln of unvegetated or deaf malt, or brown malt which has over-dried, may be turned to this purpose, if scorched till unfit for brewing into ale. Wheeler's patent superseded the use of *essentia bina*, or sugar-wort evaporated to a treacle-like consistency, the sale of which had been monopolised by the celebrated Alderman Wood.

The following analysis of Barley and Malt is from Prout, and pretty clearly shows the great change that takes place through the malting system:

	Barley.	Malt.
Hordein	55	12
Starch	32	56
Gum (or Mucilage)	4	15
Sugar	5	15
Gluten	3	1
Yellow Resin	1	1
	100	100

Constitution of Malt.—We see, by the analysis of barley and malt, given in the foregoing Table, that the hordein or matter of barley decreases 43 *per cent.* by the malting process, that the sugar increases 10 *per cent.*, at the rate of 3 to 1, its parent starch 22 *per cent.*, and the next kindred ingredient, mucilage, 10 *per cent.*, the hordein having assumed the character and constitution of one or another of them, according to the degree of transmutation that it has undergone; whilst the gluten, containing of course the albumen, has diminished two-thirds, and yet left sufficient remaining to carry on the work of future conversion; whence we once more infer that the hordein, which is the crude ingredient, first yields starch in malting; that this portion afterwards gradually becomes sugar; and that the gum of the first formation is the first also to yield sugar by transition; and by parity of reasoning we conclude that the gum yielded by the bursting starch, which the analyst has here confounded with mucilage, was the last formed, and had not time, while on the maltster's floors, for farther transmutation into sugar; but we do not by any means charge the trader with the imperfection, because, if he had humoured the farther progress of vegetation till more of the hordein had become starch, and the starch already formed had more of it become sugar, neither he nor the brewer would have been any gainer thereby; for, as before observed, both the acrospire and the radicle are principally nourished and maintained by the newly-formed fluid sugar, after the former breaks through the husk; so that it is better to stop here, and to transmute the remnant by some subsequent mode of treatment less hazardous, since an extension of the malting process would present even less saccharum than now matured, as the longer and hardier the blade grows, and the more lengthy and ramified the rootlets become, the more of this sweet nutriment they require to devour for their support; and if left to the care of nature alone, they would completely empty the husk.

The analysis of barley chosen for the Table is not quite so exact in numbers as one of barley-meal by Einhof, who has starch and hordein 67·19, saccharum 5·21, mucilage 4·59, gluten 3·52, phosphates 0·24, volatile matter 9·38, husk 6·77, albumen 1·12, undescribed 1·98. In some of the leading particulars the two accounts differ but little, yet it appears that full 20 *per cent.* of that which Prout could save in transmutant or convertible farina, was lost by Einhof in separating his husk from the substance, and permitting a quantity of his meal to evaporate and fly off in volatility; and that the material which one separates as albumen, the other has passed unnoticed or classed as resin; but neither of them has noticed the oil.

The character given of resins is, that they abide in almost all plants, and in almost every part of the plant; that they are tasteless and inodorous unless they *retain* some volatile oil; and that they are kept in solution by that oil when extracted from the plants that bore them; but that when the oil becomes exposed to the air, it either escapes or is *converted into resin* by the absorption of oxygen. Thomson supposes that resin is in reality volatile oil, not only combined with oxygen, but also deprived of some of its hydrogen, and splits the opinion as to its destination with Prout, who says that "when volatile oil is exposed to the air, it is partly converted into a resin and partly into a crystallised acid." Well, therefore, may the 2 *per cent.* lost in Einhof's analysis through his haste to evaporate, include the 1 *per cent.* observed by Prout in his cooler process. Such is the ready fate of the resin of barley or malt, which, by its solution and dilution, tinges wort with a golden colour.

We have seen that green barley is one-half volatile matter, including the oil; that meal does not contain 10 *per cent.*, though, according to Einhof, barleycorns contain 43 parts in 384, or rather more than 11 *per cent.*, though its resin amounts only to 1 *per cent.*, which it retains in the state of malt; and this shows that the whole or most of the matter accounted volatile gradually disappears, except the oil, which will go likewise, unless by chemical synthesis it combines with oxygen to form the more concrete substance, which is found to be a species of resin.

The necessity of preserving this transient qualification of the barley, which is done by malting, is better known and more appreciated in the distillery than the brewhouse, as it is asserted that whisky owes its peculiar flavour to "a volatile oil that exists in the barley," and which is known to dissolve in six times its weight of alcohol, or double its weight of ether. Hops yield a similar substance; for when they are digested in alcohol, chemists find a greenish yellow solid matter, consisting "partly of oil, and partly of resin;" but the older the hops, the more resinous it is; which again shows that the volatile oil progressively transmutes and becomes more concrete in its nature; and then, according to Payen and Chevallier, who have tested it, it will require water ten thousand times its weight to bring it into solution.

Resins, as appears from various authorities, generally contain from 77 to 83 *per cent.* of carbon, and about equal quantities of hydrogen and oxygen; and best volatile oils from 80 to near 90 *per cent.* carbon, and little oxygen or none, and are devoid of nitrogen also.

We will now take the elementary principles that constitute the more prominent characteristics in the transmutation of malt, and compare them relatively.

ELEMENTS.	Symbols.	Hordein.	Starch of Malt.	Gum or Mucilage.	Sugar of Malt.	Gluten.
Oxygen	O.	49·39	51·8	53·09	56·71	22
Carbon	C.	44·44	41·6	41·4	36·2	55·7
Hydrogen	H.	6·17	6·6	5·51	7·09	7·8
Nitrogen (Azote)	Az.	..	..	..	..	14·5
Total......	..	100	100	100	100	100
By whom Analysed	...	Thomson.	Brande.	Marcet.	Proust.	Marcet.

This Table, compared with the elements of various similar substances before made prominent in this chapter and the former, affords two elucidations: one of the approximate or absolute identity of products obtained by chemists of divers nations from the same substances; and the other explaining, at one view, the changes that take place during the conversion of barley into malt, through the secret powers of germination. The comparison between unconverted hordein and the same turned into starch of malt, already appears in the former part of this chapter (page 60), the latter in the same numbers, and the former nearly so, except that Thomson has not detected the nitrogen, of which Prout gives nearly 2 *per cent.* distinct from the oxygen; and there also this kind of starch stands distinguished from that obtained from raw materials. The "gum or mucilage" here inserted does not identify itself by any means with the amidin or gum of solvent starch, as given at page 36, in any of its elements, but would nearly resemble Guerin Varry's mucilage of linseed, were we to consider the probability of Marcet's carbon being united with nitrogen; and the coincidence may serve as a key to unlock the mystification which has confounded these two proximates in the hands of analysts. The elements of the sugar of malt are nearly as those of the sugar resulting from starch, but do not, of course, agree with the principles of the cane sugar, except in the amount of hydrogen; and it is again remarkable that the above is all but identical with that obtained by Proust himself from starch and honey, which yielded exactly alike, each containing C. 36·36, O. 56·57, H. 7·07; and Saussure's analysis of sugar of grapes is C. 36·71, O. 56·51, H. 6·78; but crystallised sugar, according to Berzelius, Brunner, Proust, and Liebig, as well as Gay Lussac and Thenard, noticed before, contains from 5 to 6 *per cent.* more carbon and as much less oxygen.

In the second place, a decrease of hordein and an increase of mucilaginous gum, show how a portion of the former is converted by the maltster into the latter, through an exchange of 3 *per cent.* of carbon and about a half *per cent.* of hydrogen, for an equivalent supply of oxygen from the water of the air; that between this and starch there exists a difference of 1 *per cent.* in the hydrogen, a larger countercharge of oxygen, with very little disparity of carbon; this mucilage coming directly from the seed or its hordein, chiefly by an accession of oxygen, and a loss of carbon, under new circumstances. The gluten, which appears to contain 2 *per cent.* more oxygen and less carbon than that given by Boussingault, or by Jones from wheat, shows a completely different arrangement of the elements, besides an appropriation of 14½ *per cent.* of nitrogen, and proves it to be altogether a different substance from those that ran from one into another through a transmutant disposition: thus it sustains its own character throughout, though not its quantity, as it undoubtedly aids the various transitions, and helps to form the root.

These decompositions, at different stages of the process, sufficiently account for the carbonic acid gas found in the floors of the malt-house, though it is not very conspicuous there, on account of its being buoyed by the lighter elements blended with it, and kept in agitation by progressive chemical change. It is also worthy of observation, that throughout all these transformations, the hydrogen and oxygen increase, and yet constantly maintain about the same proportion to each other which they hold in the formation and constitution of water, but that with mucilage it is otherwise, the hydrogen being considerably reduced; therefore, the elements of this substance are not in keeping with those stages of transition, but it is a distinct kind of matter not dependent thereon; and again, that as the carbon continues diminishing while the oxygen increases, malt sugar is an oxide of starch, and malt is oxidised hordein.

Tests of Malt.—The best pure malt is light, because it has been well digested; and if the malt heap contains much rootlet or "commings," it has grown too long, and especially if the "cockspur" appears, which is, in fact, the young plumula shot through the husk. Equality of colour and uniformity of size are both good tokens, unless one end be friable, and the other hard; for the change is progressive, beginning at the lower end of the seed, and keeping pace with the growth of the acrospire till it comes out at the top, when the whole will crumble, and all further progress robs the seed of its saccharum.

A thin wiry rootlet is likewise a bad sign, and for this reason,—that in barley sown in good soils, the root is moderately short and bushy, the effort of nature being the support of the blade; but that if put to vegetate in inappropriate land, the roots run out much longer, to the detriment of the plumula or stem; and from the same natural reason, if kept remaining in a loose heap on the malting-floor for any length of time, the warmth and moisture will wiredraw the rootlets very much, and thereby impede the process and impoverish the future malt.

It is important to remark, that malt made late in the season, when the weather is becoming warm, is very inferior in its strength and constitution, from possessing lactic acid and other objectionable properties, which operate against the keeping quality of the beer, and thereby counteract its otherwise natural potency.

Another, and now very common test of the virtue of malt, but by no means novel as an experiment, is to put a handful into a glass of cold water, when the well-malted seeds swim, and will float twenty-four hours before they absorb a sufficiency of water to precipitate them; but the flints, or unmalted kernels, immediately sink to the bottom; and those partially made dip obliquely, in angles of depression that adapt themselves to the extent of their imperfection, becoming more perpendicular as they imbibe the liquid in their suspended position, till their gaseous buoyancy is overpowered by imbibition, on which they fall to the bottom after the flints and grit; and no greater proof of inequality in the perfection of the malt can be found, than in the variety of positions taken by the several corns when dropped upon the water. The sample is good when the sunk corns stand upright in the glass. After all, experienced dealers can decide at first sight; and with the eye, the teeth and palate seldom fail as tests in proving quality.

Malt newly pulverised is inflammable, and apparently electrical. The destruction of Barclay's brewhouse, London, in 1832, was attributed to the accident of a man happening to lift one of the covers upon the box of the Jacob's ladder which conveys the malt to the hopper, and to thrust a lighted candle amongst the fine powder-like malt that was flying about when the ladder was in motion. Probably, the dry state of the grain, and its electrical condition, arising from friction in breakage between the rolls, had occasioned a state of gradual decomposition, and brought some hydrogen into the box from the vast quantity of malt that was being crushed at once, and hence its inflammability; but the danger of such an accident does not arise when the process of crushing has been ended, and the gases have been allowed to subside.

Recovering damaged Malt.—Unless malt be perfectly dried and well stored in dry rooms, secluded from atmospheric currents, it will absorb moisture, and thenceforth a decomposition of the grain, and at first of the nitrogenised parts in particular, takes place; the husk becomes tough, the farina yellow and putrid, and the released and fugitive elements impart a foul offensive odour; and it is needless to say, that such malts never produce sound beer. Broken roofs, damp walls, and bad floors, strongly tend to beget this calamitous state, and to render the health of the stock incurable;

but the best restorative known to the author, is to sprinkle the damaged mass with chloride of lime, blending them well together by repeatedly turning and mixing the malt well with the lime, till every corn becomes enveloped within its influence, after which the whole should stand ten or twelve hours if the heap is thick, or forty-eight hours if the premises afford convenience to spread it thin. By this means the strong affinity which the lime has for water, will extract it from the malt, and the noxious vapours will accompany it in its exit, at the same time neutralising the acidity and putrescence which have predominated. The malt thus medicated must next be subjected to gentle drying on the kiln, screened twice, and brewed immediately, with two-thirds or three-fourths of a superior article ; or if it is coloured brown or black for porter, that will perhaps be the best purpose to which it can be applied, since when mixed with uncorrupt malt, there is a danger of contaminating the whole mash.

Treatment of Malt.—In the introductory chapter to this treatise, page 10, among other definitions it is explained that the word *malt* is the idiomatic Saxon contraction of *malled*, signifying *bruised*. Their Roman predecessors called a broad-faced hammer or pestle *malleus*, whence the origin of *malt;* but the mill, by the Saxons called *molin*, and by their descendants *miln*, as we learn from the Dom Boc and other ancient records, was a mere mechanical invention for crushing flour or meal, whereas the malt-mill now in use is a modern innovation, introduced for expeditious cutting into larger fractions ; for if malt be ground to a fine powder, it will *set* at a lower temperature than such as is severed into larger pieces, which opposes its parting with the water with the freedom which is requisite in order to obtain a transparent solution, and hinders at least. if it does not entirely prevent, the necessary extraction of the valuable portion of the malt. Sometimes in the application of mill-stones set for coarse grinding, the smaller corns will scarcely be touched, or only partially ground, though the larger are literally pulverised, and the husks are so minced into pieces, that the raw mealy flavour of the farina is given to the worts, which want of uniformity is particularly observable in the finer brewings for ale. Steel mills have been considered an improvement; but they sever the husks as well as the kernels, which is a highly objectionable practice; for the great object is, to have the grain so *malled* that the liquor may have free access to every portion of the kernel, that it may extract its virtue without suffering the meal to collect into paste. With this view it is better so far to destroy the cohesion of the interior, as to detach the husk from the meal without removing it, but converting it into a kind of bag or shell which shall confine the soluble farina within its own bounds, and in a subdued state, cohering, as Donovan says, " with just as much force as will prevent their falling into flour." In plain truth, the idea of a malt-roll, to obviate the evils that had arisen from fine grinding on the one hand and rough on the other, was to the doctor the *ne plus ultra* of the brewer's art, and ingenuity soon gratified his desire. By this device the husks are crushed and partially severed from the kernel; so that when the *malled* grain (not *grist*, or that which thou *grindest*) is infused in water, those crushed husks become a filter, giving out only that from within which is valuable and flows freely through. Hence the superiority of rolls to mills of any kind: indeed, they are now universal in breweries, and have been found to answer in all the important points, becoming more and more efficient as talent and opportunity have improved their construction.

A recent act of parliament prohibits all mills but those with smooth cylindric surfaces. They waste little of the farina, the expense of their repair is very trifling, the husk is not torn and rendered so frail as to fall in pieces in the mash-tun, yet the rolls are sufficiently close to pulverise the whole of the saccharised contents, leaving the unconverted cuticle and less fragile portions of the farina merely split, or so dislocated as to be still held together by the integuments: thus the corn is sufficiently broken for the action of the heat and water, and of the mashing machine; but not too much so, as by the ordinary means. The goods also are light, and free from those pasty depositions so much to be guarded against, the large corn not being crushed too much, nor the smaller too little.

In order that the rolls may break the corn perfectly, without pulverising the husk, which is their principal utility, they should be of the same size, and travel with equal velocity; for when one is larger or swifter than the other, the unequal pressure on the corn tears the cuticle into fragments. Prior to rolling, it is expedient to introduce a wire screen, to prevent the encroachment of hard substances, and is valuable, as far as it allows the small pieces of grit, which would cut the rolls, to pass off with a considerable portion of the rootlet. Misfortunes from such a cause, whether arising from pure accident or from a mischievous disposition, are not altogether either pleasant or profitable, whether a check or an axle be broken, whether the whole fabric be shaken by a private jerk, or whether the driving-gear merely give way, and the cogs be stripped off a wheel.

The Patent Malting Apparatus is described by Dr. Sheridan Muspratt, p. 241, 242, in his new work on Chemistry, as relating to the Arts and Manufactures, thus:—

"In concluding the account of Malting, the Editor cannot refrain from making a comparison between the present system and the ingenious and excellent one lately patented by Mr. W. L. Tizard, the eminent mechanical and consulting engineer of London.

"It is well known that an ordinary malting establishment consists of an extensive range of buildings, containing a cistern, a couch, extensive floors, and the kiln. Mr. Tizard's newly-invented malting apparatus consists of a vertical cylinder, containing a series of wire trays, provided with sprinkling and turning apparatus, and steam pipes, vacuum and plunge pumps, vacuum and pressure gauges, thermometer, &c., and worked throughout the whole year with 75 *per cent.* less labour, and 50 *per cent.* less fuel than the old one. Experienced men admit, that of late the harvests have been so unpropitious, that the farmer is unable to secure his barley crop sufficiently dry for the purpose of the maltster, and the latter asserts that it is necessary to dry or sweat the grain artificially on a kiln, previous to its saturation with water in the cistern. The process of sweating is, however, neglected, on account of the great trouble it gives, or from there not being an extra kiln provided for the purpose. Hence the malting is commenced in a slovenly and imperfect manner. The temperature of the steeping liquor, and the number of hours allowed for the saturation of the grain, are also disregarded as matters of routine, notwithstanding that they are points of very great importance as affecting its manufacture into malt. With the new apparatus, the process is commenced and finished in one vessel, which is a cylinder, occupying but one-twentieth the area of a malt-house. The barley gravitates from the stores above into each tray; after which the door is screwed up, and the cylinder made air-tight. The conversion of the grain into malt commences thus:—A current of steam is passed through a series of tubes lying under the bottom of each tray, which imparts its caloric to the grain, by which all superfluous moisture and atmospheric air escape from each corn in the form of vapour. When the contents of the cylinder are heated to the temperature of about 100° Fahr., the vacuum pumps are put in motion, by which such vapour is extracted, and a partial vacuum created. The atmospheric pressure being thus removed, and the dilatation of the grain effected, a vacuity necessarily exists in the pores and interstices of each corn. In this favourable condition it imbibes steeping liquor at a temperature of 53°. Thus the steeping is accelerated, and a perfect saturation produced. The grain is now allowed to germinate; but throughout this interesting process, the laws of nature are subject to the controlling hand of science, which has here brought to its aid all the mechanical means necessary to achieve the great object of the maltster, namely, that of thoroughly exposing and making available the whole farina of the corn, without which the article would be imperfect. This is effected and kept within the range of proper temperatures by a steady sprinkling and evaporation of cold water, accompanied by the constantly evolving carbonic acid, which are together removed by the vacuum pumps. On the other hand, its temperature might be increased, and the process accelerated, by occasionally applying the plunge pumps, which subjects the manufacture to atmospheric pressure. The great revenue arising from the malt duty will, to a moral certainty, render this invention as acceptable to Her Majesty's Commissioners of Excise, and the Chancellor of the Exchequer, as to the honest maltster; inasmuch as it admits of being locked up, like a rectifier's still, as soon as the barley is introduced, and need not be opened till the manufacture is complete, and the malt ready to be removed to the stores; so that the whole process is proof against fraud, and the daily supervision of the officers of excise could be dispensed with.

"Space will not admit of a disquisition on the comparative merits of the old and new processes of couching, flooring, sprinkling, germinating, turning, heaping, and withering, but a brief description of the curing or finishing process, termed *drying*, cannot be dispensed with. This can be accomplished without the painful experience of having destroyed the vitality of the grain by the barbarous shovel, or the soles of the feet; by excessive light; cold or hot currents, or other incidental causes. Presuming, then, that the new apparatus has supplied the necessary moisture and atmospheric air, and abstracted all superfluous caloric, and the carbonic acid gas generated by the germination of the grain, which it cannot fail to do to perfection, the drying is performed as follows:—Steam is passed through the pipes, speedily raising the temperature of the contents of the cylinder to 90° or 100°. The vacuum pumps are also put in requisition, which immediately extract the steam as it flows out of the grain, preserving a partial vacuum on its exterior, during the withdrawal of the whole of the moisture. The malt is thus thoroughly dried in a distended form, and its original plumpness is preserved. It is acknowledged that the palest malt produces the largest amount of extract, and that it cannot be too pale if properly desiccated. The apparatus thus briefly alluded to, has been designed by a practical maltster and brewer, with the view of advancing one of the most important of our national manufactures, and one which is most susceptible of improvement, the common malting processes being rude and unsatisfactory in the extreme. Here is a complete set of apparatus to enable an intelligent operator to control the various processes of sweating, steeping, and converting the farina of his corn into sugar, and of desiccating it to perfection, without imparting the least possible colour or contraction to the grain. Indeed, malting is now reduced to a science, and cannot fail to meet with the support of the government, and the most intelligent of the malting and brewing communities. For the pale ale brewer, this invention ought certainly to be invaluable, and the Editor would strongly recommend the leading firms at Burton and elsewhere to introduce the apparatus into their establishments."

CHAPTER IV.

WATER.

CONFLICTING OPINIONS—HARD AND SOFT—ORGANIC MATTER—SALT IN WATER—SNOW—RAIN, SPRINGS, AND WELLS—RIVERS—THE SHANNON—WASHING AND TEA WATER—ALKALIES AND LIME—VIRTUE OF HARDNESS—BURTON—GYPSUM—FILTRATION—SUN AND AIR—ILLUSTRATIVE ANECDOTES—MINERAL WATERS—TESTS—SPECIFIC GRAVITY—LOCALITY AND TASTE.

The subject for the brewer's consideration next in order to his malt, is the selection of his liquor, or the water in which he has now to infuse that malt for the purpose of converting both into wort; and perhaps nothing in nature varies more in its properties than this outwardly apparent simple fluid, which is not the *aqua pura* which it seems, and is vulgarly said to be, but *hydor* impregnated with a heterogeneity of earths, acids, gases, alkaline and metallic salts, and sometimes even animal and vegetable matter, some held in chemical union, and some in mechanical suspension. Pure water, or *oxide of hydrogen*, is obtainable only by art.

Brewers differ most widely in their opinions of the necessary qualities of water, some preferring hard, others soft, and others again treating the choice indifferently; in short, the stoic is contented enough to conclude that water is water, while the sceptic never considers any water good enough for his purpose, be its properties what they may.

If men would thoughtfully consider the destiny of their worts, and the value of cold water for refrigeration and other useful purposes, they would not hesitate in their choice; for though a brewer already established can seldom choose his spring or his stream, the case is otherwise when the site of a new brewhouse is being selected. In adjudicating preference in brewing waters, writers have differed, the greater number being neutral, as Shannon, Donovan, Black, Combrune, and his disciple Hayman; of the soft-water advocates are Richardson, Wigney, and Roberts; and for employing hard are Levesque, Ham, and, under his own system of general management, the present author.

Ham, in venturing to disagree with the doctrines espoused by the generality of brewers, has not measured his terms, and his reason is powerfully substantial. "We feel a diffidence," says he, "in being obliged in some degree to dissent from received opinions on the qualities of this menstruum, when applied to brewing. There are two methods of producing the higher qualities of beer, the slow and the expeditious; the former in country places principally, and the latter in larger breweries of cities and towns, where the adoption of the plan of producing early ripeness by hastening the fermentation is become common, to the impoverishment of the national beverage; and the distinguishing marks of the superiority of the British brewery to all others are now nearly lost. We would therefore wish, if possible, to see it brought back in some measure to its original excellence, not by increasing the quantity of materials used, but by making the most of them in conducting the fermentation much more slowly than it is at present the custom to do. For this purpose we most decidedly prefer hard spring water, particularly that from wells dug in a chalk soil, where it can be obtained. . . . . We can now oblige the hardest water to make an extract from the malt in equal quantity, if necessary, to that produced by rain or snow-water, possessing, besides, the valuable property of checking the fermentative process. To those, therefore, who still wish to hasten that process, so as to anticipate age, to the impoverishment of the liquor, we would by no means recommend the use of hard-water, for if the fermentation is to be conducted with expedition, hard-water will be found inimical to its progress; but in all other cases, where a fulness of the palate is sought to be preserved after keeping the beer a considerable length of time, we invariably approve of the hardest and most transparent water that can be procured" (p. 31). This is sensible language, and so far explanatory of the grand *ultimatum*, that it becomes the very motive by which the author of the present treatise is actuated, and the principle to which his system is peculiarly adapted throughout its several stages.

Water that is free from saline matter, or that holds it in scarcity, is not fit for the brewery, being impotent. The softest is in the state of snow, which, according to Bergman, is destitute of all gaseous bodies, so that fish, as announced in the Journal de Physique by Carradori, cannot live in it, because it has no function; whereas good water, which, according to Thomson, is entirely colourless and as transparent as crystal, contains 1 *per cent.* of carbonic gas, with other ingredients, such as silica, oxygen gas, salt, muriate of lime, sulphate of potash, and the carbonates of lime and soda, all of which were discovered by Bergman in the springs round Upsala, which are considered to be exceedingly pure; but rain or soft-water does not contain carbonate of soda, sulphate of potash, or silica; and it has been observed by Morveau, that rain-water which drops from the roofs of houses, after the rain has continued awhile, contains only a little sulphate of lime, which it has disengaged by trickling down the slates. As for the muriate of lime which rain can contain. it must, according to the same learned philosopher, be exceedingly small.

The next gradation is into springs: these are no other than rain-water, which gradually filters through the earth, and by collecting at the feet of declivities, forms fountains and channels, and comes out at the surface. From this circumstance it is as pure as rain-water, unless it have met with some soluble substance in passing through the soil, and become impregnate with it. Various streams may thus be formed, and flow in sundry directions, according to the internal stratification of the land, and with variable acquisition accordingly; which accounts for the fact that soft and hard springs are often found close to each other; but it is generally found that in the purest of springs some little carbonate of lime and common salt are found, besides the usual quantity of air and of carbonic acid gas, with sometimes muriate of lime, carbonate of soda, or both. In 100 cubic inches of water, from which Dr. Henry expelled the air by boiling, he found 4·76 inches of incorporated gas, of which 3·38 inches were carbonic acid, and the remaining 1·38 atmospheric air.

Well-water is the same as spring-water, because it comes from the same source; a well being a cavity to receive the contents of one spring or channel, or perhaps more; but as its waters do not pass away, as in the case of an ordinary spring, it is more likely to receive an accumulation of foreign matter, till by repeated deposition and by stagnation it becomes *hard;* that is, till the quantity of earthy salts held in solution by it will not allow it to dissolve soap.

River waters are a collection of rain and springs, fluctuating with the seasons, but usually possessing greater softness than springs, both from admixture with rain and snow, and from their depositing the matter mechanically suspended, as they proceed in their course, retaining only the usual extraneities that are in chemical union, as air and carbonic acid gas, with a very little salt and carbonate of lime. That the quality of this kind of water is variable according to season and geological construction, might be analogically inferred from the natural realities that heavy and continued rains penetrate farther into the earth, and urge their course by greater pressure, than ordinary wet, each stratum in the road of descent furnishing pregnable matter different from that above it. But the chemist goes beyond this in his views, and gives demonstrative proof of the facts; for instance:—

Mr. St. Pierre Foley, Lecturer on Chemistry and Geology at Limerick, in three experiments on the water of the Shannon, undertaken under different states of the contents, in March, 1842, has produced the following as the fruits of his analyses, an imperial pint being his integer:—

I. As passing from the river up a pump, in its usual state.

	GRAINS.
Carbonate of lime	5·95
Sulphate of lime	0·62
Sulphate of soda	0·30
Chloride of soda	1·97
Magnesia, carbonated	0·25
Dead organic matter	2·10
Total grains	11·19

2·62 grains of carbonic acid in addition, hold the 5·95 of carbonate of lime in solution; therefore, there are in every pint of such water 8·57 grains of bicarbonate of lime.

II. The same filtered and tested afterwards.

	GRAINS.	
Carbonate of lime ..	5·55	The 5·55 grains of carbonate of lime were again held in solution by 2·62 grains of carbonic acid, making together 8·17 grains of bicarbonate of lime to the imperial pint.
Sulphate of lime ..	0·60	
Sulphate of soda ..	0·30	
Chloride of soda ..	1·97	
Magnesia	0·20	
Vegetable and animal matter	0·02	
Total grains	8·64	

III. Taken up in a flood and unfiltered.

	GRAINS.	
Carbonate of lime ..	5·9	The carbonate of lime is not increased, nor does there any appear in addition, that the filter will not remove.
Sulphates	1·0	
Muriate of soda and earthy matter ...	7·0	
Vegetable matter ..	2·0	
Total grains	15·9	

To this the analyst adds: "I think it right to remark, that on a hasty analysis of the Shannon water, made about the latter end of September, 1841, I then found that the water contained much more chloride of soda than at present, and somewhat more organic matter, but the proportion of lime seems constant."

From the above results Mr. Foley deduces these conclusions:—

1. That by a series of tests similar to those by which he discovered the presence of the enumerated properties, he proved the absence of others, such as all

nitrates, free alkalies, alumina, potassa, iodine, and silica.

2. The hardness of the water for economical purposes established by the excess of lime held in solution by the carbonic and sulphuric acids.

3. The great advantage of the filter in removing the whole of the mechanical mixtures thrown in by the floods, and almost all the vegetable and animal matter.

4. The non-removal of the lime by filtration, through its being held in chemical solution, chiefly by an excess of carbonic acid: this he looks upon as the chief "*bane*" of the water; but though he has encountered "Father Shannon," he is not bound to be a brewer.

5. That the lime must, nevertheless, be removed, ere the water can be fit for those domestic purposes in which soft water is effectual; and to accomplish that object, he recommends Professor Clark's process, and concludes by urging the necessity of purification.

The following analysis of a spring which supplies an eminent brewery in Kent, and of a well which the brewers have upon the premises, but from which they never brew, shows the great dissimilarity of waters in the same locality, and the necessity of good judgment in giving preference. The quantity in each case was a gallon.

The Spring.	GRAINS.
Chloride of calcium (muriate of lime)	6·043
Sulphate of lime (gypsum)	5·210
Carbonate of lime (chalk)	18·160
Carbonate of magnesia	0·150
Nitrate of soda; by estimate	6·476
Total contents	36·039

The Well.	GRAINS.
Chloride of sodium (common salt)	50·085
Sulphate of soda (Glauber salt)	2·124
Carbonate of soda	17·200
Carbonate of lime (chalk)	5·760
Carbonate of magnesia, no sensible weight.	
Total contents	75·169

The well-water, which comes from a bed of blue clay, though as clear as that of the spring, is rather unpleasant to the taste, as might be expected; and surely no uncommon sagacity can be needed to ascertain which of the two best suits the brewer in the exercise of his profession.

Depositions may be found adhering to a tea-kettle, or other vessel in which hard-water has been boiled, and serve to purify rather than strengthen the water. Every thrifty housewife knows that carbonate of soda, or that pearlash, which is a subcarbonate of potash, will expedite the process of making tea, and will assist her in the washing operation; and she knows practically that snow will have the effect of softening hard-water. The effect of alkalies is to precipitate the earthy substances; but by the addition of snow, the water is merely diluted, and the same quantity of foreign matter is diffused through a greater bulk of water; but the lime which hard-water holds in solution by its action upon the soap decomposes it, and thus renders the water unfit for the washerwoman's use. Rain-water contains about 2½ *per cent.* of atmospheric air, and the gaseous bodies composing it are set at liberty by the boiling of the water.

Carbonate of lime is but sparingly solved by pure water; but when carbonic acid is present, as in the case of the Shannon, the solution and retention are more effectually and permanently secured; and this is another argument for not heating the water in the brewery so that it shall expel the property that holds it in existence there; and moreover the disposition is increased when the carbonate comes in contact with the sugar of the malt, and, of course, afterwards in the ale, where an additional portion of carbonic acid is generated by fermentation; for sugar is a powerful solvent of lime, though the brewers who know the truth of this appear loath to take advantage of it. Dalton asserts, from the results of his own experiments, that the hardest spring-water seldom contains in solution so much as one-thousandth of its weight of any foreign body; and Foley proves that the filtered Shannon contains one in nearly 1012: since, however, the fact is admitted that sulphate of lime, gypsum, selenite, or be it called by what synonymous term it may, is the constituent that makes water hard; and since the sulphuric acid, which is its essence, probably corrodes the gluten, albumen, &c., and renders their powers inert in their decay, its good qualities must at once be acknowledged by the brewer; but it cannot be every where obtained; so that it would be well to consult some able chemist on the readiest and cheapest mode of impregnating certain waters artificially with such properties as are desirable.

The sulphate of lime is found as a mineral, in great abundance, at Chelaston, near Derby, and at Beacon Hill, near Warwick; it is also procured in large quantities from France and North America, and has become greatly esteemed as a manure. The anhydrate of Werner contains a still larger portion of sulphuric acid; as a specimen analysed by Klaproth was found to consist of sulphuric acid 56·5, lime 42·0, muriate of soda 0·25, loss 1·25 ; total, 100.

Has, then, the use of hard water no good effect in the management of the brewery? The author knows, from his own experience, that worts made from water of this kind require pitching from ten to fifteen degrees higher than those from the very pure waters, in order that the same attenuation may be effected in the same time ; but there is, besides, another advantage in the use of hard water, which is, that more saccharine matter can be left in the article, by which the fulness and flavour will be greater, without the risk of becoming acid, as other full-bodied ales do, especially in hot weather.

The Burton ales principally owe their superior qualities and uniform permanency, to the nature of the water there used, and which, according to the best evidence, is strongly impregnated with this hardener of water, gypsum or sulphate of lime; the principal geological feature of its environs being described as a tolerably perfect gypsum, occasionally interspersed with carbonates.

When Booth, or rather his employers, the "Society for the Diffusion of Useful Knowledge," first brought out their Treatise on the Art of Brewing, some reflections there cast upon the Burton brewers induced them to stand forward in a body, and to commence legal proceedings against the publishers, Baldwin and Cradock ; and the cause was brought before the Court of King's Bench on the 10th of May, 1830, when Mr. (now Lord) Brougham stated that chemists of eminence had been sent down to Burton to analyse the worts and the waters, and that the Committee of the Society were satisfied with the honesty of the brewers, who had thrown open their doors to receive the analysts; but he added, that "the learned person, the author of the treatise in question, who was a practical man, being a brewer of twenty years' standing, had been misled upon the subject, by circumstances which might have misled any body. He had said that he could make Burton ale similar to that of these brewers, if he were allowed to add certain saline impregnations, chiefly gypsum. Now it so happened, though the fact was not known to the author at the time the treatise was written, that the springs at Burton ran over a rock of that substance, which gave them a natural impregnation." Under these circumstances, the learned counsel admitted, on the part of the Committee, that nothing deleterious was used in the Burton breweries; and the rule for a criminal information was discharged upon the condition claimed by Mr. (now Lord Chief Justice) Campbell, that the contradiction should be as extensively circulated as the libel had been. "Very well," said Lord Tenterden, who presided, "the lovers of Burton ale may now drink it without fear;" to which Mr. Brougham responded, "If they drink it in moderation." The above apology or explanation was to appear in the future editions of the work; and in an ungracious accordance with the covenant and decree, the following appears in the 52nd page of the second edition, published in 1834:—

"One of the affidavits gratuitously acknowledged the occasional use of flour and salt, to assist the fermentation of the inferior ale; and the jalap, of which it only was said that, 'some recommend' for the same purpose, (and the use of which is doubted at page 28, Part I) may as well be left out of the supposed accusatory list of ingredients. These, then, are reduced to salt of steel, 2 ounces to 20 barrels; honey, 1 lb. *per* barrel; sulphate of lime, 6 ounces *per* barrel; and black resin, 1 ounce *per* barrel." Thus stands the notable attack on that communicative, and, as Lord Brougham called them, "generally respectable" body, the brewers of Burton-on-Trent, whose chief excellence lies in sulphate of lime; and yet men will decry hard water, as though it were a detriment and plague, though one ounce of that which makes it so, will preserve six gallons of ale "for ever and a day." But David Booth preferred, like Naaman, or rather Combrune, "Abana and Pharpar rivers of Damascus, to the waters of Israel;" and, like Gehazi, was subjected to a legal leprosy in consequence.

The author, unwilling that his judgment should be circumstantially dependent, has made enquiries on the spot, and is obliged to the politeness of Messrs. Bass, Ratcliffe, and Gretton, the eminent Burton brewers, for the following information on Burton water.

"The wells in Burton, used by the brewers, are from twenty to twenty-four feet deep, and are supplied by springs which enter them on the opposite side to that on which the Trent runs.

"Some years ago, Mr. Cooper of London analysed some water taken from the well at our brewery, the result of which was as follows:—the imperial gallon contained of uncombined carbonic acid, 7·5 cubic inches. Its specific gravity was 1·0013, and the solid contents obtained by evaporation 79 grains: those solid contents were composed of—

Carbonate of lime	9·93
Sulphate of lime	54·40
Muriate of lime	13·28
Sulphate of magnesia	0·83
	78·44

"The water used by Burton brewers is not exposed to sun and air: it is generally pumped direct from the well to the copper. There are not more than two or three reservoirs in the town, one of which is on our premises, and is under a roof. It is certainly not used for the purpose of exposing water to the sun and air. (In reference to this, see forward, p. 118.)

"As to the locality of Burton, it is certainly favourably situated for brewing, on account of its abundant supply of peculiar and excellent water for the purpose; and in that respect it would, perhaps, be very difficult to find a place equal to it."

On this information, only one conclusion can be formed, which is, that an indifference to the quality of the water is equivalent to a carelessness of the fate of the wort, Burton water containing special virtues not to be found in soft. It appears that this water is 9 *per cent.* harder than the Shannon, the incorporated matter being one grain in each 892.

Sulphuric acid, in its native condition, will undoubtedly prevent a secondary and acetous fermentation when a small quantity of this acid, or muriatic acid with alum, is added to malt liquors; and it does this in one or both of two ways, namely, absorbing all the superfluous oxygen present, instead of allowing it to attack the alcohol; or acting caustically upon the albumen and gluten, and rendering them insoluble as the mixture increases in density, and precipitates them to the bottom: hence the desirable properties of the limestone are attributable to its acid; and if this idea is correct, the attributes belong to the sulphate, and not to the carbonate; nor has it been shown that carbonic acid will accomplish much of this. Chemical practice determines, too, that carbonate of lime is generally accompanied by a sulphate or a muriate, either of potassa, or of soda, or of magnesia, or of lime, and often by both of those kinds of salts, as at Burton, and in the swollen Shannon after a flood.

Water highly impregnated with gypsum, is much harder than that containing carbonate of lime, and for reasons already advanced, though the quantity of each be the same; and this difference is to be attributed rather to acids than to the alkalies or the like. When waters run off moors and fens, and the brewers in certain districts are compelled to use them for want of better, it will be found desirable to impregnate them at second hand with gypsum, or with such limestones as are easily procurable. If calcined, their solution by the water is thereby facilitated; but the operation expels a portion of the sulphuric, carbonic, or other acid, and of the water combined with the lime; but not without some deterioration of their anti-acid virtue; and they form hydrates, and afterwards become carbonates, by re-absorbing the carbonic acid of the liquid which they were intended to improve and preserve. Where the burnt mineral is obtainable in great plenty, the loss of disengaged sulphuric acid may be compensated by employing a superfluity; but it is much better to use it in the primitive state, giving more time for gradual solution, as in the Burton and Chelaston soil.

Notwithstanding the excellency of many inventions, by which men have professed to purify water, no permanent and economical filter which has yet been devised, can answer the especial purposes of the brewer; nor has any, however ingeniously constructed, been found to sweeten foul water when its tetricity has passed from suspension to combination; nor will any other means yet known, including evaporation, do it on a scale suitable to brewing. If communities will inhabit places which will not naturally supply their proper wants, particularly for this purpose, and if they are too poor or too idle to obtain a purer beverage by artificial means, they had better import their beer from localities that can produce it in perfection. Waters brought from a distance across the country in open aqueducts, are often so surcharged with decomposed vegetable and animal matter, and have lost so much of their better qualities by evaporation, that they nauseate within a few hours after coming upon the premises; and even when not precisely so, passing all that distance in subjection to the sun's rays in the summer months, warms them till they reach 60° or sometimes 70°, which renders them completely useless as a cooling medium. It is surely enough to repeat that such places had better have their beer brought to them than their brewing water, and thereby burst the wretched trammels which monopoly, locality, and custom, compel them submissively to wear, to the destruction of their health, their capital, and their comfort.

Gypsum, which, according to Ure, is 2·2 in specific gravity, or nearly the same as the carbonate, is constituted of 28 parts lime, 40 sulphuric acid, and 18 water, which are also the weights of its prime equivalents, shall now be considered in a way that cannot reasonably fail to create alarm in the mind of the careless but sensitive brewer. The author having in his experience tried all sorts of water, from the hardest to that which is called the purest, and never having failed to obtain as good an extract from the former as from the latter, is sure that the principal objection to the hard is founded on the old erroneous notion of its want of capability in extractive power; he is therefore persuaded that nothing but a correct knowledge of the art of mashing, and a little patience in attending to the fermentation, can be wanting to bring it into general repute: this theory has so often been practically proved of late, that no other than the confirmed bigotry of senseless custom can oppose it. Should any further arguments be necessary, the following surely will suffice:—A near relation of his was, a few years since, connected with two breweries in the same town, only a few yards asunder, and supplied with water from the same stream, which water was notoriously hard. In one of these breweries, the copper was commanded by a very large and flat liquor-back, which was exposed to the sky for the purpose of rendering the water softer, previously to being used in the mash-tun; and precipitation and evaporation, of course, did their part in effecting that change, and in proportion to the time that the water lay in its tranquillity. The other brewery had no liquor-back, but was provided with a good dome copper, the pan of which received the water as it was pumped up from the stream. The two establishments were just at par in regard to strength, price of materials, connexions, plant, and management, except as above described; but the truth was notorious, that during the summer months, the ale brewed from the water which had been deprived of a part of its saline contents by exposure to the air, would not keep so well as that made at the other house: indeed, a sour article was scarcely known in the latter brewery, nor were finings ever used or needed. In another house at some distance from these, an event, sufficient to satisfy all reflecting men, came beneath the author's own personal observation:—This brewery was situated on a limestone rock, from which issued a beautiful stream of hard water; and this was uniformly used in the brewery with invariable and complete success, until a change took place in the practical department, through the introduction of a "clever young man" from a soft-water country, who took the reins, and being an adept in art and mystery, very skilfully and chemically softened all his water prior to using it, by adding sub-carbonate of potassa and some other alkaline extract of grave and serious importance. All this in cold weather went on smoothly enough; but lo! summer came, and brought the brewer's sour foe; and our clever young operator, who was to have shone as a paragon among the brethren, was obliged to learn that he had disengaged the sulphuric acid, and deposited the lime, by a misapplication of potash; and while smarting under the extreme mortification of seeing nearly as much sour ale brought home as had been sent out to the consumers, he attributed his disastrous fortune to the original nature of the water instead of himself!

The author one day, when expatiating on the virtue of hard water, was asked by a gentleman rather largely connected with a brewing-house, "Admitting that sulphate of lime is indigenous to grain grown upon gypsum or other limestone, and is desirable in malt liquors, why not put it in the water or the mash?" His reply to the question was and is, that the more gradual the impregnation, the more minute and copious are the particles imbibed, and the more permanent are their existence and hold; for as it filters through the soil, it dissolves a portion of the soluble salts with which it comes in contact, either by its own solvent power, or by the action of the acid it contains, whether native or incident. The same will apply to the grain grown upon alkaline earths, with these additions, that the alkali impedes the formation of an acid such as is generated during the ripening of the corn, and the existence of which is natural, more or less, in all grain; and besides this, the particles of the alkali are of the finest and most soluble description, being macerated, filtered, and literally grown in and with the farina of the grain, as its vegetation advances; and when thus imbedded in the corn, it is still more minute and more intimately blended throughout its parts, being aided by the best means, namely, the solvent powers of the native sugar of the barley when in a green state, and particularly just before ripening; nevertheless the idea of putting it into the mash is original, and in some cases really valuable. This favourite mineral water of ours is more efficient to the brewer as an anti-acid, than mineral corn, the quantity of the essential properties possessed by each, being vastly different in proportion to the bulk: the advantage is in each case, however, decidedly great, whether they be taken separately or connectedly; and in the common system of brewing, both are highly desirable when attainable, let the decriers of hard water declaim as they are wont.

While treating of mineral waters, the author must not forget that he is addressing his observations to a brewing portion of the world, or to such as wish to be conversant with that art, and would therefore be particular in recommending such waters as are invaluable to brewers especially, some of which may be unfit for the majority of manufactures and domestic uses; while, on the other hand, some which those classes of persons employ, are not of fit quality to be introduced into the brewery. Water, for instance, that contains such large quantities of salts and such a variety of gases as are usually found in the medicinal fountains of our fashionable spas, are often unfit to be taken into the brewery, on account of their purgative or other peculiar properties; yet many of the inhabitants employ them for their regular common domestic purposes, some of the saline and gaseous properties from which they derive their medicinal celebrity by operating on invalids, being removed by boiling or exposure to the atmosphere;

or it may be that the water does not materially affect the healthy and constitutionally strong, in whom custom has established the prerogative of second nature. Be this as it may, the object now sought is not to cure sickness, but to prevent it; and it has been shown that at least some hard waters can be used in the brewery with considerable advantage.

A little above the head of Cradley Mere, near Dudley, a case precisely in point exists in the "Lady Wood Spa," and the ale at the inn attached to it, which is brewed from a well upon the premises, not exceeding 200 yards from the medicinal fountain or "Salt well," which latter has been analysed by the aforesaid Mr. Cooper, and found to contain the following ingredient salts, in grains troy, to each wine pint of $28\frac{7}{8}$ inches, when freed from water of crystallisation:—

	GRAINS.
Muriate of Soda	49·75
,, Lime	19·07
,, Magnesia	7·50
,, Iron	0·13
Sum of Muriates	76·45

	GRAINS.
Carbonate of Lime	1·50
,, Magnesia	1·70
,, Iron	0·90
Sum of Carbonates	4·10
,, Muriates	76·45
Salts in solution *per* pint	80·55

Besides which, it yielded carbonic acid 2·1, and azote 6·4,—total 89·05 grains. The water thus compounded, is, of course, strongly purgative, whence its virtue as an antiscorbutic remedy; yet the ale sold at the inn, and which contains lime abundantly in its *sulphate* state, is not more operatively relaxing than other malt liquors, nor can it be surpassed in excellence by any in the united kingdom.

Chemists divide mineral waters into four classes, namely, the acidulous, the chalybeate, the hepatic or sulphurous, and the saline; the first of which, though generally containing earthy carbonates, have an acid taste; the second are replete with iron; the third, by their sulphur, present an obstacle to fermentation; but the fourth sometimes possess all the necessary qualifications by containing salts whose base is lime, and generally the carbonate or the sulphate, or perhaps both, while others have an alkaline or magnesian base; the latter of which are purgative and bitter.

Leamington water contains 150 times as much of the sulphate of lime as of the carbonate, and nearly four times as much muriate of soda as of both, the whole of these constituting about one-fourth of its whole quantity; and Dr. Garnet has not shown that Harrowgate water contains any sulphate of lime, or more than $\frac{1}{5600}$th part of the carbonate; so that the public have little need to fear that brewers will purge them with such as are denominated medicinal waters: their medicine is not water, but sweets and bitters.

Some waters possess all the properties that are serviceable in the brewery, and yet, like these, are unfit for use in consequence of something inimical which they also possess, as in the following specimen, taken from a spring near Shooter's Hill, in Kent, one quart of which on analysing gave these very important constituents in various states of combination, amounting in all to 151 grains:—Sulphate of magnesia (Epsom salts), 88; muriate of magnesia, 10; muriate of soda (culinary salt), 32; sulphate of lime, 8; carbonate of lime, 10; and argil or common clay, with a little calx of iron, both diffused but not dissolved, 3. This result must surely at once point out the necessity of examining all waters before they are brought within the precincts of the brewery; for notwithstanding that water is the brewer's most important compound, little attention has been paid to its latent properties, except where its effects have been so striking as to produce an extreme of good or harm. According to Cavendish's original tests, the composition of pure, tasteless, and transparent water, is H. 11·1, O. 88·9; but later and more refined experiments give H. 15, O. 85. In all probability, spring-water was never found perfectly colourless, but with a yellow, blue, or green tinge, according to the properties of the vegetable, animal, or mineral matter held in solution, or being in contiguity to it; and some ascribe its shades of colour to optical causes or illusions not clearly understood. The waters generally called hard, however, in which soap will fall into flakes resembling snow, are rendered turbid by a solution of gold in *aqua regia*, or of silver in mercury, or of lead in nitric acid, or acetate of that metal, and they may be tested by any of these several means; for the difference in water generally, may be discovered by appropriate tests, for which purposes a long list of the substances found in mineral waters, and of the re-agents employed to detect them, is given in Carey's "Chemistry as it was, compared with what it is;" yet nothing completely definite can be achieved without recourse to analysis, which was long considered a difficult process. Experimenters will now find a code of rules, and a description of the requisite apparatus, in Kirwan's "Essay on the Analysis of Mineral Waters," and in the "Annals of Philosophy" as communicated by Dr. Ure. The following, with the tests applied to each, are from Carey, and are simple and useful:—

Acids in general; discoverable by infusion of litmus.

Acid, boracic; by acetate of lead.

Acid, carbonic; by litmus, lime-water, or barytic water.

Acid, muriatic; by nitrate of silver or of lead.

Acid, phosphoric; by solutions of barytes, or nitrate of mercury.

Acid, sulphuric; by barytic salts, pure barytes, or acetate of lead.

Acid, sulphurous; by its smell and its effect on black oxide of manganese, the colour of which it changes.

Alkalies in general; by vegetable colours or muriate of lime.

Alumine; dissolved by acids, succinates.

Ammonia; by its smell, or by nitrate of mercury.

Carbonates in general; by effervescence on adding acids.

Earths; by precipitation on boiling them, or by an alkali.

Hydro-sulphuret of lime; by sulphuric or nitrous acid.

Iron; by the same tests. The sulphuric acid dissolves it.

Lime, pure; by water saturated with carbonic acid.

Lime, dissolved; by oxalate of ammonia, or barytic solutions.

Magnesia; by precipitation on boiling, if dissolved by carbonic acid and pure ammonia; or the phosphate of soda, when by other acids than the carbonic.

Muriates of alkalies; by solutions of silver.

Muriate of lime; by the same or by oxalic acid or oxalic ammonia.

Sulphates in general; by barytic solutions or acetate of lead.

Sulphate of ammonia; by barytic solutions or by boiling with fixed alkalies, which dissolve it.

Sulphate of lime; by barytic solutions, oxalic acid, or oxalates.

Sulphuret of alkalies; by polished metals or nitrous acid, or by their smell when sulphuric or muriatic acid is put to them.

Sulphuretted hydrogen gas ; by its smell, or by acetate of lead, polished metals, or infusion of litmus.

Such are some of the means to which others as well as the author have resorted in order to discover the quality of water; and he can with truth add, that there are few specimens in which some of the symptoms do not appear. As a general rule for discovering the extent to which any particular supply of water has imbibed foreign impregnations of a saline or other mineral character, the specific gravity of distilled water which is equivalent to a cubic foot, is 1000 ounces; this is made a standard of weight, and kept as the criterion of specific gravity where substances have to be compared, throughout the world of science and of commerce; and is the foundation on which all measures of bulk, hydrometers, and other statical instruments, are based. Water from the same stream, and sometimes from the same fountain, is often, from the causes that have been assigned, found to vary in its specific gravity, and thereby to indicate a variableness of density, being at its *maximum* on the commencement of a flood, and at its *minimum* soon after such flood becomes slow and limpid; but these changes are seldom so far perceptible in the majority of spring and mineral waters, as to allow the brewers who use them to calculate upon them with any degree of certainty. The acids are weightier than water, and so is lime; therefore each of these will increase the specific gravity of the liquid in which it is mixed, in proportion to the quantity of the mineral present; though a question may arise as to which of these takes the greatest part in adding to the density of the water; but upon making comparisons, we shall find that which contains the most acid, and especially the sulphuric, to be not only the hardest, but also the heaviest; the increase of density and gravity depending in some degree on the principle of condensation, so apparent on the admixture of the acid with water in the ordinary way. Scudamore, in his "Chemical and Medical Report of the Properties of Mineral Waters," page 2, copies Kirwan's work on this subject, where he gives the following formula for estimating the quantity of solid matter from the specific gravity, which, he says, will give the true proportion within 1 or 2 *per cent.*:—"Deduct 1000 from the specific gravity of the water, and multiply the difference by 1·4; the product will represent the quantity of solid contents. It gives the weight of the salts in their desiccated state, and consequently freed from the water of their crystallisation. The weight of the fixed air must be also included. *Example:*—Let the specific gravity of the mineral water be 1079, and that of distilled water 1000; $(1079-1000)\times 1{\cdot}4=110{\cdot}6$; or 1000 parts of water of that specific gravity should, according to Kirwan's rule, contain 110·6 parts of saline water. He adds, that Brisson found a solution of two ounces of salt in sixteen of water, to have its specific gravity 1079: here eighteen ounces of the solution held two of salt. Now, as 18 : 2 :: 1000 : 111·1."

In consequence of the indifference manifested towards the subject of water by a certain class of writers, and of the acerbity evinced by some brewers, and the nescience of others, especially in handling the waters termed hard, the author has opened his thoughts, and spread their contents more diffusely than every-day affairs could have justified,—being convinced that not all practical men have time to bestow upon recreative reading, though it be instructive; if, however, the arguments and proofs which he has adduced, are calculated to awaken the understanding incidental to men of common sense and prudence, which has been his aim and wish, he has his reward in the conviction.

Men are too apt to think of others only in comparison with themselves, as though all were surrounded by like circumstances, which may account not only for the disparity of judgment between Booth and the Burton brewers, and our "clever young man" and his customers, but likewise for the failures of many others whom shame or policy has withheld from publicity.

The localised brewer, who is unacquainted with the public taste abroad, seeing as through spectacles made to suit his own eyes and age, is ready to attribute other men's misfortunes to unskilfulness or neglect, and hesitates not to suggest or dictate such antidotes as are reasonable to his own thought, though others can see that nothing could be more erroneous if made general. How different for instance, is the ale brewed in Scotland from that produced in the South and West of England! Who is there in Britain that cannot discover a difference of flavour and gust between the London and Dublin porter? Who that has travelled would expect to find the London taste in Newcastle ale, or either of these in the ales prepared at Liverpool, Lincoln, Nottingham, Sheffield, Birmingham, Derby, the Staffordshire Potteries, Maidstone, Dorchester, Devonport, Alton, or North or South Wales? The brewers of Manchester supply varieties of flavour and excellence, but still it is all Manchester ale. Each respective article in any of these places, is of good quality, is preferred by the local consumers of "the cheer" generally, to every other that in their opinion can be brewed. The inhabitants of the towns and villages "round the Wrekin," which is situated in the centre of a splendid barley-country, will have their ale brewed of a pale straw-colour, and consider that all of a darker cast is adulterated; whereas the "Pottery chaps" will have it nearly "as red as blood," and imagine that paleness is only another term for smallness. At Wheelock, in Cheshire, in the margin of the salt country, are two large porter establishments, watered from springs in the rising ground immediately above them; and their neighbours say that no place besides Wheelock can produce porter that is truly good; though travellers think otherwise. This porter has a black shade; but peculiar taste may not depend so much on the quantity or colour of the malt, as on the selection of the hop, and less on either than the fermenting heats; nor yet on these together so much as on custom, founded on ancient practice; and the brewer is in a great measure bound to conform to the will and taste of his customers thus formed, whether it be refined or vitiated, addicted to sobriety and taste, or given to wallow in the depths of dissipation. As the market is, so must be the commodity, or it will cease to be a market. It is, however, in the power of a skilful brewer to improve the quality of such beer by gradual means, which he may do almost imperceptibly, until the public and himself will be equally gratified; and it is moreover his duty; and amendments of this kind *never* go unappreciated.

CHAPTER V.

MASHING.

REFLECTIONS—QUANTITY AND QUALITY OF MATERIALS—OARS AND MACHINES—INITIAL HEATS—STATE AND CHARACTER OF CONSTITUENTS—ATMOSPHERIC DATA—THE MASHING ATTEMPERATOR—STANDARD HEAT—VALUE OF THERMOMETER—BENEFITS OF ATTEMPERATION—PROGRESS OF CHEMISTRY—NEW MASHING SYSTEM FOUNDED ON PRACTICE—TRANSMUTATION OF INGREDIENT SUBSTANCE—RESULTS OF EXPERIMENTS—DEFECTIVE PLANS—COMMERCIAL COMPARISONS—EXAMPLES OF BREWING—INCREASED PROFITS.

According to the admonition of Lord Bacon, he who would duly prepare himself for business must neither be guided by antiquity nor cling to novelty, nor must he be servile in his submission to authority, hasty in his affirmations, or too sceptical in his doubts; but must place each particular in the position assigned to it by proof evidence. He must have prudence enough to discover the lapsings of truth into error, and the conversion of error into truth, from a just knowledge of his own nature, and a correct sense of the scale and measure of his own ability in judgment; complying with the nature of others, and surveying the order of affairs with one eye, and their relative uses with the other; seeing also, that as discoveries proceed, the art of discovering advances with them. Man should not be vain, as the same moral philosopher reflects, in communicating the knowledge he has acquired, nor cunning in the concealment of what he knows, but ingenuous and free, rendering his subject suitable to the understanding and capacity of those whom he intends to enlighten or improve.

With these sentiments before him, an author must feel desirous not to indulge in superfluous words or double meanings, nor to pretend to any kind of mystery, but to be plain and intelligible, treating his subject fairly, truly, and practically, with rationality and unlimited candour; for science has the effect to open and ennoble the mind to experience; but quackery and conceit only mystify and mislead, thereby debasing the character and losing the object pursued.

Brewers have always experienced great difficulty through their inability to maintain, increase, decrease, or vary at pleasure, the heat of the whole mash: a power which it is the object of the present chapter fully to confer as an essential boon. We may really be astonished that through ages, when many valuable facts might have been apparent, and would have been elicited by careful attention to the progress of the mash, the tun did not derive improvement from the introduction and application of some machine contrived to neutralise the variations of temperature arising from change of season and other causes, and which must have occasioned incalculable loss and inconvenience in every brewery.

Each generation happens to produce its class of men who consider the age in which they live to be as perfect as necessary, and are therefore content to sleep in hypothetical security, letting events pass as they are, unless improvements actually suggest themselves to their own minds, or come recommended by personal friends. These are they whose supine doctrine tells us that nothing more can be done towards converting malt into wort, than is done already:—so men said years ago, when 75 lbs. *per* quarter were considered the attainable *maximum*, though 90 lbs. and more are now realized, so that such people judge beyond their own comprehension, and will continue to do, till convinced to the contrary by reason, science, and practice. If we consult the most intelligent and well-informed observers, we find them frankly admitting that the art is either misunderstood, or so insufficiently known, that a vast deal has been remaining and still remains to be discovered. They know that the merit and value of a thing are ascertained by comparing it with others, and the result of that comparison they term experience; but here the ground of true comparison has been wanting, and consequently the *summum bonum* has not been attained except in the imagination, and there only at an outstretch. Now, although the practical brewer has not opened the eyes of the otherwise discerning, to a just conception of this subject, because he has not clearly understood the true principles of dissolution and transmutation in the components of malt, yet certainly many have unconsciously approached the criterion consequent upon the discovery of that "something unknown" now at length found out, clearly understood, and reduced to practice.

Very few until lately were the brewers at all acquainted with the secret workings of hot water in the mash-tun; and the best of scrutineers could do no more than imagine this incomprehensible "something," in forming or developing the sweet principle of the grain, on which the successful issue of the mash, the after process, and all the qualifications of the various properties connected with them, must ever depend. So select has been the number of practical brewers acquainted with the science of chemistry to an extent to become available, through possessing knowledge sufficient to enable them to make elaborate analyses of materials, that we did not become acquainted with the natural basis of this secret, till the chemists of the nineteenth century spread a diffusion of light abroad upon the world, and encircled a special halo round the brewery, by discovering, not largely, as to fill a nutshell, but within the bulk of a mite, the existence and superlatively powerful properties of DIASTASE, and the necessity of watching and humouring it. This generation has been taught to see this, or at least to acknowledge it, till men of sense cannot longer urge that the further progress of improvement is impossible or impracticable: as well may they say that mucilage is of equal value with saccharum in the composition of malt-liquors, as to deny that improvement must take a new and wide range; as well may they contend that the niceties observed by ingenuity and perseverance, are equivalent to a mere waste of time, talent, and patience; and that every notion of improvement is a chimera, because, forsooth, persons like to stumble in darkness, as to deny that modern chemistry has thrown open that door to the hitherto hidden area of perfection, round which authors and operators have long been hovering, like bees and butterflies round some captivating flower enveloped in a web of gossamer. Self-sufficient declarations must cease, whether parties have been dilatory on the one hand, or extravagant and presumptuous on the other.

The brewer having selected his materials from the best market, and his water from the choicest fountain, his next object is to know how to use them to the greatest advantage, which undertaking is often attended with difficulty, and especially when the selection has not been made according to his wish, or when the malt has not been properly malted, so as to loosen the farina without cutting the corn into segments.

In the first place, it is always advisable to have the materials ready over night, as the contrary practice has a dilatory appearance, and is often the cause of unforeseen delay; for if one thing is unready the whole must stand waiting, to the great hindrance of business. This advice is supported by common prudence, and by two useful ancient maxims, one of which is, "*Leave nothing undone till to-morrow, which to-day can accomplish;*" and the other is the wholesome proverb, that "*The early bird catches the worm.*" In fact, the hope that encourages him not to rest, and that eye of his which oversees his engagement, must dictate this course to him as the most expedient; and having accustomed himself to "*plough deep while sluggards sleep*," the retrospect yields a consolation in the idea that cherishes the knowledge of having done right; which idea hope cannot suggest, in consequence of the existence of a chance of doing wrong.

We can fairly presume that in the middle of the nineteenth century, when art is fertile and fine, and elegance accompanies every acquisition, no need can obtain for writing an essay on the necessity of cleanliness in the brewhouse and utensils, since no man can tolerate the slightest deviation from it.

In the next place, take the hint already given, and mash early in the morning; and if the mashing liquor shall by accident attain the boiling heat of 212°, it must be slackened down to the temperature wanted, and precautions must be taken to prevent its becoming hotter in future than is necessary for mashing, particularly where the advantages of good calcareous water exist. On the contrary, if local circumstances enforce the use of such soft waters as contain ammonia and animal matter to an injurious extent, some boiling with proper *correctives* would be beneficial as a curative of the disorders engendered by their impurity. It may be objected that the sulphuric acid and lime, which constitute the sulphates and harden water by their presence, would be expelled and precipitated during the boiling of the worts ; but this, *with moderate boiling*, we have no need to fear, *because saccharum, the basis of our commodity, is a powerful solvent of lime*, and the strong chemical affinity of the compounded wort for both these desirable constituents of a hard brewing water, renders their detention and amalgamation peculiarly and particularly beneficial.

The act of infusion, or mixing the liquor with the malt, is done by bringing them together in such manner within the mash-tun, and so taking care to preserve an equal penetration by the fluid throughout every portion of the solid, that the process of solution be no where prevented or retarded by inequalities. To effect this purpose properly, some brewers introduce 2 barrels of liquor to each quarter of malt employed ; others turn on $2\frac{1}{4}$ or $2\frac{1}{2}$ barrels, either at once or periodically, according to custom, old or new system pursued, or other attendant motive ; $1\frac{3}{4}$ barrel will, however, sufficiently saturate the malt, especially if let into the tun at a proper heat, and at the same time and speed as the malt is running in from the hopper above, or otherwise ; but if at the same time the operation is performed by the common mashing oars, the mash cannot be properly made, because the balling of the malt, and the cooling and in part acetifying of the worts and goods, cannot be prevented. Nothing but a mashing machine can do the work quickly and efficiently where the body of goods is of much magnitude. If the object sought were no more than a solution of the sugar provided by the former partial vegetation of the seed when malting, why should the operatist, in thus mashing or compounding his elements, be so particular in his heats, as shall presently appear? Why should such diversity of opinions prevail, since we know that water of almost any temperature will readily perform this simple office? Why do many who know not the use or value of the thermometer, take the precaution to see their faces in the liquor intended for the first mash, as in a mirror, before they add the first malt to it, if they have no object or solicitude beyond obtaining a mere fermentable sweet?

Malt, however well made, as seen on reference to our analytical table, Chap. II. p. 26, contains 30 *per cent.* of sugar and mucilage in about equal portions, and from 50 to 60 *per cent.* of starch, with 12 *per cent.* of hordein or unconverted farinaceous matter, the remainder being composed of albumen, gluten, and a little resin. Under this composition, if the mashing liquor have been too hot, the consequence, even if balling have been prevented, which is improbable, will be a gelatinising or setting of the whole mash; and though the sugar and gum (or mucilage) may have been dissolved, they will be so enveloped in the pasty mass, that not a gallon of wort can be disengaged and drawn off; and if the mash is made at too low a heat, only the 30 *per cent.* of the corn reduced to sugar and mucilage by malting can be made available, which will show an extract of about 35½ lbs. to the quarter by Long's saccharometer; and although one-half of this wort is decidedly the best that can be obtained under any circumstances, yet the whole compound will be of the character called *mawkish*, or inclining to insipidity, because the most valuable properties are neutralised by the equal amount of mucilage, which is destitute of sweetness. This wort will also be foul and white, like thickened milk, owing to the presence of a large quantity of starch and some hordein, *both in their primitive state;* for although they disengage themselves from the goods, and run off with the mucilage and saccharum, they do not dissolve or yet affine with them, but are merely held in mechanical suspension; and the starch would ultimately precipitate itself to the bottom, and granulate like laundry starch, unless immediately subjected to fermentation, in which case it would create more evils than benefits. Thus we see that by treating the malt erroneously, we procure nothing on the one hand, and only about two-fifths of the capable produce on the other; so that it is hence evident that some intermediate stage or course is required; and the nearer we approach perfection, the more we increase the quantity and quality of the beverage extracted.

Experience teaches this aforesaid fact to all brewers; but they are not all equally well versed in the causes that operate to bring such different results; nor are all aware that in either of these examples, the whole starchy portion of the malt is entirely lost to the trader, not having been developed in a tangible way. To realise such an amount of extract as would be satisfactory, we must use a certain quantity of water, and no more, at such a temperature as will dissolve the starch and convert it, with as much of the hordein as possible, and assimilate these two constituents with the saccharum, by the chemical transmutation described in Chap. III. The gradation of the converting process will thus arrange itself:—The 15 *per cent.* of sugar will not undergo any perceptible change of character, but will to some little extent officiate as a sacchariser by contagion and assimilation, aided, of course, by other constituents and circumstances; the 15 *per cent.* of mucilage will become sweet, and partake of the nature of sugar; the 56 parts of starch will be macerated by the gluten and a principle that accompanies it, and will then become mucilage, and some of this starch will be transmuted into sugar; and the more matured portion of the 12 *per cent.* of hordein will assume the mucilaginous character; but the perfection of these transformations will be in proportion to the temperature of the mixture, the skill of the operator, and the means which he has to carry out his designs.

To proceed with the same subject in a more lucid, and, it is presumed, a more scientific manner, we may observe that in consequence of the great discovery made by those very eminent French chemists, MM. Payen and Persoz, we prove that by right application of certain principles contained in hot water, grain, &c., the gum that the maltster leaves in his malt, and a great proportion of the starch also, can be made into a sweet liquid, chiefly at the expense of the very ingredient that causes turbidity, acidity, and the long train of misfortunes to which brewers have heretofore been liable, and with which, consequently, they are too well acquainted: hence it is that, for the first time, an instrument can be placed in the hands of the managing operator, by which he can now clearly see the nature of the mashing process, examine its capabilities fully, and select such heats, and maintain them such time, as his advanced knowledge dictates and his business requires. This is a mashing machine of entirely new construction, which also embraces the character of an attemperator, by which the casualties already named, and many more, will be effectually avoided. The great necessity of such an introduction has become imperatively urgent, and the advantages derivable from it can easily be demonstrated; for they consist in its *entire efficiency* and its *profitable utility.*

The multifarious opinions by the host of brewing writers and writing brewers on the subject of mashing heats, since the reign of George II., when his physician, Dr. Shaw, first let light into the brewery, would afford a rich fund of amusement to the curious in thermometry and to the fastidious connoisseur in ales, were it consistent with the measure of the present design to collect and contrast them; but one modern writer, in particular, attaches much importance to atmospheric changes, and assuredly he cannot attach too much. The valuable observations on this head by the "Scottish Ale-brewer," to the extent that they reach, are declaratory of the present author's own practical views, and give pleasurable expression to a train of his preconceived ideas. Mr. Roberts believes that the great aim of all brewers (but he believes more than enough) is to ensure an attendant heat of 147° to 152° to the wort running through the mash-tun tap; and that if they are successful in obtaining this, with a free and transparent stream of wort, carrying a fine pearly head, they are satisfied with their own judgment, and rest contentedly upon their oars with self-gratulation.

But, as he rightly sees the misfortune, the temperature of the atmosphere will sometimes reduce that of the unemployed grist or bruised grain 25° or 30°, and at others 40° or 50°, according as the state of the weather may be; for if tried by a thermometer soon after preparation, it will vary from 80° to 90° in the bulk; but as it lies and mellows, it also cools and imbibes more moisture from the superincumbent air than it would have done if kept whole; and as this absorption of atmospheric damp amounts to the same effect as drinking a certain quantity of cold water, and is apportioned to its chilness, a hotter mashing liquor will be demanded accordingly, and more especially if it have lain some days in its bruised state. Moreover, these variations in the atmosphere, which may range as wide as 30° or more, will also necessarily affect the goods in the mash as well as the resulting wort, cooling both more quickly at a lower than a higher temperature ; in consequence of which a still hotter liquor must be employed in colder weather, unless we can be allowed to say that we can prescribe a remedy; for that can most assuredly be done.

Whatever be the temperature of the malt or grist, of the water or the atmosphere, whether varying or stationary, prior to the admixture, the mashing apparatus may be heated either before or after the ingredients are poured into the tun, or while infusing, to any degree that may be requisite to bring the goods from an extreme to a mean and desirable warmth; but a little experience will enable the brewer to find that the better way is to defer the attemperation until the machine, as a masher only, has blended all the malt and water into a homogeneous mass; for where it is to be used, the mash can be made with liquor from 10° to 30° lower than the prevalent and often dangerously high practice; by which new method and amendment in the art, the goods will be gently operated upon, the slightest risk of setting them will be avoided, and the malt will be better prepared for the forthcoming accession of heat found necessary to complete the chemical organisation of the constituents composing the mash.

The intervention of philosophical research and the experience in modern practice, have determined that the desired metamorphosis of the contents of the brewer's mash-tun will require the process to be continued several hours, and that the solid and fluid particles be kept in contact at the heat of at least 160°. By the time that the first mashing is finished by the old process, the heat of the goods is always many degrees lower than 160°, and is seldom, if ever, above 160°, even in the summer season; and though such a medium might be said in common phrase to "answer" for the time being, in an ordinary way, yet the position cannot be retained during the space necessary to produce the desired saccharisation, notwithstanding frequent applications of additional hot liquor, regardless of its disproportion in comparison with the quantity of malt, even though it be aided by the quickest possible operation of the old cooling mashing machine. It has recently been observed by certain practical gentlemen of considerable repute in the brewing world, that if more than two barrels of liquor *per* quarter are used in the first mash, the diastase, and the ingredients on which it would operate, will be too much diluted and weakened, and consequently their respective atoms will not be sufficiently in contact with each other to effect the necessary conversion.

Kirchoff, whose experiments are recorded in the fourteenth volume of Schweigger's Journal, saw something of a secret movement, but could not find the true cause any more than others. He saw that barley-meal contained both gluten and starch, that starch could not be converted into sugar by merely infusing it in water, and that gluten did not become saccharum by the like inefficient mode of treatment; but that a mixture of pure pulverised wheat gluten and potato starch, by being infused in water at a certain temperature, caused the conversion of the starch into sugar after a certain time; and he afterwards found that the action of the gluten of malt would produce abundance of sugar from raw grain; and why? It is thence evident that some principle connected with the gluten acts upon the starch, converts it into gum, acts again upon the gum, and sweetens and changes it into sugar. It is in reality the diastase, that unvoluminous discovery of the French gentlemen above named, which has been latent within it, waiting only for the means of action which a proper temperature alone can exert, in order to do the work of transmutation silently, secretly, and radically; for, like jalap, it works best when kept at a certain congenial warmth.

Thus it may be seen that great cause exists for the introduction of an attemperating power, capable of acting as a saccharifier in transmuting the goods to a new state, which entirely depends upon the mode of operation; and having noticed the utility of an efficient mashing machine, which shall perform its appointed work in the manner least prejudicial to the future wort, the author begs now to introduce his invention, as an apparatus adapted to the purposes required in this double capacity; and to explain the principles upon which it acts, both as a mashing instrument and as an attemperating medium. These requisites and many others will be found combined in

The Mashing Attemperator.

The motion of this apparatus and the manner of working it, with its effect as a mashing machine, being of the ordinary description now employed in the best establishments, nothing has now to be particularised except the principle which constitutes the novelty of its character. The shaft and arms, or rakes, in the first place, are made hollow for the conveyance of hot or cold fluids, and through these hollow branches hot water or steam can be introduced at such times, and in such quantities, as the operator may require; the same being conveyed up the central shaft to the lower end of the vertical rake shaft, where it commences its tortuous course within the body of the mash, and through the machine, on its return towards the top of the central shaft, where it is discharged into the atmosphere in an exhausted state.

The first advantage of this apparatus, its *entire efficiency* as a diffuser and controller of heat, as well as a masher, is explained in the description here given; for when it is heated and put in contact, through the rotatory motion, with all parts of the mash successively, density or mobility of parts offers no impediment to the equal diffusion of the attemperating heat; but on the contrary, the caloric is equally circulated throughout the tun, after the first revolution or two from the admission of the steam or hot water; and the temperature of the mash can either be preserved at an uniform standard, or may vary according to skill or pleasure. Experience, nevertheless, fixes a standard of 165°, and neither to rise above 170°, nor to descend below 160°, lest the powers of nature be paralysed by excessive heat on the upper hand, or soured by sluggishness on the lower.

Here the 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 needs a thermometer to prove that it is properly attempered. This must not be an instrument of the ordinary make, either with or without its case and reservoir; because the latter, with its contents, conveys the progressive heat of the mash too slowly to be of accurate use; and on the other hand, with an exposed bulb, the mercury drops so instantaneously on its removal from the mash, and with such rapidity, especially at high temperatures, that before the grains can be wiped off the scale, and the vision of the operator has penetrated the cloud of steam, and perhaps a foul or worty glass, so as to discover the tiny top of the mercurial column, it will have fallen many degrees below the real heat of the mash; that is, if the tube has escaped being smashed by the revolving machine, which is very uncertain. Dipping a thermometer into the goods and drawing it out again, is therefore so unsatisfactory, and indeed so dangerous in its results, that its indication might betray to the setting of the whole mash; and consequently experience has dictated the following contrivance:

At the back of the central shaft of the mashing machine, as at present constructed, two moveable brackets are attached, the extremities of which are provided with sockets, reaching midway between the centre and side of the mash-tun. Into these sockets a long thermometer is dropped, having a scale which stands above the surface of the mash, and a little lamp attached. Thus the instrument travels with the machine, and its enlightened index faithfully declares the heat of the mash, and tells its variations exactly as they occur; and the operator has only to *touch* the steam-cock and turn off or slacken his steam, whenever the mercury has ascended to the desired point. With such an auxiliary, the Mashing Attemperator can be pronounced, without a moment's hesitation, a tested apparatus far superior to any other power-machine or hand-implement ever yet ushered into the brewing plant, and may safely be challenged against all competition in its first attribute of *entire efficiency*.

I. As a diffuser and controller of heat in the mash;

II. As a concentrator and an economiser of the extract;

III. As a promoter of alcohol;

IV. As a creator of a delicious flavour, and of brilliancy and durability in the production; and

V. As a sacchariser and rectifier of imperfect malt.

Let us now proceed through these heads *seriatim*, and show how this invention is

I. "*A diffuser and controller of heat in the mash.*" We admit that brewers, or some at least, have become acquainted, to an extent, with the nature of the truths here explained; but they have been curtailed in their system by limitation of time, which has hurried them through their work, to the great deterioration of their property. Diastase, like that leaven spoken of in Scripture, which the woman hid in two measures of meal, until the whole was leavened, is thoroughly searching when once loosened within the volume of its operation; but it must in like manner have *time* for its performance, and its demand is peremptory. Its astonishing principle in converting starch into sugar, at the rate of two thousand parts of starch to one of diastase, is named in Turner's Chemistry, seventh edition, (by Liebig and Gregory,) which is very high authority; but they apprise us that this wonderful conversion requires *some hours* to be complete; that the diastase will not act freely unless the temperature exceed 158°, and that it does not combine with any other substance. "The paste of starch," say they, "loses its gelatinous consistence if an infusion of malt be poured on it. It then forms a mobile liquid, and if there be enough of malt, the starch is completely changed into grape sugar *at the end of some hours*, provided the mixture be kept at the temperature of 160° or 170°."

All brewers are aware, that in a rateable proportion to the height of colour in the malt, will be the diminution in the quantity of extract which it can yield: amber, for instance, does not afford so much as pale, and brown considerably less than either; which difference arises from the degree of destructive heat suffered by the diastase or saccharising principle of the grain, while it lay upon the kiln, and which principle acts the part of a ferment in the mash-tun, proportionate only to its strength. They who have seen the evil of starving the mash, have been led by theory to err in the contrary extreme, by mashing too high. The renowned Dr. Ure, in his Dictionary of Arts, Manufactures, &c., page 98, puts this great and infallible truth into an unequivocal light, by publishing an experiment in which he stirs from 6 to 10 parts of finely ground pale barley malt, into 400 parts of water heated to 80°, raises the heat of the compound to 140°, and then adds 100 parts of starch, which he also stirs well into the first mixture; again increases it to 158°, and keeps it constantly at that point, or between it and 167°, as extreme limits. The solution, which originally is milky and pasty, becomes thinner in 20 or 30 minutes; and soon afterwards, as the starch bursts into gum, is nearly as fluid and limpid as clear water. This fluid is now available for two very different purposes; for if it be quickly raised to the boiling point, *to prevent the further action of the malt* upon the starch, and then be suitably evaporated, "it may serve for those purposes in the arts to which gum is applied;" but if, on the contrary, this same fine fluid, which in this state he declares to be a mixture of mucilaginous gum with a *little* starch and sugar, and to be called *dextrine* by the French chemists, be chosen "to promote the saccharine fermentation for the formation of beer," he insists that "*we* MUST *maintain the temperature* at between 158° and 167°, *for three or four hours, when the greatest part of the gum will have passed into sugar.*" Hence the desirableness of obtaining and preserving this statutory heat in the mash, which can only be done by attemperation.

So important has the preservation of the proper heat been considered, that several have written on this subject, of which the fallacies enumerated in the introductory chapter, page 21, are instances; and many other contrivances have been brought into use in distilleries as well as breweries, in order to break up the goods speedily, and with as little loss of heat as possible; but, for the reasons there stated in substance, nothing has been done that was calculated to sustain it steadily, and accordingly the results have been imperfect; no need therefore remains to submit further evidence of the superiority of the theory here propounded, of its truth as a practical measure, or of the necessity of its application in either brewery, distillery, or vinegar works, as the brewers who have adopted it are the best judges of its superior efficiency; therefore the inventor at once proceeds in his endeavour to make the system of his first mash understood, as an advantage of importance to all traders who adopt it. He never mashes with liquor hotter than 165°, and he blends the malt with it as it runs into the tun, by the use of the mashing-machine alone; and his plan is, to run on from $1\frac{3}{4}$ to $1\frac{7}{8}$ barrel of liquor *per* quarter and to mash long enough, without regarding diminution of heat, to separate every corn from the rest, and to surround it with the infusing liquor. After being satisfied that the malt is prepared for a finishing operation, the mashing-machine acts upon the goods in its new character of an attemperator, by imparting the caloric, now passed into its hollow rakes, to the mash. By this proceeding, the whole of the contents of the mash-tun are raised from 130° or 140° to 160° or 170°, in 20 or not exceeding 30 minutes, and are maintained at this heat for three, four, or six hours, according to the colour and quality of the malt, and the discretion of the brewer. Thus a principle is carried out on sure grounds, which neither double mash-tuns, nor fixed steam, nor hot liquor-pipes, nor an additional machine, nor the repeated and erroneous application of extra boiling liquor among the goods, or such as is very hot, can at all comparatively effect: all these have totally failed from the impossibility of conforming, through such means, to the nature of each different constituent, and to the necessities and chemical affinities of all.

Such is the retentive character of dense fluids, that when the quantity used does not exceed $1\frac{3}{4}$ barrel to the quarter, and the heat of the mash is properly elevated, the contents of the tun do not materially part with their caloric during as much as six hours; and the worts are as sound at the end of this time, or even after standing twice as long, as they are at any intermediate or former period. How different is this very important condition from that of worts which are extracted from more fluid mashes, and indeed from the state of those denser worts that are occasionally, but experimentally, drawn by other plans! particularly such as are subjected to a prolonged agitation and oxidation, during the most critical and least safe period the mash can experience! Of this character especially, it may here be in place to notice the half-made worts that are removed from the goods, heated, and again and repeatedly pumped up upon the mash, on the plan of John Long, of Dublin, adopted in 1790, his specification for which appeared in the Repertory of Arts, &c., Vol. VI. p. 297. This practice, which was found not to answer better than the rest that have been alluded to, has recently been revived and introduced as modern inventions (with pirated titles) by Crockford, Lawrence, and others.

Reverting, then, to our duty as brewers: before an attempt is made to saccharise the malt in the mash-tun, every particle that constitutes the farina should be saturated with liquor of a moderately low temperature, which will dissolve the originally-made malt-house sugar *first*, and give it time to flow out of the fractured husk, and to make way for the advancing liquor into the expanded pores and vacant cells, towards the interior of each particle.

The course open to us, then, is to take our time, and judiciously to proportion the liquor according to the malt, applying the attemperator at a proper period; for by so doing we make the most economical appropriation of the gluten, diastase, starch, and gum, during the first and *only* mash; whereas without such an arrangement, we shall not be able to reduce this new and valuable theory to practice; but with such a machine it can be done without the slightest possibility of danger or risk, and with certainty and precision.

It has been somewhat unguardedly objected, that when one substance changes its character and complexion to become another, it must necessarily undergo an increase or decrease of some of its elementary gases, or that, in fact, a chemical change must transpire, and gases must evolve, as in the fermenting gyle, or as occurred in the first malting process upon the floor, where certain elements were imbibed, and others were emitted, which interchange was perceptible to the outward senses; and the objectors add, that as no such evidence exists in the brewer's mash-tub, no further conversion of the grain takes place between the malt-house and the fermenting gyle.

This objection to our theory may at first sight appear formidable; but it is at best but a one-sided view, which a little further inquiry and observation would have demonstrated; for the chief beauty of science lies in being able to prove in a variety of ways, whatever comes within its scope; but it is the province of an ignoramus to assert that which he cannot prove; and the author verily believes that this gainsaying is limited to two or three mere novices, and that it has originated more from want of knowledge than from any vicious motive; but the following may perhaps lead them to the light, if they are disposed to improve their understanding. It is true that the external appearance of the mash does not present any decided evidence of chemical change; but, it is asked, would not the extreme density of the whole contents of the mash retard the ascension of gases, if any were generated during this first mash? We know that fluids of the lowest specific gravity, part with their aërial or gaseous contents with greater facility than richer liquors: thus soda-water, champagne, bitter ales, and small beer, give off their *fixed* gases more easily and more copiously than stout and full-bodied and dense new ales; and though it may not be wise to aver that gases are evolved in the mash-tun, it may not be amiss to notice another circumstance which may tend to show that such an occurrence is far from impossible. All practical brewers have had opportunity to observe, that just as the copper "is through," the furnace fire requires damping or checking, to prevent the swelling worts from flying over the edge of the copper from their tumultuous ebullition; and that at this critical period the turbulency of the wort is always preceded by a foaming head, which gathers and breaks violently for some minutes, during which time it is not unlikely that something more than caloric is exerted in the struggle, particularly as the excessive agitation soon ceases, and is not resumed upon the introduction of more caloric.

The boiling of fermented beer evinces the same appearance; so that this phenomenon seems pretty evidently to imply, that upon the accession of surplus heat and motion, gases are emitted in both cases alike; and as the same convulsive foaming occurs in worts that have been made from water that had been previously boiled, the escape of fixed air cannot in this instance be the cause; and besides, mere water could not, under the circumstances, absorb a thousandth part of the quantity developed. These aërial vapours, then, consist of an accumulation of atmospheric air that formerly inhabited the grist or bruised malt, and that were absorbed and retained by the wort during the mash; therefore the phenomenon is accounted for, which is one step gained towards the solution of our problem, and as such, is not mere speculative theorising; and though the original objection raised against the theory of transmutations in the mash-tun has not yet been fully met, it may at once be answered that no evidence of the evolution of gases in the mash-tun is sought, because the circumstances attending the diastatic saccharine fermentation and the vinous processes, are widely different, and that our senses, our instruments, our experience, and our actual knowledge of the metamorphosis in question, combine to render objecting observations unavailing; but as even this species of argument may be deemed illogical, perhaps the following is more lucid and conclusive.

Every brewer who uses the thermometer in his mash-tun, may observe that during the first 15 or 20, or perhaps 30 minutes of the infusion of his grist, and consequently that when his mash is at the hottest, a spontaneous and gradual increase of temperature takes place; and one moment's reflection must convince him that this accumulation of caloric, which is similar to that which subsequently arises in his fermenting squares, is caused by some chemical action within the volume of the mash; and he will further reflect, that the well-directed efforts of nature soon afterwards become retarded, then stayed, and ultimately are reversed, all through a compound relaxation of heat, from the standing of the mash, and the cessation of the chemical action.

If this is not enough to lay all speculative scruples upon the point to rest, the following assuredly will. Guerin Varry assures us, and Liebig has lately corroborated the testimony, that diastase liquefies starch and starch mucilage, converting them into sugar, without the disengagement of any gaseous products, and that "*the action takes place even in vacuo.*" Hence in this, as in other chemical metamorphoses, the elementary gases do not perceptibly evolve, which shows why they are not recognized in the brewer's mash-tun; but they arrange themselves and form new compounds according to temperature and substance, and to their consequent natural affinities. Who, then, can longer presume to deny the theory of conversion, or reject the discoveries of the chemist, and the practice founded thereupon by the co-operation of the artisan? or, in a plain word, who can doubt the efficient merit of a machine, such as the one here described? The objection must be particularly out of place, after viewing the attemperator in its next light, as

II. "*A concentrator and an economiser of the extract.*" The following will elucidate the stages of saccharific transition in practice. The author, by the aid of this machine, took a course of experiments, the result of which was conclusive and satisfactory, that the theory which he had sought to establish was founded in truth. Samples were drawn from the mash-tun at the end of each hour, after the heat had been raised to 160°, and was kept above that point; and so small was the deviation in any case, that the progress here reported corresponds with each experiment to a nicety not worth distinguishing :—

Standing of the tap in hours.	Density by Dring and Fage.	Increased density.
1	35·9	0·
2	38·	2·1
3	39·5	1·5
4	40·3	0·8
5	40·8	0·5
6	41·1	0·3

Total increase 5·2. All these mashes were of pale malt and of the same quality, and just two barrels of liquor were used *per* quarter, at the statutable temperature of 160° F. After mashing about fifteen minutes, all the malt was well blended with the liquor, and the whole had a mealy smell and a milky appearance, the heat of the mash at this period being in a few of the instances higher than 137°. After a limited time, steam was passed through the mashing-machine, which was kept moving; and in about half an hour the mash usually attained the temperature of 165°, below which it was never allowed to descend, but was in some instances elevated to 166° or 168°, by merely having recourse to the steam-cock for a few minutes when the heat was receding below the point considered to be expeditiously saccharising. At this period, as taught by chemistry to expect, the appearance and odour of the mash underwent a very remarkable change, the former thick mealiness being dissipated, and the extract becoming quite clear and transparent; and so it always continued to the end.

The subjoined table will illustrate the effects of a right application of heat still more strikingly, where the malt is mashed with the ordinary quantity of $1\frac{3}{4}$ barrel of water to each quarter, or one-eighth less than in the former case, the extract coming off thus:

Hours infused.	Density.	Increase.
1	45·	0·
2	47·4	2·4
3	49·	1·6
4	49·9	0·9
5	50·5	0·6
6	51.	0·5

Total increase 6. In fact, all who have introduced the system, now admit that the worts are drawn at least 25 *per cent.* heavier in saccharum than they ever could be before the Mashing Attemperator was erected, and that no other extant means can compete with it. One of the principal advantages of being enabled to obtain such weighty worts is, that comparatively very little liquor is required to exhaust the goods after the mash is made. For example:—if we use 20 quarters of malt that will produce 90 lbs. *per* quarter, or 1800 lbs. in all, and if we at first draw 20 barrels of wort at 50 lbs. each, or 1000 lbs. in the aggregate, we have drawn considerably more than one-half of the extract. This may be done; and when due precaution is taken in supplying the remainder of the liquor, we shall experience no difficulty in bringing off the remainder of the extract with 24 barrels of liquor, yielding on the average 33 lbs. *per* barrel, or 792 more. Thus the whole product is obtained in 44 barrels of wort, weighing nearly 41 lbs. *per* barrel; and with more facility, because in this latter case a larger quantity of sparging liquor may be used to produce the necessary length for the more ordinary beers; whereas worts made upon the old system require boiling down to the density wanted; but the evaporation which attends that process has long stood condemned as wasteful of time, fuel, and material.

The consequence of such concentration alone, as the Mashing Attemperator accomplishes, *considered apart from additional extract*, are not only extraordinary, but are beneficial in a pecuniary sense, as seen on view of the eight subjoined comparative examples of brewings with malt that is brought to yield 90 lbs. density *per* quarter.

1. Examples of four brewings by the ordinary practice, from which the usual lengths, with table beer or return wort, are drawn, either of them estimated at 1*s.* 2*d.* *per* lb.

Specimen.	Qrs. of malt.	No. of barrels.	Density.	Price *per* barrel.	Value.	Lbs. extract of T. B. or R. W.	Value.	Total extract.	Total value.
				s.	£. *s.*		£. *s.*	lbs.	£. *s.*
1	10	30	26	36	54 10	120	7 0	900	61 10
2	10	$22\frac{1}{2}$	32	48	54 0	180	10 10	900	64 10
3	10	20	36	58	58 0	180	10 10	900	68 10
4	10	15	40	72	54 0	300	17 10	900	71 10

2. Examples of four brewings by the Attemperator, with the same made malt as above, the extract forming an entire gyle of the same densities in the several cases as before, and charged at the same prices, with the additional profit upon each.

Specimen.	Qrs. of malt.	No. of barrels.	Density.	Price *per* barrel.	Value.	T. B. or R. W.	Total extract.	Total value.	Amount saved.
				s.	£. *s.*		lbs.	£. *s.*	£. *s.*
1	10	$34\frac{8}{13}$	26	36	62 6	None.	900	62 6	0 16
2	10	$28\frac{1}{8}$	32	48	67 10		900	67 10	3 0
3	10	25	36	58	72 10		900	72 10	4 0
4	10	$22\frac{1}{2}$	40	72	81 0		900	81 0	9 10

Total gain by the four brewings, £17 6*s*. In further elucidation of this, let us suppose that a brewer consumes 2000 quarters of malt annually at 54*s*., and that his chief productions are Nos. 1, 2, and 3, in equal quantities, as it is presumed that little of No. 4 is brewed in common practice, and that probably the quantity of No. 1 exceeds that of No. 3; we omit No. 4 in the calculation as a consequence, which gives the average additional profit 5*s*. $2\frac{2}{5}$*d*. *per* quarter, or £520; and if to this we add the value of the additional extract obtained through the powers of the machine, at 5 *per cent.* only, and in many cases it is double of this, it gives the 20th of 2000 × 54*s*., or £270 more, and shows the additional profit on the 2000 quarters to be altogether £790 a year; and when we deal in the extract No. 4, this profit will be more than doubled.

To brewers of strong beers, and those whose demand for inferior qualities is limited, the vast economy effected by the application of this principle of concentrating the whole produce of the malt into one gyle, however weighty, must at once be obviously clear; but where it is understood that this may be done without discolouring the worts by extra boiling, and is attended, amongst other advantages, with an additional quantity of superior extract, amounting to many pounds *per* quarter, the merits of such a means cannot be doubted by any one; but surely the trade in general must appreciate it, and particularly brewers of Vatted Beers, if only by reason of its concentrating powers. At a moderate calculation, the increase of gain is more than sufficient to pay the whole expense of the home establishment at least, which is no false theory, but a fact which the author is prepared irrefragably to prove.

Admitting as a simple hypothesis, that the saccharometer indicates the extracts by two different processes to be equal in quantity and gravity, still this will not stamp their identity in respect to *quality*, inasmuch as one may be much more starchy and mucilaginous than the other, without its gravity being sensibly affected thereby. The very serious importance of the distinguishing properties and products of these two principles, cannot surely fail to attract the lively attention of all who trade in the fluid extract of grain; for while the two widely different characters of mucilage and saccharum are blended in nearly the same proportion within the malted corn, and the inferior constituent increases as well as the superior, when placed in an ordinary mash-tun, and they stand at the same cost to the trader, he certainly must perceive his interest, if he is wise, in providing the readiest, the simplest, and at the same time the most efficient means within his reach, to increase the latter at the expense of the former, thereby improving the flavour, the strength, the constitution, and the permanency of his manufacture, be he brewer, distiller, or vinegar maker.

III. "*A promoter of alcohol.*" If this new and thoroughly chemical theory, which is here carried into practice, were ill-founded, or of doubtful benefit in its result, it would not be countenanced by philosophers at large; and much less would they embrace it as a principle, or embark in its promulgation as a doctrine; but if its basis be good, and its apex clear and accessible, then the practice of acclination must be made to correspond with the detail. One step in the way of accomplishment, is to exemplify the amount of spirit produced from various materials, in order to show how far the approximation to the character of sugar increases the tendency to create alcohol. This is proved by the simple fact that malt, which is more saccharised than barley-meal, will make more spirit in proportion to its weight; and that Indian sugar and molasses will yield more than malt. The order of gradation that attends the vinous decomposition of farinaceous starch, as it passes through its stages into gum, sugar, and alcohol, shews that the original sugar is the first to decompose, that the latter formed saccharum follows in succession, that the more perfectly starchy particles are the last to yield, and that, therefore, the more the produce is purified, or converted from mucilaginous gum by transition into sugar, the more spirit it will contain ; and here the principal question is, how much more spirit will clear and pure saccharum produce, than an equal quantity of matter which is half saccharine and half mucilaginous? That gum of itself will not undergo the vinous fermentation, no doubt exists, the proof negative being before us ; but "its aqueous solution acquires an acid taste in a few days, and becomes muddy." This is an old and long recognised principle. "As to strength in beers," saith an old and intelligent author, "as in wines, cider, and every fermented liquor, the foundation of it all is sugar." And again, "Every particle of it is the creation of vinous fermentation ; and no such fermentation can be excited except in a liquor that is drawn from some species of sweet, and is ever in proportion to the sweet extracted."

According to certain experiments prosecuted by the House of Commons, under the joint superintendence of Drs. Thomson and Ure, a quarter of malt, with proper management, will yield 18 gallons of proof spirit, and a quarter of barley from 18 to 20 gallons, (which shows that mucilage can be brought to spirituosity when in affinity with other matter,) the best grain producing the higher quantity, and weighing 55 lbs. *per* bushel, or 440 lbs. on the whole ; and the average weight of the malt being 42 lbs. *per* bushel, or 336 lbs. *per* quarter.

The annexed quantities of various sugars and sweets are also each equivalent to a quarter of malt, or will respectively produce 18 gallons of proof spirits, the truth of which has been determined by an eminent distiller with whom the author corresponds: West India molasses 275 lbs., refined or sugar-house molasses 295 lbs., Jamaica inferior raw sugar 234 lbs., best West India sugar 175 lbs. This subject largely engaged the attention of Baverstock, who gave the average of sugar 200 lbs. and that of treacle 240 lbs., which last is lower than modern experiment goes, probably because as the manufacture of sugar was then less perfect than now, the molasses contained more saccharine matter. But he also notices another sweet, and that is honey, 226 lbs. of which he gives as an equivalent to a quarter of malt. The following table of equals in productive matter will therefore be found practically useful:

Materials employed.	Lbs. giving 18 gallons.	Gallons in 100 lbs.	Lbs. *per* gallon.	Value. £ *s.* *d.*
Best West India sugar .	175	10·286	9·72	4 11 11
Jamaica raw sugar . . .	234	7·692	13·00	5 16 2½
West India molasses . .	275	6·545	15·28	3 18 5½
Sugar-house treacle . .	295	6·102	16·39	3 18 7
Unadulterated honey . .	226	7·964	12·55	3 10 2
Best samples of barley .	396	4·545	22·00	2 13 8
Malt of medium quality .	336	5·357	18·66	2 19 0

Whence it appears, that if we go so far as to consider that the whole of the best sugar became spirituous in these examples, little more than half of the malt, and less than half of the barley, was turned into alcoholic beverage, though capable of a greater yield, because much of the farina or hordein remained unconverted; and it is evident from these results, that sugar formed the basis of alcohol, which is a powerful argument in favour of a saccharine extract, in preference to such as is mucilaginous, both for the brewery and for the distillery.

We have now to treat of the Mashing Attemperator as a

IV. "*Creator of a delicious flavour, and of brilliancy and durability in the production.*" Although a gradual and very considerable increase in the absolute gravity of the first wort is clearly indicated after attemperation, yet we cannot thereby readily demonstrate the whole of the benefits arising from a judicious appropriation of the first mashing heats, and for this reason: having kept in recollection that the saccharum in some barleys is to the gum as 100 to 88, differing in others as far as 100 to 80, or as 5 to 4, and that the difference in the ratio of these compounds diminishes during the malting operation, till at its termination they appear in the malt at an equality of 15 *per cent.* each; still from the most satisfactory experiments that the author has yet been able to make, he finds no real determinable difference between the specific gravity of the unalloyed saccharum and that of the gum, nor does analogy alter the matter much; but this subject will be found more fully treated upon in Chapter VII.

The ingredient mucilage has other peculiarities which war against the interest of them that are obliged to deal in it. When blended with sugar and fermented, as in ale for example, the sugar is always the first to decompose, and the mucilage does not transmute so fast as its accompanying sugar, particularly towards the latter stage of the fermentation; but in low temperatures, it often happens that every trace of sugar is lost, and that the fulness of the article depends upon the perishable support of the remaining mucilage and the presence of carbonic acid gas. Be it recollected that ale, when attenuated and fine, shall retain one-half of its original extract; yet it is by far less than half so sweet as before fermentation; thus demonstrating that the unattenuated matter consists of an almost tasteless mucilage, attended by a bitter from the hop, which of itself would neutralise the sweet to an extent proportionate to the progress of fermentation. The want of flavour in mucilage, and its proneness to acidity, place it incomparably beneath sound saccharum, inasmuch as a smaller quantity of the latter by 90 *per cent.* will impart adequate sweetness, devoid of clamminess and turbidity: how useful, then, must be that process which can aid the transmutation of the gum into saccharum, leaving only the more slimy portion of mucilage, or amylin, unconverted, and even softening that in its harsh temper!

A ready and common test for proof of perfection according to quality, is the palate: by this simple means alone, it has been a matter of great surprise to the individuals who have but merely tasted the worts produced by the patent machine, that the increased rich sweetness and high odour should be so obvious to the senses during the saccharising process; and the extreme brightness of the worts is also a remarkable feature. The fact that the mucilage, when in a separate state, is clammy, poor, and insipid, shows clearly that the increased sweetness of the mash must be attributed to the transformation of the gum, more than an improvement of the original saccharum of the corn.

These observations do not apply to the first wort alone, but to the whole extract when embodied in one gyle; and the superior richness and smoothness of the perfected beer, as tested by the palate, declare its paramount virtue to be out of comparison. The action of the diastase on the more advanced portions of the starch, and indeed upon nearly the whole of it, *begins* in a way almost immediate, and certainly decisive, as soon as the heat has sufficiently advanced; for in none of the worts made by the new system, though minutely examined by a noted practical chemist who assisted the patentee in some of his experiments, could a particle of starch be traced as such by the indefinite test of iodine, though in a few instances there were slight indications that could not be distinguished from the appearance caused by the presence of amylin alone; and thus it is that future brilliancy is given and guaranteed, because all obstacles are removed by the attemperation. *The mere transmutation of starch into gum is not*, however, *the sole object*, *but a provision upon which greater things depend;* for it is practicable, as shown by analysis and enquiry, as well as by the common every-day use of the attemperators in present use, that by following up the same means to a greater length of time, the advancement of the several constituents of the grain to a most valuable saccharum resembling the sugar of grapes, would be more complete.

Testing wort at the tap with the tincture of iodine, has of late been considered a good practical experiment, since, if any of the starch has escaped the action of the diastase, the iodine will turn it blue; but this is fallacious for the brewer's practice, because it is also a test for dextrine, and nearly all the amylaceous substances, and produces similar signs and colours. Suppose the whole of the starch to be rent asunder, and the iodine test to be applied to the wort, it will give a blue or reddish colour; but the starch does not do this from its having partaken of other properties, as the cause of the colour is then the presence of an amylin, or the untransformed enclosure of the starch, which continues to resist the diastase, though the amidin, or enveloped interior of the starch globules, have passed into sugar.

Still, after all, as the tincture does not tinge, which is generally the case to a great nicety with the attemperated worts, it certainly shows the clearness and brilliancy to have been commanded to the full extinction of all the convertible matter; and brilliancy is as much the cause of profit as flavour, though both are better when they are, as here, co-existent.

West of England brewers and others, who vat their beer and keep a large stock, are frequently disappointed on broaching a vat, by finding its contents thick or cloudy, or "grey;" and with some brewers this is general during the warmer months of the year. Such beer often changes from tolerable fineness to a low fretful fermentation in one night; yet this fickleness and instability of the article is never experienced by brewers that *make their extracts upon correct principles;* because with them the azotised parts of the grain, the originators of these troubles, are so far reduced, dissolved, or simplified in the mash, as to render their further decay or dissolution so easy and certain during the vinous fermentation, that *the residue is less susceptible of further decomposition when in the store*, whether induced by heat or shocks. This has also been proved by experience; and besides this, we have the declared opinion of Liebig, not only to warrant the general system of saccharisation into one substance, but also to speak to the permanency of the substance itself, where he says, "There are many facts which prove that the most simple inorganic compounds are also the most stable, and undergo decomposition with the greatest difficulty, while those which are of a complex composition yield easily to changes and decompositions. The cause of this evidently is, that in proportion to the number of atoms which enter into a compound, the directions in which those atoms act will be more numerous."

Finally, as regards the attemperation of mucilage into a saccharine consistence, it is found to be more adhesive than sugar, and this will account for Dr. Thomson's finding more of it in the last and weakest worts than in the first drawn: it also deposits much more sediment and yeast during the decomposition, which in some measure shews its deficiency in yielding alcohol, when compared with saccharum, and helps to explain that high gravities are not always the best signs of a perfect wort. The reduction of the many distinct substances in the complicated admixture of hordein, starch, gum, and albumen, into the one pure, simple, and soluble article, sugar, renders the wort issuing from it less liable to run into an acetous fermentation, because the change has been attended by a general decomposition and purgation. Doebereiner shews the fatal effects of retaining these crudities, and has exposed them in the "Journal de Chimie de Schweigger," where he says that after trying experiments on starch, his researches convinced him that pale beer contained a considerable quantity of it; and avers that it makes it nourishing, but "at the same time disposes it to turn acid." This is the evil that has abundantly prevailed; but the saccharum, which is more nourishing still, has not that tendency while properly treated; and hence the policy of converting the starch through purification by diastase; for where acidity enters, it breaks a hole into the brewer's purse. This truth being cleared up in a few words, we proceed to speak of the Attemperator as,

V. "*The clarifier and rectifier of imperfect malt.*" A variety of circumstances have contributed to increase the intrinsic value of malt. Farmers have of late been more choice in their seed than formerly, and have exercised greater judgment in the selection of soils and manures, have improved their lands much better for the reception of the corn, and increased competition has made the malster more attentive to his department of the preparation; and the invention and adoption of the saccharometer has doubtlessly been an excellent handmaid in inducing and carrying out the work of amelioration. Notwithstanding all this, the brewers of the present day pride *themselves* upon their increased extracts, and attribute them, correctly in some few instances, to an improvement of their own devising, either in the heat of their liquor, or upon their mashing or extracting process, or to some novel cause to which their forefathers were strangers. One difficult task, however, yet remains unfinished, which is, that not having had a fair and full opportunity of proving their superiority, they cannot be justified in affecting to display it. In dealing with flinty or otherwise imperfectly made malt, whether occasioned to be such by bad management, by unfavourable soil, or by *unpropitious seasons*, and particularly this last cause, the management of such malt is a duty of very serious consequence to the brewer, inasmuch as not only are the flavour and the amount of extract alarmingly diminished below the common average, but the misfortune is often, if not invariably, heightened by high prices; yet through the want of unanimity or faith in the trade, and the peculiar nature of the brewing business, any attempt to counteract such precarious casualties, by lowering the gravity or increasing the price of the beer, is ever attended with great risk to the trader, and is probably followed by great ultimate disadvantage; for it is well known that brewers, unlike many other commercial men, must keep their prices almost stationary, let the market value of their raw materials be what it may.

It is really important to observe on this point, that the Attemperator has been found a most efficacious machine where the malt has been of imperfect nature; for as diastase is kept constantly present and in vigour by the peculiar standard of heat introduced and prolonged, this singularly agitant property having originated at the commencement of germination, and remained latent *ab initio*, until heat and moisture have been duly applied, and each particle of both has been brought into close contact with the hardy starch, gum, and hordein, of the broken grist or bruised malt, these latter are forced into an active state of transformation through the restless disposition of the aroused diastase; and the result is similar to the former process of sweetening the corn by malting, but with this difference, that in the mash-tun no roots or spires spring out of the vitals of the seed to feed upon them! Now it must be admitted, that by the ordinary means, these flinty and barley-like malts cannot derive much improvement by infusion; because the brewer is unable to maintain the heat of the mash at a safe and suitable temperature, or at any thing like it, for more than 60 minutes, or 90 under the most favourable circumstances; and that during one-half even of this time, unless the goods are swamped with boiling liquor, the heat of the mash will not average 154°; but whether that malt be of a steelly or of a deaf character, if some portion of it has germinated at all, though unkindly, the right application of the Attemperator through a proper period of time, will so soften the hordein and stubborn or fibrous starchy matter, as to enable the diastase to pursue its natural and supremely active course. These impure malts contain from double to triple the amount of hordein to that of the best samples, and consequently they require more vigilant treatment and longer care to bring the saccharific particles into solution. Such malts should be ground finer or crushed better, mashed more carefully, and with colder liquor, and the temperature should be raised by more stages, till the ultimate heat of the goods becomes some 5° or 6° higher than usual, and the infusion should occupy *considerably more time.* There are, besides, other indispensable conditions which will make such grain nearly as valuable as the more expensive, all of which will be explained to those who will possess the means of making them available.

It may be proper to observe, by the way, that another practical measure arises hence, which may one day be of vast mercantile consequence. Distillers and vinegarers have for a long time been allowed to use a certain quantity of raw corn in proportion to the malt they consume; therefore it is really very important for them to know that such accustomed indulgence can *now* be fully appreciated, because the new patent process must, as it assuredly does, greatly enlarge the scope of solvency, thereby materially increasing the amount of solid extract, and promoting its richness, and consequently *augmenting the measure of alcohol.*

The author's experience with *raw* grain is limited; but his theory of convertibility has recently been established in the practice of a large country vinegar works, by the following results. To make the necessary length before the "Hot Masher" was erected, they required a mash of 10 quarters of malt with 22 of barley; but since the improved machine has been introduced, 8 quarters of malt and 18 of barley have produced the same length and quantity. Astonishing as this may appear, the proprietors of the establishment will certify its accuracy, and may be referred to for the information of any interested and respectable enquirer: it can be accounted for only by the facts which follow.

Worts obtained by this procedure are less clammy than those of the ordinary kind often are, without being mawkishly sweet like the latter; and though many pounds denser, they drink with a cleaner taste and more pleasant relish, leaving the palate sensible of an agreeable delicacy, with a prominency of flavour and an aromatic odour, part of which excellent quality may truly be attributed to the action of the oil resident in the husk of the grain, which the long-continued heat developes and probably increases, beyond what science has hitherto discovered of its native quantity; but although this minute proximate principle imparts strength and prolongs preservation, it has a disadvantageous effect on the saccharometer, being lighter than water. When the author's attention was first attracted to this gratifying result of his mash, outwardly so mysterious at first view, he fancied that as he deviated in his management, his wort, and subsequently his beer, bore some peculiar trait, which always displayed itself in the ever interesting process of fermentation; and further observation and experience soon convinced him that some unseen principles were involved, till at length these became apparent, and the causes of variation during fermentation, and of the peculiarity in the article, were accounted for, not only by difference of gradation in the time, heat, and liquor employed, but also by other attendant causes producing their own effects.

The most important feature of his worts, because it is the most convincing, and embraces the greatest variety of consequences concomitantly, is that in proportion to the time occupied (within certain reasonable limits) in the mashing and attemperation of the goods, the less evident is the increase of density according to the senses; and although the accession of extract is at the same time duly indicated by the saccharometer, yet it is not a due indication of the quality of these highly saccharised worts, as the ultimate character of the beer, and the additional alcohol it produces, unequivocally demonstrate. This conclusive observation is correct in practice, and further enquiry shews it to be chemically consistent, which must evidently arise from the purity and simplicity of the extract itself. At first thought, it might seem to imply an absolute elasticity in the attempered worts, by which their volume had increased; and as we are assured by chemists of note that 100 parts of starch will afford 110 parts of sugar, then as six parts of malt will saccharise 25 parts of starch, yielding 27½ parts of sugar, exclusively of that furnished by the malt, the idea does not appear incredible; and it is evident how rare the fluid must have become after such tendency to change its character, and such long inducement to do so.

That the quantity of starch rendered into saccharum under circumstances similar to a good and properly made mash, exceeds the amount of its amidin, is evident from an experiment published, with many others, by the great chemist Querin Varry, in the "Annales de Chimie et de Physique," LX. 32, where from 100 parts of starch *in the state of mucilage,* (that is, with the shells broken,) and 39 times their weight of water, mixed with 12½ parts of diastase dissolved in 40 parts of water, he formed 86·91 parts of sugar, which distinctly shews that amylin, the most obdurate of mucilage, does not altogether resist the potent impetus of diastase, though learned analysts have averred that it does; but perhaps they had not patience to give the trial sufficient time; for it has been shewn in Chap. II. that the amidin of starch is but 38 *per cent.*

Whence, then, the 87 parts of sugar, if the amylin were unconvertible? And if convertible under common circumstances, why not even more so by the extraordinary means expressly provided for that purpose? It may be considered egotistical and superfluous to produce any further reasons for preferring these means to enable the brewer to exercise as much control over his mash-tun as his Attemperators afford him over his fermentations; for this long wished-for *desideratum* has been well received, and continues to experience daily increase of patronage from the most intelligent portion of the trade; we will therefore conclude this subject by observing that, while we are converting primary and other compounds, we transmute a gross compound into a finer and less complicated article, acquire ADDITIONAL EXTRACTS AND PROFITS *to a very considerable extent*, and are proportionately rid, to a like amount, of the impediments which until now have served only to weigh, muddle, acetify, and perplex.

CHAPTER VI.

SPARGING.

SCOTCH METHOD—ASSAY OF GOODS—PARTY GYLES—RETURN WORTS—GREAT ECONOMY IN TIME, LABOUR, AND FUEL—DILUTION—FILTERING MASH—PREVENTION OF ACIDITY—GRAINS—IMPOSTURE EXPOSED.

The proper time for setting tap having arrived, this must be done so that it may draw off the wort as fine as possible; and if the Attemperator has been rightly used, it cannot be otherwise than bright; but as the first runnings will contain a large quantity of the finest of the grist, which will have unavoidably dropped through the perforated bottom during the former part of the mashing process, it is advisable to replace the first few gallons of such wort upon the surface of the mash.

Immediately on setting tap, start the sparger also, to allow the hot liquor to flow upon the goods quietly and rather slowly, but at the same pace that the wort is running off; and continue that course without intermission, passing and keeping as much liquor on the goods as is required for the necessary length. Although the process is a slow one, it is far preferable to frequent mashing, and is much approved by those who practise it. Many brewers defer sparging until one-half, three-fourths, or the whole of the first wort is run off; but it appears that a majority mash a second time, whether a sparger is used or not, and aver that the whole extract cannot be obtained by one mash and a sprinkling. Richardson was of this opinion of old, because he had not sufficient patience.

Most brewers must have observed, that during the drainage of the first wort, the goods settle down into the lower part of the tun, which settlement causes a circular chasm, sometimes of considerable depth, between the goods and the tun ; and as the mashing-machine remains stationary within them, the lowering goods rest upon its shaft, and subside between that and its numerous rakes, forming vacuities beneath them ; and cracks and channels are formed in other parts of the goods, increasing in width or number, according to the time engaged in drawing off the worts. Sparging upon goods in this state must be disadvantageous, in consequence of a partial drainage through these various soughs, fissures, and void spaces; therefore reparation is usually sought in a second mash, but can only be rendered of tolerable service by keeping the goods in a very fluid state during the after-process of sparging. Difficult and unequal drainage is yet the more evident with gritty malts containing a superfluity of insoluble particles, which accumulate in strata, stop the pores of the mash, and create impervious masses, often causing the extracting liquor to shoot across the surface towards some hidden cavity, or to run off obliquely in currents to fill the chinks, instead of percolating directly and equally from top to bottom.

The sparging liquor should never be colder than the first mash; for if so, the pores of the husk, hordein, &c., will contract, and the more sparingly, therefore, will the malt part with its matter, then held in a state of solution. When the highly concentrated and hot condition in which the worts quit the mash-tun is considered, possessing as they assuredly do, in a corresponding degree, the preservative essentials which are purified by percolation through the kindred goods, these circumstances combine to prevent the danger of acidity. Add to this, that of course nearly all the extract will require dilution to reduce it to its proper density in the wort copper or boiling back, when a light article is demanded. In accordance with the principle of this theory, a hint may not be considered untimely. It will be found better to dilute with clear fresh water, than with an impure wort, impregnated with nothing more or less than the germs of acetic acid, as all those weak and paltry worts are after an ordinary *first* mashing process, and when obtained by the old method of repeated mashing.

The inutility of a series of mashes with the same goods seems generally to be known in Scotland, as we find another writer on this subject, arguing that, as his countrymen mash but once, properly speaking, they cannot be said to have more than one wort, the first running of that wort being the extract obtained from the malt by the liquor used in the infusing process, besides a considerable portion of that which the sparging produces; the after-running being entirely the result of the sparging operation. The sparger so generally used by the Scotch brewers, is now tolerably well-known in England; but to the uninitiated it may be necessary to describe it. The apparatus consists of a perforated horizontal tube, resting upon a bar and supported by a pin in the centre, above which and the tube a receiving vessel is placed, to supply the tube with liquor. The perforations extend through the whole length of the two or three arms of the tube, so that the sparging water may spout horizontally, but in the opposite directions; and the reaction generated by the issuing of the water from these side holes is sufficient, through its centrifugal power, to keep the pipe in a rotatory motion, dispersing the liquor equally over the goods. In short, this common sparger is a modification of the well-known and much admired "Barker's Mill," and is another application of its principle.

In consequence of recent improved arrangements in the mechanical construction of the Mashing Attemperator, by which it is made stronger and simpler than any old machine, the whole extract of the malt can be obtained by ordinary sparging, and the expensive and somewhat complicated apparatus, named the Hystricon in the former editions of this work, is superseded. Besides this, wherever steam boiling is adopted in conjunction with the "Hot Masher," the worts are kept at any requisite degree of heat after the first few barrels cover the lower coils of the boiling worm in the underback or Hop Convertor, so that the process of dissolving the hop in the wort at a moderate heat, and never permitting the wort to cool below a given temperature, but constantly keeping up its heat until it reaches the cooler, preserves it from acidity, and from acquiring any bad odour;—a result highly gratifying to the operator. For the methodical particulars of this new process, see forward, Chapter VIII., under the head of Hop Convertor.

Every brewer is sensible of the inferiority of weak worts from party gyles, and many usually give a pound or two of saccharum *per* barrel on their ales, when under 20 lbs. *per* barrel, if drawn from the same goods as an article of greater strength. It is a fair presumption that this liberality on the part of such brewers does not emanate from a conviction that their saccharometer presents a false indication of the actual density of the saccharine body of these weak ales, but that the instrument is affected by a foreign agent: they certainly ought not in any wise to do it from the apprehension that the individual saccharum of itself, and alone, is inferior in sweetness to the first extracts. The ales are inferior only in specific gravity and in richness or flavour, the most valuable constituents of which have evaporated or passed off with the first worts. The pound or two *per* barrel, then, must be given as compensation for the injurious effect of some uninvited attendant, or apparent "necessary evil," as it is called by some who calculate on a wrong basis; which evil has the effect of smothering, sooner or later, the most desirable qualities of the saccharum.

Other and very serious evils attend party gyles. There cannot be any real difficulty in working them, but there is a great doubt of their working satisfactorily when the worts differ in constitution; and there is much trouble, some perplexing calculation, a great loss of time, and sometimes of material also, in obtaining any certain gravity requisite to sustain a given price.

Another matter requiring serious consideration, is that of return worts. Brewers of strong ale, economists of a certain class, and those whose peculiar trade and practice enforce the use of these worts, as well as persons who reject them, know too well that they have but a choice of evils. Amongst the latter ranks Levesque, who wisely observes, that though throwing away a wort of five or six pounds *per* barrel may seem extravagant, it is "like skimmed milk, but of little value." Thus one throws away that which another estimates at an equal proportionate value with his other worts; but in the new system such worts are unknown. The merits of these people's practices may be best illustrated by reference to the following common-place example:—

Of two successive 20 quarter brewings, the first shall produce a return wort for the second day's brewing, amounting to 36 barrels, at 5 lbs. *per* barrel, or $36 \times 5 = 180$ lbs., which being divided by 95, or the quantity that good malt will yield, gives nearly 1·9 quarter of malt, which at 65*s. per* quarter, amounts to 6*l.* 3*s.* 6*d.*; and supposing this to occur only once in each week, the loss exceeds 320*l. per annum.* This is undoubtedly extravagant, and the advocates of the wasting system content themselves with the declaration that it is next to valueless, which surely must signify, that although 36 barrels of wort contain 180 lbs. of fermentable matter, it so abounds with impurities, *through the manner in which it is extracted*, that they neutralise the benefits expected to be derived from any saccharum which it may contain, to such a degree, that the whole becomes no more valuable than the original water. Thus we see that the consequence of such a practice is, that 5½ *per cent.* at least of the available saccharum of the malt, in every brewing where short lengths are drawn, is devoted to the feeding of pigs or cattle! This reduction of profit, with its concomitant disadvantages, has hitherto been in a great measure unavoidable, in consequence of the absence of proper means for the extension of the malting or saccharising process to the mash-tun, and for dividing the rich soluble properties of the malt from the poor and insoluble. But whether these return worts be milk without cream, or water without sugar, or worse than either,—or whether they be profitable or injurious, they need no longer be desired or feared, nor need party gyles be made.

The grains left after the operation of the Mashing Attemperator and the Sparger are too remarkable in their structure to be thrown away without notice; for on examining them, the fleshy parts of the farina, which constitutes the chief part of the draff as food for hogs, is found adhering to the husk, and constitutes that which chemists term hordein, being a farinaceous substance too obdurate for conversion into starch, probably from the imperfection of the seed, since in some husks the appearance of empty honeycomb is presented by the microscope, the cavities of which are numerous, and are deeper at the end which has connected the skin with the farina which has dissolved away from it in the mash: indeed, the ragged appearance of these grains is more or less perceptible in every house, but is more particularly observable in the undissolved portion of the grain that has been operated upon by a judicious use of the Attemperator. Even during the first mash, before the sparging has commenced, the adhering farina feels softer, and appears more spongy, than when brewed by the ordinary process; and the conclusion to be formed from this striking fact is, that the gluten, &c., has, through the long continuance of a suitable heat, released its cementing hold upon the particles of the farina, and has thus opened a free passage for the solvent power of the liberated diastase, and the assimilating property of the saccharum to and on the starch and more matured parts of the hordein, there enveloped by the more hardy portion, and by the less soluble and fibrous, or lignine parts of the grain; which is probably the chief cause of the gradual increase of convertible extract, and of the consequent improvement in the density of the wort.

It has long been observed, rather than argued, by many of the London brewers, for unfortunately for this delicate art, and them who profess it, discussion on business subjects is seldom resorted to; and amongst those observers rank some of the leading men;—that an entire grist should turn out an entire gyle; that truly good beer, of whatever kind or colour, cannot be brewed without the full measure of each constituent of the malt; and that, therefore, mucilage is as essential as sugar to the formation of a perfect malt beverage; whereas, an examination of bitter ale, the fact of a more or less complete conversion of the ingredients in all mash-tuns, and the certain knowledge that they cannot depend upon any two results turning out alike, might enable them to see through the whole philosophy of their observation. Notwithstanding the principles which they thus hold, but cannot advocate upon tenable ground, not half-a-dozen of the brewers in town dispense with return worts. The practice of those who brew ale as well as porter, is to arrange that the porter mash shall follow the ale brewing on the succeeding day; and to make a large quantity of return wort after the ale has come off, and pump it over to the porter brewer. Surely, this is preaching one doctrine, and practising another with a vengeance! for evidently either the ale must contain too little of this essential mucilage, or the porter must be overdone with it; and where mucilage prevails, there must be a greater approximation to spissitude without an increase of value; because, as we shall have occasion to notice in our further progress, a mechanical analysis or separation of the thin sugar from the thick gum, takes place during the drainage; and this gum, as before shewn, is the last to yield. Without stopping to enquire respecting the suitableness of such a wort for the vicissitudes of alternate cooling and heating, pumping and jumbling, about twenty-four hours longer perhaps, the system affords evidence enough upon the mere view of it, that it is compulsory and likewise disagreeable to the person who is desirous of concentrating his extracts into one naturally proportioned gyle, and of avoiding surcharge and pollution. Now, however, the day has arrived when both the ale and the porter brewery may each employ its own materials within its legitimate confines: at least, the inventor of the *means* has done *his* duty towards furthering that desirable object; and it remains for the brewers to perform *their* part by reasoning upon the plans here presented, and if they find them good,—well.

*** Having advanced his sentiments thus plainly and truly, the author has no wish to *thrust* himself into greater conspicuousness than is due to him as his position in society; but "England," said the brave Nelson with his last gasp, "expects every man to do his duty;" and here, if allowed the use of nautical phraseology, having defensively expatiated in his second edition against privateers and wreckers, in order to ward off some antagonistic cross-sailing which he reconnoitred, but which has since passed away with the gale, he now rests upon his rudder, looking out for nobler craft, not dreading the approach of any adventurer who may steer out to sea without a compass, or seek to intimidate by his colours. All past transgressions have sunk into the deep; therefore he claims no victory,—seeks no triumph,—requires no booty.

CHAPTER VII.

SACCHAROMETRY.

CUSTOM—GRAVITY AND DENSITY—ORIGIN, HISTORY, AND USE OF INSTRUMENTS—DICAS—DRING AND FAGE—THE IMPERIAL ACT—ALLAN—SCOTCH AND ENGLISH EXCISE—BATE—LONG—COMPARISON OF GAUGES—EGREGIOUS ERRORS—DOCTRINE OF EXPANSIONS—NEW UNIVERSAL THEOREM—DEDUCTIONS—THE ALCOHOLMETER AND ACETOMETER.

The introduction of the Saccharometer in the middle of the last century, led to one of the most beneficial improvements that have at any time come within the brewery walls; inasmuch as it enables the practical man to estimate the value and perfection of his manufacture according to its comparative weight, and to its consequent quality as thereby affected, and to regulate his gyles by the criterion which it affords. Notwithstanding the value of the invention, it has, like most others of really utile character, met with so much stubborn opposition as to retard its success, though many frivolous and superficial projects have had their myriads of butterfly admirers to flutter out their day, whilst intrinsic excellence kept dawning in its twilight.

The truth is, that the younger branches of society are enticed by speciousness, whilst the seniors, from their knowledge of failures and crosses in speculation, and from an abatement in zeal and credence, which naturally accompanies the decaying vigour of their own nervous capabilities, become negligent of new pursuit, and obstinate in resisting novelty of design, from a fixed apprehension of future danger. This contrariety of feeling was particularly exemplified by the Baverstocks, father and son, in the infancy of Saccharometry, when the younger was obliged to hide his instrument in his pocket, that he might carry on his experiments without encountering the prejudiced eye of the parent.

Ignorance, the companion and preceptor of obstinacy, has a ponderous influence in retarding the progress of science, because scientific acquirement moves in a sphere of action which is incomprehensible in the blind or beclouded view of the uninitiated; and upon this principle only can we account for the inconsistent conduct of those provincial proprietors, and they not a few, who rely upon their palate as their test, to guide them in their affairs, making mere taste the basis of their calculations, even when by the advice of some friendly maltster or hopster, they have become actual purchasers of this indicator to a sounder mode of judgment, for their permanent relief and satisfaction. Unaccustomed to preside over their own business, they rely upon the care of some stout workman who is possessed of good natural sagacity, and willing to labour at a trifle above common hire; but who, not having emerged from literary barbarism, cannot conceive a propensity to deviate from an old path, lest the sight of figures should Will-o'-wisp him into a quagmire, or fearful that his rude finger should damage a toy of such delicate construction; and hence the *bauble*, as they term the Saccharometer, is preserved in curiosity to be looked upon as an ornament for the mantel-piece, rather than employed as an implement adapted to enlighten and direct the understanding in its proper channel.

Selfishness is also a wonderful weapon when put into the hand of power, and wielded by ignorance against principle; of which a remarkable instance occurred in one of our larger inland country towns, only a very few years back, where a master brewer was determined to suppress the Saccharometer, from an apprehension that it enabled his assistant to judge of his profits by knowing the gravity of his worts; therefore, as the latter could not attenuate without his index, so as to satisfy his own mind or please his customers, they had a rupture and parted; the man to a more genial locality, where he could use his right hand, and the master to lose his trade through an avaricious jealousy utterly destructive of certainty in the computation of his prospects. Had this person possessed the ordinary senses of a tradesman, he would at once have seen that the cause of his decline was centered within himself, and that the source of his success was less attributable to his capital, however respectable, than to the managing brewer, upon whose very judgment and prudence, especially in the system which he so strenuously opposed, his confidence was made dependent when he entered upon his engagement; and that physical energy could but ill avail, unless directed by wisdom and cultivation commensurate with the magnitude and importance of his undertaking, through having received an education by which he was taught the use of his instruments, in order to elevate his mind above the level of mediocrity; to prevent a profuse waste of malt, hops, and time; to know the advantages afforded by good samples; to make up deficiencies arising from inordinary badness; and to found and maintain a character for his productions by ensuring perspicuity at home and abroad, that his business might secure for him a constant source of meditation and experimental recreation, at once instructive, interesting, profitable, amusing, and consolatory to himself and his employer.

Such are the benefits arising from a correct acquaintance with the working of a good system in a hand properly trained to the use of a good instrument; for to depend upon a certain fixed quantity of extract from a given bulk of goods, is a most dangerous fallacy, to the evil of which every fluctuation of quality and season, and each deviation of temporary heat, materially contributes; whereas the Saccharometer may be made a corrective in every extremity except that of reckless mismanagement:—how necessary, then, that its theory should be understood, for its practice to produce correspondent and successful results!

Saccharometry, or the means of determining the true value of wort by its density, is now brought by practice to great perfection, though by some it may have been considered intricate, or more mathematical than chemical in its nature and dealing, and may have therefore been less satisfactorily and effectually explained. The words *gravity* and *density* in worts, and in general, are by some used consignificantly; but on this topic, and on the means of ascertaining their existent reality, and its value in the market, something definite requires to be said. *Gravity*, (from *gravis*, deep or heavy, whence *grave*, *gravy*, and the like,) is the absolute weight of a body when submitted to comparison with a known standard medium, such as air or water in a certain state, and may be otherwise called *barosity*; and *specific gravity* is the relation which the weight of one body bears in proportion to that of another of the same bulk, or occupying an equal quantity of space; but *density*, or the accumulation of fermentable matter within the body of the liquor, (from *densus*, thick or full,) signifies closeness, and is in the degree of compactness existing between the particles of the same body, without reference to any other; so that density is the property on which gravity is reliant.

The *hydrometer* or water-gauge, which laid the foundation of Saccharometry, has been in use now nearly a century. The inventor was Martin, the Fleet-street mathematician, of whom Baverstock purchased one in 1768; but Martin himself tried it with beers instead of worts; and as their gravity depended on the degree of attenuation they had undergone, as well as on their comparative ripeness and clearness, he was so bewildered in his experiments that he gave up the pursuit. Mr. Whitbread, founder of the Chiswell-street brewery, was consulted, and thought as lightly of the invention as Martin had been led to do, by his own ignorance of its proper application; but the celebrated Thrale, of London-bridge, who was persuaded by Baverstock to test his worts with it, which he did by a course of experiments made in the presence of Dr. Johnson, at once saw its merits and gave it his cordial approbation. Martin was improved upon by Quin of Fenchurch-street, to whom the Society for the Encouragement of the Arts awarded their silver medal in 1781, and afterwards another medal and 20 guineas. In 1785, Troughton's was high in favour, both for finish and a correct index; and about the same period, Richardson of Windsor had the merit of constructing an instrument with a scale expressly calculated to shew the excess of gravity possessed by a barrel of wort or other examen, over the same quantity of water; and as this increase was supposed to be all saccharine matter, he named the instrument the Saccharometer. The instructions which now accompany Bate's Government Saccharometer, say that the tardiness of experimenting with the weighing bottle, led to the introduction of an instrument the reverse of the bottle, which by the addition of weights placed upon it, was made "to sink to the same depths in other liquids, and thus always displaced an equal bulk or measure of each liquid: this instrument is named a *gravimeter*."

The next to claim attention was Dicas, of Liverpool, whose instrument was of this floating kind, and "shews the quantity of solid extract held in solution, and is lighter than water." His principle was, that the larger the bulb or ball of the instrument, the more correct its indications would be; and this observation led to Dring's improvement on Richardson's principle. The art of Saccharometry had then arrived at such exquisite nicety, that a tenth of a grain was expected to turn a balance loaden with 1500 or 1600 grains at each end; and Dicas's scale especially was "so very delicate that it required an extremely nice balance to weigh the instrument." It was also found necessary, when using Dring's instrument, to be scrupulously particular in keeping both it and its weights perfectly clean and dry; because when used in those establishments where large quantities of strong worts were drawn, a viscid substance was found to cohere, which affected their future accuracy.

Dicas's hydrometer shewed the number of pounds of extract contained in a barrel of wort, each pound being estimated to occupy ·06 parts of a gallon of the water; whereas Quin's, Richardson's, and Dring's, merely shewed the additional gravity in a barrel of wort, caused by the difference of weight between the extract and the water displaced, slightly differing in their indications; but averaging the three, each pound of gravity additional to that of water, indicated the existence of 2·6 lbs. of extract, according to Dicas's rule: thus a wort of 36 lbs. *per* barrel, above 1000 ounces to the foot, was calculated to contain 78 lbs. of saccharine extract, as exhibited by Dicas. In this way the Saccharometer became a separate instrument from the Hydrometer, which became a spirit meter, and was improved by Sykes in a material degree, till by an Act of 58 Geo. III., the standard of proof spirit was fixed at 923·08 by this instrument, at a temperature of 50°, or at 919 at 60° by Fahrenheit's scale.

In 1805, a commission was issued for regulating the Scotch excise, and the members being examined before the House of Commons, made a long report of their proceedings, from which Dring and Fage drew some practical hints, leading to considerable improvement in their mode of manufacture. They have two *poises* to their instrument, one adjusted to gravities varying from 20 to 40 lbs., and the other to those between 40 and 60, such as are under 20 being declared by the bare stem, the principle of action being this, that if a barrel of water (old measure) weighs 367 lbs., a barrel of wort in which the Saccharometer floats at 20 on the side engraved 0, will weigh 387 lbs., and the No. 1 weight, when put upon the instrument in the same wort, will sink it to the upper division marked 20 on the side of the stem marked 1. Booth, who wrote the brewing treatise for the "Society for diffusing Useful Knowledge," before referred to, observes, that in order to reduce Richardson's or Dring and Fage's indications to the proportion of 1000, we must multiply by $2\frac{7}{9}$, because 1000 is $2\frac{7}{9}$ times 360, which is the weight of an imperial barrel of water in pounds; but Drs. Hope and Coventry, who were employed with Dr. Thomson by the Scotch Commissioners to experiment, came to the singular and ridiculous conclusion, that *by trial* they transferred Dring and Fage's indications into the language of specific gravity, by multiplying the degrees under 12 by 3, and those above by 2·75, which bungling they were content to term "sufficient accuracy." Upon this they reported that the common Saccharometers did not precisely denote the *attenuation*, properly so called, but were all constructed on the principle that each degree on their scale should indicate a certain quantity of weightier matter contained in a given measure of wort; but that none of them exhibited the real specific gravity, nor yet the change that took place in it. Accordingly Dring and Fage set their wits to work anew; but it appears that it was not till 1834 that they published a prospectus, in which they declared that all those errors were removed in the instrument which they then recommended, and which they had adapted to the imperial standard.

The Imperial Act is that of the 5th of Geo. IV., chap. 74, dated 17th June, 1824, and denominated "An Act for ascertaining and establishing uniformity of weights and measures," which provides, that "the gallon shall contain ten pounds avoirdupois weight of *distilled* water weighed in air, at the temperature of 62° of Fahrenheit's thermometer, the barometer being at 30 inches;" and fixes the cubic inch at 252·458 grains, at the same atmospheric pressure and temperature, the pound troy at 5760 grains, and the pound avoirdupois at 7000; and confirms the standard gallon at 10 lbs., its capacity being made 277·274 inches. This enactment is correctly estimated in one sense, because $277·274 \times 252·458 = 70,000$; but in another view the framers of the bill have acted unphilosophically; because, according to this arrangement, the cubic foot of distilled water, without any reference to the convenient and well-attested principles of philosophy, is hereby reduced to $252·458 \times 1728 = 436,247$ grains, which, at 7000 to the pound, are 62·321 pounds, or only 997·136 ounces instead of 1000. The imperial measure is therefore wrong only in its estimate of the number of grains that arbitrarily make a cubic inch; for if we consider that each ounce is equal to 1·728 inch, then the gallon of 10 lbs. or 160 oz. is 276·48 inches. On the other hand, if 437½ grains are an ounce avoirdupois, 437,500 grains are a foot, and its 1728th part is 253·183 grains, or a cubic inch; so that by assuming this as a correct division of the imperial gallon, the product of these, or $276{\cdot}48 \times 253{\cdot}183 = 70{,}000$ grains to the gallon, as before. Sir G. Shuckburgh's experiments on highly distilled water, as published in the Philosophical Transactions, give 252·525 grains to the inch, which is between the imperial enactment and that of philosophers. This is independent of the trivial difference occasioned in the density of a fluid by a change of temperature from 60° to 62° (about 0·2), which is nothing in comparison with other discrepancies presented in the practice of Saccharometry.

Dr. Thomson, at page 79 of his Chemistry, Vol. III., also gives 1000 as the specific gravity of water at 60° F., and at page 193, says the Thames water weighs 1000·043, and that of the Clyde 1000·024; and the "Scottish ale-brewer" says that most of the Edinburgh brewers either have wells of their own, or are supplied from the Pentland hills; but as this is spring water, it is not softer, we may presume, than the running Clyde; and the Scotch calculators found heavier than this; for admitting the principle laid down by Dicas, that each pound of extract occupied ·06 of a gallon, they took as an example 369 lbs. of water, at 10¼ lbs *per* gallon, and added 78 lbs. of extract, which they thought would displace 4·68 gallons of water, leaving 31·32 gallons, or, as they say, 321 lbs., and with the sugar 399 lbs., which therefore would give an excess in gravity of 30 lbs. by Dring and Fage, instead of the absolute addition of 78 lbs. of sugar; but why they assumed 369 lbs., when the old gallon of water weighed no more than 367 lbs., and why they estimated it at $10\frac{1}{4}$ lbs. to the gallon, when it was an ounce less, they leave unexplained. Not being in a position to confess the palpability of their own errors, they were content to blame the instruments; and accordingly Dr. Thomson, by the assistance of Alexander Allan, contrived a new one with no fewer than thirteen different poises to a range of 130 degrees, with a thermometer and a sliding rule attached, which sliding rule was intended to estimate worts "of particular strength;" and they give it this laudable character, that "worts of different strengths do not all expand alike; on this account the sliding rule would give erroneous results when the strength of the worts is very different from that for which the rule was constructed." We are then referred to Thomson's tables, for instruction, and are told that the last column in the table "is not much to be depended upon;" for "the worts, when so *very* strong, are so *very* viscid, that the instrument does not move with sufficient ease to give good results:" neither are any of his *other* columns to be depended upon, as shall be presently shown. Such are some of the deserts of a Saccharometer which was "appointed to be used by the Scotch Excise as far back as 1805." They account it a merit that "it indicates the specific gravity of the cubic foot of all liquids heavier than water, which is taken at 1000 ounces;" but this is no discovery, because all those that preceded it did the same; moreover the Scotch brewers cheated themselves by the use of it, till the Excise forced them to continue the imposition. The Scotch law of the 56th Geo. III. c. 156, s. 44, enacted, in 1816, that "the instrument to be used in order to ascertain the gravity of wort or wash, shall be the instrument commonly called Allan's Saccharometer; and all wort and wash shall, for the purposes of this act, be deemed, taken, and declared to be of the gravity at which the said saccharometer shall denote or indicate such wort or wash to be;" and the 4th Geo. IV. c. 94, s. 56, (1824,) declares that "for and in respect of every 100 gallons which shall be brewed and made in any distillery, of any distiller licensed under this act, the officer of excise shall charge such distiller with duty for a quantity of spirits at the rate of one gallon of proof spirits for every *five degrees* of gravity of such wort or wash as shall be attenuated; that is to say, for every five degrees of difference between the original gravity of such wort or wash, as declared by such distiller." Now, the main object in saccharometry is to shew a true indication of the extract produced *per cent.* or otherwise; and as the distiller pays duty according to spirituous produce, which is dependent on strength, who knows whether a similar tax may not at some day be put upon beer? At all events, strength is a criterion of charge to the consumer; and where Allan exhibits 131·686 lbs. to the imperial barrel at an indication of 100, Dring and Fage give no more than 118$\frac{1}{3}$ lbs.; and with a gravity of 150, where the former has 199 lbs., the latter only account for 170$\frac{2}{5}$ lbs. One of them is therefore in error; and if the Scotch saccharometer indicates from 11 to 13 *per cent.* more than it ought to do, the subject requires vigilant care and correction.

The Scotch brewers, from want of proper attemperation and efficient sparging, appear, till the remarkable epoch of this celebrated commission, not to have produced so much good from their mashes as might have been wished; but from that period their extracts have been wonderful. Booth, the "practical man, being a brewer of twenty years' standing," and of course the cleverest practitioner whom the society could select, gives the following results from three quarters of malt;

and his annotator considers this, as an experiment, one of his best :—

7·6 barrels of ale wort, of 30 lbs. gravity ..	228·
5· barrels of return wort, of 2·5 lbs. do ..	12·5
Imbibed by $13\frac{1}{2}$ lbs. of hops used	6·
Producing a total of	246·5

or $82\frac{1}{6}$ lbs. *per* quarter, being only $80\frac{1}{6}$, besides the quantity absorbed by the hops; whereas the "Scottish ale-brewer," who gives two specimens of his own skill, obtains 111 lbs. *per* quarter in one instance, and 106·3 in the other, by the use of Allan's prolific saccharometer.

Booth obtained his barrel factor by weighing his grains when he had evaporated them to the dryness of malt, and found them to be 308 lbs., leaving $617\frac{1}{2}$ lbs. for the weight then missing, inclusive of the $246\frac{1}{2}$ lbs. contained in his wort; and by dividing his whole extract by this his whole gravity, he obtained 2·505 as the "proportion of dry malt required to form a pound of specific gravity;" and the average yield by the old process, as taken from the twelve examples published in Dring and Fage's prospectus, is 2·495; and hence the observation that $2\frac{1}{2}$ is very near the truth. Were malt all of a quality, these results would furnish the useful proposition that the barrel factor to each degree of gravity above par, is equal to the quantity of malt that yields a pound of extract; and at all events it serves as a line of guidance. With respect to the factor, Dring and Fage's principle, as already stated, is 2·77 *per cent.*, or 277 to the gallon of 10 lbs., which is higher than agrees with other calculators; but Allan appears to have a constant factor, or rather one that varies and ought to be constant, of ·02967 or thereabouts, as he estimates the saccharine matter *per cent.* at 0·296 at an indication of 1 in gravity above par; 2·967 at 10; and 29·669 at 100. These figures, though too high, are strictly serial, and some of them stand confirmed upon their basis in his third table, where he has 0·0296 *per* gallon at the index 1, and 0·2997 at 10; but at 100 he has wandered wide from his principle, writing 3·2636, which is considerably above the 10 lbs. *per* gallon deduced from his former computation; and the divergency will appear the more glaring when multiplied by 36 to express the quantity in each barrel, as he obtains 117·5 lbs. by the latter table, but only 106·8 by the former. We will now examine his indications at 15 and 150, to which he gives us 4·450 and 44·504 by his former table; but when we refer to his latter, or gallon of 10 lbs., his produce is 0·4517 at the lower standard, and 5·1182 at the higher; yielding 16·26 lbs. *per* barrel when the gravity is 15, and 184·254 lbs. when 150, which is an excess of 22 lbs. beyond the tenfold product, and therefore is inconsistent.

Following the Scotch example, the English Excise issued an order through the Lords of the Treasury, dated 17th October, 1823, commanding that "for the information of all persons using hydrometers and saccharometers, none but those made by Mr. R. B. Bate, of the Poultry, London, will *support them in any suit at law* in any matter of dispute relative to the strength of spirits, &c. They are the only ones recognised by law, and used by officers of excise." Let us see, then, the extent to which the English Excise has applied its wisdom in this restriction:—In the fourth table to "Bate's Patent Saccharometer," published in 1837 with his "Directions," we are told that "the proportion of solid extract by weight" is ·0026 upon 1 degree of gravity, ·0255 upon 10°, and ·2357 upon 100°; but intermediately ·0381 upon 15°, and ·3394 upon 150°; all of which denote, that if any standard factor have really been assumed, it has not been wrought into a regular expression, though he was bringing out a Saccharometer, if we believe him, "at once *convenient* and *truly accurate*, where nothing was taken for granted or guessed at," (except, perhaps, the regular necessary graduating factor or additor,) "but, on the contrary, great diligence and scrupulous exactness were employed, and neither expense nor labour spared," though the factor lies *somewhere about* ·026 after all. Referring to the table above-noticed, the extract in the gallon of 10° gravity is stated at ·258, but for a gravity of 100°, it is put down at 2·593, which certainly differs far enough from 10 times the ·2657 placed by its side in the adjoining column, the extract being a great diminution; whereas Allan, as has been shewn, makes it a large increase.

The fact is, as the tables clearly prove, that instead of seeing that the gallon ought every where to be exactly 10 times the gravity of the "proportion of solid extract" there named, and in some places is really so, there is a very general want of correspondence, for which no arithmetical reason can be assigned; for he begins by making the gallon less than 10 times the factor for extract, and ends by valuing it at $11\frac{1}{2}$ times, the gallon being represented at 3·903, and the extract at ·3394, when the gravity is 150°; whereas Allan, by a perpetual augmentation in his scale, peculiar to himself, gives an overweight of ·6227 of a pound, or about 10 ounces to every gallon, more than his own original factor would produce at 150 times its inordinate capacity. It is useless here to argue supinely that *comparative* indication is enough for any man's purpose; for here is no comparative steadiness; and if there were, no man could estimate his income, according to his strength, by any such vague comparisons; for no one can be correct who employs a false saccharometer, and especially if he relies on such tables as those of Allan or Bate, which, being under the wing of the British Government, ought to exhibit unequivocal accuracy; but as this is not the case, the license of toleration to either of them, let alone the compulsion to use them, is unpardonable. To place the matter in a clearer light, the plain quantities of solid extract *per* barrel and *per* odd gallon, as enforced by the Scotch and English excise laws, stand thus:—

Specific Gravity by the Saccharometer.	Quantity of Solid Extract in Pounds.				Excisable difference in each Barrel.
	In each Gallon.		In each Barrel.		
	Allan.	Bate.	Allan.	Bate.	
1001	0·0296	0·026	1·0656	0·936	0·119
1010	0·2997	0·258	10·7890	9·288	1·501
1015	0.4517	0·387	16·26	13·932	2·328
1100	3·2638	2·593	117·484	93·448	24·036
1150	5·1182	3·903	184·254	140·508	43·746

Taking, therefore, the results at large, from these two legalised national monopolists, without any present notice of temperature, which in many places would enlarge the disparity, the above specimens, from a whole range of similar discrepancies, distinctly prove that whatever test be applied to the Scotch saccharometer, it every where indicates considerably more than it ought to do.

Bate's improvement upon his predecessors, appears to consist chiefly in having five poises instead of Allan's thirteen, and a float to shew which of them will act applicably in each case; and in the abolition of the sliding rule, for which he substitutes a volume of tables for practical men; and he tells us, in the description of his instrument, that "great care has been taken to preserve, by its figure, the utmost sensibility of motion and freedom from the liability of retaining air;" and the compiler of his "Directions" assures us that the experiments on density, taken to investigate the power or law of expansion, were 346, and the actual weighings in experimenting on extract, 290. His tables are exceedingly voluminous, and elegantly displayed, the third alone containing 40,000 figures, in more than 10,000 numbers, and covering a range of 448 columns, occupying 16 pages, calculated to every degree of specific gravity from 995 to 1150, and to every alternate degree of temperature from 50° to 150°; but after all these precautious arrangements, it is scarcely possible to look down a double column of degrees and results, and especially towards the right, and there to discover such regularity in the deductions, as we had learnt to infer and expect.

Now, as the saccharometer or "brewer's compass" is not a simple tool, like a yard wand or quart pot, but a compound machine, indicative of weight and measure combined, and affected by every delicate measure of heat and humidity, its correctness is of the utmost consequence to those who would prefer facts to lame comparisons; and the simpler the corrective, the better understood and more extensively available. In this respect, the instrument by Mr. Long, of Little Tower-street, deserves to be particularly noticed on account of its elegance, and the simplicity of its principles. It has but one poise, and that only for wort exceeding 25 lbs. gravity, or 65 lbs. of extract *per* barrel, and was, in 1835, the only instrument that shewed the strength of worts by the imperial barrel.

Mr. Long says in his synopsis, that a 20 lbs. wort *per* barrel gravity contains 52 lbs. of extract, or solid fermentable matter, and consequently that each pound of gravity that the barrel exceeds water, contains 2·6 lbs. of saccharine or other solid extract, which at ·06154 parts of a gallon for each pound, occupies the space of 3·2 gallons of the liquid, leaving 32·8 gallons of the water, which at 10 lbs. to the gallon amount to 328 lbs.; to which, when the 52 lbs. of extract are added, the total weight of the barrel is 380 lbs. as it ought to be; thus clearly demonstrating that each degree of gravity in lbs. *per* barrel above par, contains 2·6 lbs. of saccharine or solid matter, and that each pound really occupies ·06154 parts of a gallon, and displaces that quantity of water in each gallon that contains it. On what authority this ingenious mechanist has founded his barrel and extract factors, he does not say; but it is evident that if a gallon of solidified sugar weighs 16¼ lbs., which shall forthwith be shewn (see page 197), the factor ·0615384 will correspond, and we take the admission as granted; and as Booth used 16·65 lbs. for the weight of an old ale gallon, or 16·3 imperial, and this is allowed by the Scotch calculators, in one place, "*rather* to exceed that of pure sugar as determined by Fahrenheit," and in another "to weigh *about* 16 pounds," Long's principle appears correctly based; or at least he has as good a foundation for his factor as any of his predecessors; and he informs us, moreover, that he was advised by a gentleman of known experience as a London brewer, to make gravity the principal feature of his instrument, with a line of comparisons of extract *per* barrel; and on the reverse side he has a "line of barrels with an appropriate line of gravities, by which the brewer is enabled to regulate his lengths, and to produce uniformity of strength from a superior or inferior malt." He has also a line of shillings "for estimating the value of malt according to the strength produced, whereby the brewer is enabled to calculate the worth of malt as well by sample as brewing," and to asve the trouble of a reference to common alligation; and he gives a number of examples of his mode of applying his thermometer and saccharometer side by side, by which correct results in the reduction of heat "are at once given, without calling in the aid of the sliding rule in the common routine of business."

These principles demonstrate the solidity of their basis, and the commercial usefulness of the instrument; and though Mr. Long cannot bask in the influence of auspices such as an impartial government has at command, and is therefore unprotected, he has at least the consolation that no legal *veto* is put upon the production of his ingenuity. His saccharometer has the additional distinction of being covered with a coating of fine gold, which renders it durable.

Having traced the history and progress of saccharometry from its birth to its present mature state, the author presumes to advance his own sentiments on the subject, from which it will be seen that his deductions differ but slightly from those of Messrs. Bate and Long. Since 1728 inches are a solid foot, containing 1000 ounces of water or 1625 of saccharum, the weight of an inch of the latter is ·9404 of an ounce, very nearly; and adopting the arithmetical rule of Alligation Alternate, which unites quantities with reciprocal differences, taking any determined indication of specific gravity, as 1001 for example, the quantity of extract and of water respectively contained in a compound of the saccharometric gravity 1, is thus found: Differences between mean and extremes 624 and 1; products $624 \times 1000 = 624{,}000$; and $1 \times 1625 = 1625$; sum of products 625,625: which divided by 625, the difference in ounces between the compounded quantities, gives 1001, the *status*, as it ought to do. Then, to constitute a solid foot, or to obtain a general factor, we have 625 : 1728 : : 624 : 1725·2352 : : 1 : 2·7648 ; and taking these results and exhibiting them in plain figures to shew that they are the *real* equivalents of a solid foot, we have by the same process,

$$\begin{array}{lr} 1725{\cdot}2352 \times 1000 = & 1725235{\cdot}2 \\ \underline{2{\cdot}7648} \times 1625 = & \underline{4492{\cdot}8} \\ 1728) & 1729728(1001. \end{array}$$

Proof, as before.

Therefore the weight corresponding to this indicated degree of extract is 2·7648 × ·9404 = 2·618 ounces in addition to the water, or ·02618 lbs. to each imperial gallon of 10 lbs.

Though scarcely needful to pursue the subject farther, it shall be advanced one more stage, to shew that the factor 2·7648 is constant; and, therefore, those computers who alter their factor as they proceed, or who are liable to waver in their estimates, are visibly in error. As 1000 : 2·7648 : : 1625 : 4·4928, which furnishes an easy mode of estimating for any other indication, as for instance 1002.

623 × 2764·8 = 1722470·4 and 2 × 4492·8 = 8985·6; sum 1731456, the 1728th part of which is 1002, as required ; and at any other point of gravity the corresponding result would transpire, which establishes the constancy and validates the theorem, either by testing every point thus, or by adding the factor 625 times, or multiplying by 625 ; the solution in each case is 1728, and shews that if the system could be carried out till liquidity ceased, the mass would be solid extract of the true specific gravity 1625.

Dr. Thomson fixes the specific gravity of saccharine matter at 1552, and others at different standards ; but this appears to be rather dilute, and nearly agrees with the sugar of milk, which is $3\frac{1}{2}$ *per cent.* lighter than solid cane sugar, which accordingly is about 1606; and sugar of malt is heavier than either, but undoubtedly varies a little according to quality. Dicas had a factor of $2\frac{6}{9}$, which Dring and Fage altered to $2\frac{7}{9}$, as adapted to the imperial standard, which has been much tested, and gives the specific gravity of solid dry extract 622 above water.

If the elements of cane sugar, given at p. 31 above, be multiplied by their respective atomic weights, C. ·75, O. 1·0, H. ·125, the aggregate will be 83·345; and that of the sugar of malt 84·746; and on applying the same test to mucilage, p. 43, the aggregate is 84·829, differing from the sugar of malt only by 1 in 1021, and fixing the resulting specific gravity of malt sugar thus: 83·345 : 1606 :: 84·746 : 1633, agreeing very nearly with the result as computed by Long's saccharometer. But starch is lighter than either, its aggregate being 83·825, which is 1 in 92 under the saccharine, and 1 in $83\frac{1}{2}$ under the mucilaginous solution; and hence the worts are at the heaviest before they attain the desired clearness; but so near are these conditions, that the ponderable difference cannot be correctly perceived by means of the instrument. This is why Baverstock, and the controversialists in "Cobbett's Register" for 1808, would not trust the saccharometer to place a transparent wort above a thick or cloggy one of the same materials and length; and why the attemperated worts produced by the patent machinery, do not appear to due advantage when tested by it; but this does not alter their intrinsic value, nor yet the scale of their comparative density one with another.

The subjoined table exhibits the variety of opinions which dealers in saccharometers have expressed, and shews at least that some of them cannot be relied on. To these the compiler adds his own results, as deduced from the process he has explained; and he shall be happy to find that the issue of his enquiries has led the public brewer, more effectually than heretofore, to guard his own interest by stricter attention to the quality of his worts. The numbers by Allan, Bate, and Long, are extracted from their printed tables, the others from their simple factors; and the visible diversity, though entertaining as a curiosity, detects lamentable instability and inaccuracy in some of them.

Specific Gravity.	Weight of Solid Extract to the Imperial Gallon.						
	Dicas.	Richardson.	Dring and Fage.	Allan.	Bate.	Long.	Tizard.
1010	0·266	0·2535	0·2777	0·2997	0·258	0·2583	0·2618
1020	0·533	0·5070	0·5555	0·6053	0·516	0·5194	0·5236
1030	0·800	0·7606	0·8333	0·9168	0·775	0·7777	0·7854
1040	1·066	1·0141	1·1111	1·2343	1·033	1·0388	1·0472
1050	1·333	1·2676	1·3888	1·5577	1·293	1·3000	1·3090
1060	1·600	1·5211	1·6666	1·8870	1·552	1·5583	1·5708
1070	1·866	1·7746	1·9444	2·2223	1·812	1·8194	1·8326
1080	2·133	2·0282	2·2222	2·5634	2·071	2·0777	2·0944
1090	2·400	2·2817	2·5000	2·9105	2·332	2·3388	2·3562
1100	2·666	2·5352	2·7777	3·2636	2·593	2·6000	2·6180
1110	2·933	2·7887	3·0555	3·6226	2·854	2·8583	2·8798
1120	3·200	3·0422	3·3333	3·9875	3·116	3·1194	3·1416
1130	3·466	3·2958	3·6111	4·3584	3·378	3·3777	3·4034
1140	3·733	3·5493	3·8888	4·7352	3·640	3·6388	3·6652
1150	4·000	3·8028	4·1666	5·1182	3·903	3·9000	3·9270

After a deliberate perusal of this table, the brewer will do well to pause ere he determine whose saccharometer he will use. Dicas and Richardson are now out of date; Allan out of the question, except as regards extravagant charges; Dring and Fage rather too high when compared with the truth set forth in the last column; and Bate and Long a trifle below it, differing only in the simplicity or complication of their respective instruments, and the regularity or irregularity in the gradation of their numbers; such, however, is simple saccharometry. We will now consider it in its compound state, as connected with temperature and dependent upon

The Doctrine of Expansions.

This is the system of reducing hot worts of any temperature and gravity, to the quantity they will gauge when cold, or when lowered down to the standard of 60°. On an examination of Allan's theory, as published in his table, No. 1, we shall find that by reducing from 150° to 60°, the addition to be made to the apparent gravity, if taken at the highest point in the scale, is 14·7, at 100 only 14·5, and at all the intermediate stages 14·9, which is anomalous, while at any mark below 15 gravity, no notice is taken by him; though fluids take a wider range of heat at low gravities than at higher, to effect an equal change; an increase of temperature from 60° to 125° at the *zero* or par of 1000, giving the same expansion of 10 points gravity, as a rise from 60° to 110·8° at an indication of 150 points higher, which only shews that water is more elastic than the saccharine extract embodied within its volume; but on a more thorough inspection of the aforesaid table, the "increase of quantity to be added," which is about 1 *per cent.* to every 5° at the high gravity of 150, is 1·2 at the lower of 100, according to such absurd calculations as his sliding rule affords; truly, therefore, as he says, his works are "not *much* to be depended upon." But the reductions from apparent to true gravity, according to Dring and Fage, are regular and systematic, requiring more expansion at high heats, where the heat increases the elasticity, than at lower, where it has less force, presenting a series thus: 1·2 + 1·4 + 1·6 + 1·8, &c., upon each 10° above 60°. So do Bate's tables; so does Count Rumford; but Allan sometimes reverses the order as above, sometimes exceeds it, sometimes vacillates, and is sometimes gradual in his reduction for 30° to 40° together; thus his allowances for reducing from 130° to 60° of heat run as follows for each 10°, beginning at the lowest:

At gravity 50, his numbers give 1·40 + 1·24 + 1·32 + 1·54 + 1·90 + 2·00 + 2·40, sum 11·8;

But at 80, his series adds to 1·60 + 1·60 + 1·80 + 2·00 + 2·00 + 2·00 + 2·20, sum 13·2;

But Bate's series is more regular, analysing into

Gravity 50, reduction 1·2 + 1·4 + 1·6 + 1·8 + 2·1 + 2·3 + 2·5, sum 12·9;

Gravity 80, reduction 1·3 + 1·5 + 1·7 + 1·9 + 2·2 + 2·4 + 2·6, sum 13·6.

Hence, though Allan, or rather Thomson, soars far above others in his original gravities, he creeps below them in his allowances for heat, as though the law of expansion in heating fluids were regularly progressive in one place and irregular in another. According to Bate's experiments, the allowance for expansion throughout the brewer's range stands as follows, for each 10° of heat from 60° to 150°.

Sac. Grav.	Series, 9 terms, each 10°, from 60°.	Sum.
10	1·0+1·2+1·5+1·7+1·9+2·1+2·3+2·5+2·8	17·0
50	1·2+1·4+1·6+1·8+2·1+2·3+2·5+2·7+3·0	18·6
100	1·4+1·6+1·8+2·0+2·2+2·5+2·7+2·9+3·2	20·3
150	1·6+1·8+2·0+2·2+2·4+2·7+2·9+3·2+3·4	22·2

The following abstract, taken by glancing obliquely across Bate's whole table of 40,000 figures and noting the equivalents, may be made to suit all the purposes of saccharometry. Where the correspondent degree of temperature does not occur, a correct proper fraction is here attached at an average. The principle it embraces tends to this, that when a liquid whose specific gravity is 1000 (first line) is expanded from 60° to 79° of heat, its gravity is reduced two points, when to 93° four points, &c., or the instrument would sink those points if removed from a wort at 60° into one heated to 79° or 93°; or (second line) when the index cuts at 10 at 78° or 92°, &c., it would give only 8 or 6, &c., if the heat were reduced to 60°, and that which indicates 10 to 124°, would float at *zero* at 60°; those differences, therefore, of 6, 8, 10, &c., must be respectively added to the apparent gravity at those heats, as equivalents for the rarefaction, to give the true gravity when cooled down to 60°.

Specific Gravity at 60°.	Other apparent Gravities, giving the same true gravity at the accompanying heats, as the first column at 60°.									
	Ap. gr.	Deg.	Ap. gr.	Deg.	Ap. gr.	Deg.	Ap. gr.	Deg.	Ap. gr.	Deg.
1000	998	79	996	93	994	105	992	115½	990	125⅕
1010	1008	78	1006	92	1004	104	1002	114½	1000	124
1020	1018	78	1016	91⅓	1014	103	1012	113½	1010	122⅘
1030	1028	77⅓	1026	90⅔	1024	102½	1022	112½	1020	122
1040	1038	76⅔	1036	90	1034	101½	1032	111½	1030	120⅘
1050	1048	76	1046	89⅓	1044	100⅔	1042	111	1040	120
1060	1058	76	1056	88⅔	1054	100	1052	110	1050	118⅘
1070	1068	75⅓	1066	88	1064	99	1062	109	1060	118
1080	1078	74⅔	1076	87⅓	1074	98	1072	108	1070	116⅘
1090	1088	74⅔	1086	86⅔	1084	97½	1082	107	1080	116
1100	1098	74	1096	86	1094	96½	1092	106½	1090	114⅘
1110	1108	74	1106	85½	1104	96	1102	105½	1100	114
1120	1118	73½	1116	85	1114	95½	1112	104½	1110	113⅕
1130	1128	73⅓	1126	84½	1124	94½	1122	104	1120	112⅖
1140	1138	73	1136	84	1134	94	1132	103⅕	1130	111⅗
1150	1148	72⅔	1146	83½	1144	93½	1142	102⅖	1140	110⅘

Some brewers, and indeed many, though this subject materially affects their interest, have never given it a serious thought, perhaps because they considered it intricate; but it is not so; and it may be as well for the practical man to carry his scale of reductions in his own head, as to fly on each separate occasion of pondering his worts, to fallacious sliding rules or false tables. The expansion of water in heating, or its contraction in cooling, as ascertained by Count Rumford at every $22\frac{1}{2}$ degrees in its progress from the boiling to the freezing point, or from 212° to 32°, is as follows:

From 212° to	$189\frac{1}{2}$° are	18	parts.		From 122° to	$99\frac{1}{2}$° are	9·3	parts.
—— $189\frac{1}{2}$° —	167° —	16·2	—		—— $99\frac{1}{2}$° —	77° —	7·1	—
—— 167° —	$144\frac{1}{2}$° —	13·8	—		—— 77° —	$54\frac{1}{2}$° —	3·9	—
—— $144\frac{1}{2}$° —	122° —	11·5	—		—— $54\frac{1}{2}$° —	32° —	0·2	—

Being 80 parts in his whole range, of which 34 lie between the limits of 150° and 60°, at an average variation of $\frac{1}{10}$th to each degree of expansion; so that one of his "parts" is just equal to 2° in the reduction of gravity, as set forth by Bate or Dring and Fage; and the whole, for each $7\frac{1}{2}$° from $54\frac{1}{2}$° upwards, analyses into the series $1·0+1·3+1·6=3·9$; $2·0+2·4+2·7=7·1$; $2·9+3·1+3·3=9·3$; $3·5+3·8+4·2=11·5$; $4·4+4·6+4·8=13·8$; $5·1+5·4+5·7=16·2$; and $5·9+6·0+6·1=18$; which results differ but little from the experience of the English excise. Here, then, is a theory laid down on which the operator may depend without the rule or the tables, and which he may reduce to practice thus:

Theorem for reducing the gravities of hot worts.

To unity or 1, representing the par or standard of water, add ·1 (or $\frac{1}{10}$th) for every 25 points of gravity indicated by the instrument, and ·01 (or $\frac{1}{100}$th) for each degree of temperature above 60°, and multiply the sum by 10 times the latter number, for the correction. Add this to the apparent gravity, omitting decimals, and the result will be the true gravity.

Example 1. Apparent gravity 6, temperature 92°.

Here $(1+{\cdot}32)\times3{\cdot}2=4{\cdot}224$; and $6+4=10$, the true gravity as given in Bate's elaborate table.

Ex. 2. App. grav. 27, temp. 124°. This is $(1{\cdot}1+{\cdot}64)\times6{\cdot}4=1{\cdot}74\times6{\cdot}4=11{\cdot}136$; and $27+11=38$. Bate gives the true gravity 37·6.

Ex. 3. App. grav. 100, temp. 110°; give $(1{\cdot}4+{\cdot}5)\times5=1{\cdot}9\times5=9{\cdot}5$; and $100+9=109$. True gravity again, exactly as in the table.

Now, whatever gentlemen may surmise, the author takes to himself some small degree of credit for the discovery of this little theorem, in which the whole business of reducing hot worts consists; and he is fully persuaded, that by practising it with Long's saccharometer and an attached thermometer, all may be accomplished in *one minute* which has often occupied *an hour* in referring and computing, besides giving incorrect results.

Notwithstanding all the obstacles that have been interposed to prevent the progress of saccharometry, it has outlived the spirit of opposition and become a known benefit to its professors, as well as to the community, though it is still deficient in the respect of distinguishing a purely saccharine wort from such as are amylaceous, or fraught with unsubdued solid particles, in the one instance containing starch, in the other mud; which will indicate relative strength with as much regularity as pure saccharum, and at a higher figure than the purer worts, which, indeed, are rendered lighter by the clearness with which the new system invests them, notwithstanding their greater bodily strength and perfection. To meet any difficulty that may arise from this circumstance, as well as to point out the presence or absence of acidity in worts and beers, ingenuity has brought other inventions to light which deserve particular notice and commendation, because they check the irregularities which would otherwise ensue from the above causes. To be brief, then, these newly-devised and excellent appendages are,

The Alcoholmeter and Acetometer.

These are prepared and sold by Mr. Long, the Saccharometer Maker before named. Field's Patent Alcoholmeter, which is the base-work of the whole invention, was first introduced, as the prospectus informs us, with the intention of ascertaining the quantity of alcohol in wines of all descriptions, by the point of ebullition, "a scientific fact recently established, that *the boiling point of every alcoholic liquid is entirely regulated by the quantity of alcohol* contained within it, irrespective of the saccharine or extractive matter present." Its principle is involved in the thermometer, "the *per centages* of alcohol being indicated thereon in place of their boiling points;" and as all thermometers must be constructed in accordance with atmospheric weight, these new instruments are all adjusted to the standard pressure of $29\frac{1}{2}°$.

The proprietor suggests that to brewers and dealers in fermented liquors, the application of this principle will be found decidedly advantageous, because it gives the quantity of alcohol created in the wort by attenuation, as well as its original weight prior to the fermenting process; besides which, it indicates the value of malt liquors in relation to their component parts; and it affords a facile means of testing relative value in worts from sugar, compared with those from grain, and is moreover a guide to the condition of *stock* beers and ales.

To go into a minute detail of all the particulars explained in reference to this useful instrument by its projectors, would be incompatible with the purport of the present work; but it consists of a spirit lamp, placed in a boiling vessel, and having a damper for the regulation of the heat, and particularly to check the rapidity of ebullition when rising to the boiling point; and the thermometer is attached to the boiler, with its bulb immersed in the liquid, and has also a barometrical index attached to its scale, to adapt it to the correction requisite on any change in the state of the atmosphere in which it is employed. In first testing this apparatus, a discovery was made, that at the several boiling points determined by various degrees of strength in the alcohol, the stoppage of the mercury in the stem, and especially at high ranges, was too precipitate for general practical observation; but a simple and certain remedy was soon hit upon by arresting the mercury at the exact point by the application of a little common salt, for which purpose a small measure has been added, to contain 35 grains of that muriate, which will suspend the mercurial action a sufficient length of time to allow a correct observation to be taken.

We are told that "the novelty of this discovery has attracted the attention of some of the most eminent chemists of the day, and has been by them researchingly tested, and found to be undoubted in its results;" but this is not all; for the present author has himself tried it in numerous instances, and has found it true to the minutest accuracy in pale ales, &c., and can therefore most conscientiously recommend it.

THE NEUTRALISING ACETOMETER is an accompaniment to the Alcoholmeter, and was invented by Mr. Long, when a hint had been given him to the effect that the other, as it was, was not sufficiently correct in testing beers that contained acetic acid to any extent; and his ingenuity has quite removed that objection. The acetometer is merely a glass tube, graduated into 100 equal parts, and furnished with a stop-cock, so as to allow any minute quantity of the liquid with which it is charged, to be drawn off and examined. Upon the established *datum* that the excise proof vinegar contains 100 parts of acetic acid, and that by mixing 100 parts of an alkali of a certain precise specific gravity, and of a neutralising power correspondent to its task, the whole of the acid will be extinct;—whatever proportion of the alkali is requisite to be applied to effect that object in the compound, will be equivalent to the amount of acid *per cent.* in the tested liquor. Mr. Long uses the liquor of ammonia for this purpose, having previously qualified it by reduction to the exact specific gravity which a correct operation requires. The test is made by first filling the graduated tube with the liquor under trial, then emptying it into a short glass and refilling the tube with the test-water, and again drawing off any given number of parts, and pouring them into the short glass, and stirring the mixture together, when on the application of a piece of litmus paper, its blue will redden if any acid remain; but if it is all neutralised, the paper will retain its own hue; and in case of the red appearance, another portion of the test-liquor is drawn and added in the short glass, and thus the amalgamation is repeated till the rubricity no longer obtains, when the number of parts drawn from the tube will equal that of acetic acid contained in the tested beer or wine. Vinegar, and all other fermentable liquors, are tried in like manner, and the correct amount of acid in any species is thereby correctly ascertained.

To the "Directions" for use, an example is attached, and is thus explained by means of the subjoined Table: Suppose nine parts of the test-liquor to have been used in neutralising the acid, this proves that the beer contains nine *per cent.* of such acid; and opposite to nine *per cent.* stand 2·07 of saccharine and 1·31 of proof spirit destroyed by the acetous fermentation of the beer, which 2·07 of saccharine density is *to be added to the pounds per barrel*, as denoted by the Alcoholmeter.

Acid *per cent.*	Loss of Sacch. *pr* bar.	Loss of Spirit *per ct.*	Acid *per cent.*	Loss of Sacch. *pr* bar.	Loss of Spirit *per ct.*	Acid *per cent.*	Loss of Sacch. *pr* bar.	Loss of Spirit *per ct.*	Acid *per cent.*	Loss of Sacch. *pr* bar.	Loss of Spirit *per ct.*
1	·23	·14	14	3·22	2·03	26	5·98	3·78	39	8·97	5·67
2	·46	·29	15	3·45	2·18	27	6·21	3·92	40	9·20	5·82
3	·69	·44	16	3·68	2·33	28	6·44	4·07	41	9·43	5·96
4	·92	·58	17	3·91	2·47	29	6·67	4·22	42	9·66	6·11
5	1·15	·73	18	4·14	2·62	30	6·90	4·36	43	9 89	6·25
6	1·38	·87	19	4·37	2·76	31	7·13	4·51	44	10·12	6·39
7	1·61	1·02	20	4·60	2·91	32	7·36	4·65	45	10·35	6·54
8	1·84	1·16	21	4·83	3·05	33	7·59	4·80	46	10·58	6·69
9	2·07	1·31	22	5·06	3·20	34	7·82	4·94	47	10·81	6·83
10	2·30	1·45	23	5·29	3·34	35	8·05	5·09	48	11·04	6·98
11	2·53	1·60	24	5·52	3·49	36	8·28	5·23	49	11.27	7·12
12	2·76	1·74	25	5·75	3·63	37	8·51	5·38	50	11·50	7·27
13	2 99	1·89				38	8·74	5·52			

Hence, as this table is arithmetically progressive, it implies throughout that the loss of saccharum *per* barrel is nearly 2 lbs., and the diminution in spiritual strength at the rate of ·1454 for each 1 *per cent.* of acid contained in the tested sample, *besides* the quantity indicated by the Alcoholmeter, of which other examples are given thus:

Supposing the saccharometer to float at 9, this denotes 9 lbs. *per* barrel, and at the boiling point, the salt being applied, indicates 14½ *per cent.* of spirit. Place A on the slide, against 14½ on the upper series of figures engraven on the Alcoholmeter, and against B will be found 23, which being added to the former 9, gives 32 lbs. for the original weight of the beer when it left the cooler.

Such being the properties of the Alcoholmeter and Acetometer, they perfectly establish the fact of the worthlessness of an excess of mucilage, particularly where it is coerced into an obdurate black gum; and sufficiently argue in favour of a thorough malting of grain before it is presumed to brew it into black or porter-malt, and completely confirm the author's opinion as to the causes which have, during the last few years, deteriorated London and other porters. The compounded instrument does not shew the absolute original density of these granular and gummy drinks, though it gives them comparatively, exhibiting them as in a *lighter* state than they were actually pitched, and thereby casts a light upon the art of brewing, by proving that, in such instances, some of the heavy undigested particles of the black malt have been carried off by the yeast, by precipitation or adhesion, and that they cannot have attenuated because of their carbonised condition; or that if fermented, they have not produced any alcohol, because if they had, it would have been detected by the Alcoholmeter; and the attached saccharometer, which is adjusted with the nicest accuracy, would have indicated the exact pristine density without any diminution whatever.

CHAPTER VIII.

HOPS.

USE, INTRODUCTION, AND HISTORY—PROGRESS AND CULTIVATION—DRY AND SWEET WINES—TEA—OLD AND NEW OPINIONS—BAVARIAN LADIES—HOP GROUNDS—LUPULINE—CONDITION—TESTS—CAUSES—FRAUDS—NECTARIUM—THE GOOD ARTICLE—SEEDS—BAGS AND BAGGING—THE HOP CONVERTOR—STEAM PIPES AND HEATED FURNACES—PRESSURE AND REGULATION OF STEAM—MISREPRESENTATIONS BY COPPERSMITHS—HUMULINE PATENT—ABSTRACT OF DUTIES.

The brewer having made the most and best of the malt and water committed to his care, by converting it into wort, now unpalatably sweet and viscous, whether obtained by the patent machinery or otherwise, his next object is to bring this wort into a potable state, and to ensure the permanence of its virtue: this is done by converting a portion of it into alcohol, which important change is effected by means of fermentation; preparatory to which, an impregnation with some additional substance calculated to produce the desired flavour and durability, has ever been found necessary; and various, according to the circumstances of taste, custom, and restriction, have been the substances used and the mode of using them.

Liebig observes in the second edition of his Chemistry, page 320, that most of the blossoms and vegetable substances that yield a scent, owe it to a volatile oil that exists in them; but that others do not emit odour except when they undergo decomposition or change; and he thinks it probable that the odorous principle peculiar to each of various vegetable substances, is newly formed during the fermentation of the saccharine juices of the plants. Very small quantities of elder, violet, cowslip, or linden blossoms, added to a fermenting liquid, are sufficient to impart a much stronger taste and smell than could be derived from the water distilled from a hundred times those quantities. Thus the various kinds of Bavarian beer are distinguished by different flavours given them by fermenting small quantities of the herbs and blossoms of plants with the worts; and *sage* and *rue* of various species are added as a *bouquet* for fraudulent purposes, to wines fermented on the borders of the Rhine; though he says that "the fictitious perfume thus obtained differs from the genuine aroma by its inferior durability, and by being gradually dissipated."

But it is not so much for the sake of introducing a bitter that shall neutralise the disagreeable sweet of malt wort, as for the intention to add a stimulus and attendant flavour, as imparted by these flowers, that the blossom of the *hop* has become the *nosegay* of the British brewery. For information on the use of this aromatic acquisition, the author may next refer to Dr. Ure, who attributes its peculiar virtues to a yellow pulverulent substance, which, when distilled in water, affords about 2 *per cent.* of a colourless volatile oil, the basis of its flavour, to which the much admired aroma of the plant is justly attributed; and says that it dissolves in water very readily, and that it contains sulphur, because it blackens solutions of silver and acetate of ammonia. Some of this sulphur, however, is drawn from the dying fuel, or from the sulphurous *bleaching* matters that many growers illegally employ in "getting up" their hops.

This excellent plant, the hop, as well as sugar, has long been justly appreciated, and is well adapted in its admirable nature to suit the service of man; for it appears to have been cultivated from time immemorial, though it has not had its physician to commend its virtues quite so strongly as the latter; nevertheless, we have an old authority in Pliny, who describes it as a plant reared in Germany in his day, as a *pickle* or *preservative relish* to beer, and as entwining itself round *other willows* with which the *Netherlands* then abounded; and his words in one instance are very plain: "*Lupo salictario Germani suam condiunt cerevisiam.*" Another remarkable fact is, that the word *lupus* did not only signify a *hop*, but any thing *bitter*, or having *more bite* than another, as a wolf, a pike, a spider, a hook, a *bit* or snaffle, and the like; whence also, by an idiomatic contraction which marked the language of barbarous Europe in those days, come *lop*, to cut short or bite off, and by corruption *hop*; or the Romans may have borrowed the latter term from the Germans and harmonised it to their own language, and introduced *lupulus*, a diminutive of *lupus*, because they found the hop to be *a little bitter.* We do not see that in the Bavarian and Rhenish provinces, *boiling* has been adopted as a means of preserving the aroma. The expedient has found way into England instead of a better, and a habit has confirmed the practice. We may very reasonably suppose that British malt or barley wines were drunk in an unboiled state prior to the introduction of that ingredient as a general bitter, just as most of our home-made wines are now, and that boiling was deemed the readiest way of employing it in large quantities, as would undoubtedly have been likewise the case if the public taste, or the perishable quality of the grape wines, had been such as to demand the addition of the essential oil, &c., of other plants, such as hops, for instance; but grape wines are not boiled in the ordinary treatment, and yet their attenuation is perfect, and many of them are not prone to acidity.

Of course dry wines are here alluded to, and those generally used in this country; though we know that some of the French domestic sorts are highly concentrated and luscious, resembling syrups, a state to which adding brandy and aromatic seeds is necessary. In Italy and Spain, also, to hear of wines being boiled to concentrate the sweet principle, and to retard the formation of alcohol, is not an uncommon thing. Boiled wines are of great specific gravity and dark colour, and are designed for admixture with the produce of bad vintages and a certain quantity of alcohol and other surreptitious qualification. Sherry, Malaga, Tinto, Sherbet, Cyprus, and many others, are either sophisticated or are imitated by the aid of the syrup wines, from which they derive foreign colour, alien aroma, borrowed sweetness, and stolen spirit. Wines are never boiled to improve their *bouquet*, or to render them superior to the natural productions of such fruit as contains the essentials in adequate proportions; but on the contrary, instances are on record where the boiling principle has for its object the deterioration and transformation of the vinous property for some commercial fraud, or other deception. For instance, Marco Paulo found that the Mahomedans of Tauris, as much as 500 years ago, swindled their prophet by boiling the juice of the grape for the purpose of changing its character and name, and thus removed the impediments which their religious faith had placed between their propensity and their enjoined duty; like the old woman at Newcastle, who, being a teetotaller, dipped rolls in gin and ate them to evade the penalties to be inflicted on her if she *drank* ardent spirits.

It was undoubtedly from this principle of drawing out virtue by heat, that people first began to boil hops; and they did the same with the leaves of the *Thea* plant, now universally called *tea* by our countrywomen, when it was first imported into Europe in 1610, by the Dutch East India Company, and into this country in 1666, by Lords Arlington and Ossory, whose names are in other respects familiar to us. At first it was so highly esteemed that it sold as high as 66*s. per* lb.! but being easily *brewed*, it began to supplant the hop and hopped beverage at the tables of the great; and accordingly the first duty imposed upon the consumption of this commodity was 8*d. per* gallon on the infusion when sold in coffee-houses; but this mode of levying a duty was soon removed, the leaf became more common, and many ludicrous instances arose. One elderly lady, among others, had a nephew in the East India House, who sent her a pound of this precious exotic treasure as a present, with which she was so greatly delighted that she boiled the whole of it in a large pot or family copper, as the temperance societies of to-day are accustomed to do when they regale large assemblages of proselytes at their speech-makings; and having done this, she invited her friends, consisting of relatives and neighbours, to partake of the delicious treat sent by Joseph: such is the curious origin of tea parties in England; and why, we can ask, may it not be equally amusing to see an old woman of a brewer boiling hops, when she can, as the tea-makers do, extract their aroma by infusion in hot water? That this is the main purpose for which worts are boiled, was evident to a writing brewer of extensive experience in the last century, who justly remarked that the process of brewing for malt distillers, was the same as for ale and beer, except that in the former the hops were omitted, and consequently the boiling also.

In the first chapter of this volume, the history of brewing is brought down below the time of introducing the hop, in 1524, from the Netherlands, to which country the plant appears to have been indigenous, as it was successfully cultivated there in the 14th century, and of course had grown there ever since the time noticed by Pliny, the Roman naturalist. The first licences for the sale of *beer* in this country, making it a monopoly, were granted in 1552, the last year of Edward VI. In Elizabeth's reign, we are informed that the daughters of the nobility and gentry, after feeding their poultry, breakfasted at 7, on hot meat and ale, and dined at 11, except in cities, where the dinner hour was at noon; and the national beverage had then attained such celebrity, that brewings of it were appropriated, as fancy chose, to every little occasion, as *bride ale* to weddings, *leet ale* to court meetings, *lamb ale* to sheep shearings, and *clerk ale*, which was prepared by parish clerks, whose congregations furnished them with provisions during the week, feasted with them on Sundays, and bought the ale of them as compensation to them in lieu of salary. Thomas Tusser, a celebrated agricultural poet of that age, wrote thus in praise of the hop:

> "The hop for his profit I thus do exalt,
> It strengtheneth drinke and it favoureth malt;
> And being well brewed, long kept it will last,
> And *drawing* abide, *if ye draw not too fast.*"

Thus far the progress of brewing till the hop had become a staple commodity; but a question may arise as to the article employed to bitter, to spice, or to preserve the ale before the value of the hop plant was discovered. Allusion has already been made to certain exciting drugs in which the people indulged when luxurious drinking was prohibited, and probably narcotics were likewise mingled with their drink. Sir H. Davy observes in his agricultural chemistry, that the diffusion of the bitter principle in the vegetable kingdom is very extensive, and that besides the *humulus lupulus* or hop, it is found abundantly in the *spartium scoparium* or common broom, the *anthemis nobilis* or chamomile, and in *quassia amara*, and *excelsa;* from each of which substances it is extracted by the action of water or alcohol in evaporation, is usually of a pale yellow colour, is of great importance in the art of brewing, and is likewise taken as medicine, and is a check to fermentation and a preservator of fermented liquors, consisting, like the narcotic principle, chiefly of carbon, hydrogen, and oxygen, with a little *azote*, and may be extracted from hops by infusing them for some time in *cold* water. This certainly is the simplest process possible, and shews that the oil and bitter of plants may be drawn out by other means than boiling, which is expensive and dangerous. In some parts of Sweden, at this day, the *menyanthes trifoliata*, water trefoil, or buckbean, is dried and used as a substitute for hops; and it undoubtedly makes an excellent English sudorific draught for the radical expulsion of rheumatic gout, when infused hot with ginger, horse-radish, and sassafras, to which it imparts an agreeable bitter and a deep colour; and there is no doubt, from the extreme bitter of the little pink centaury, noticed by Liebig as emitting an agreeable and penetrating odour when fermented, but that it is still used by some country people in the impregnation of their home-brewed harvest beer; and if the object be to reduce their flesh, it will strictly answer their end. The use of broom is very common with poor people to whom the purchase of hops is an object, and so, in some villages, is that of wormwood, the *artemisia absinthium*, and of mugwort, the *artemisia vulgaris* of botanists; and a tradition prevails that this *genus* of plants, which is dedicated to Artemis or Diana, was medicinally employed to prevent the ravages of the plague during its malignance on the Welsh borders. At all events, the inhabitants of Coalbrookdale, where wormwood grows wild in abundance, well know its use as a bitterer and flavourer of ale, though the ale becomes disagreeable when it has been a few days on the tap. Hyssop, (*hysopus officinalis*,) the Scripture purgative, and horehound, (*marrubium vulgare*,) are also found among the old catalogues of medicinal bitters used by our ancestors in the preparation of their daily beverage, and are commonly found growing in the gardens of old cottages and farmhouses, sometimes with a little superstitious reverence attached to their character, and are abundant in crofts and in the highway sides in some of our villages of ancient standing, as hops are in the hedges of gardens, orchards, stackyards, and the like. Of late years, quassia has been much recommended by druggists as an improving accompaniment to the hop; and more recently still, chirayetta, a foreign herb much resembling centaury in its stalk, and said to contain as much warm and nutritive bitter in a scruple as hops in a pound, or 350 scruples; some people affirm, however, that chirayetta is not equal to quassia as an active preservative and wholesome stimulant to the alcohol of the wort, though chirayetta costs 3*s.* *per* pound, and quassia may be had at some warehouses for about 6*d.* With all these innovations, the British public need not be apprehensive that the hop will suddenly lose the good character which it has attained in this country, and has now preserved more than three centuries, unimpaired by substitution, adulteration, or prohibition.

Such was the demand for the hop when first brought into this country as an article of commerce, in 1524, as above named, or in 1530, as affirmed by others, and so great was the excitement caused in the minds of the authorities lest the consumers should shorten their days and ruin their posterity, that an Act of Parliament was shortly afterwards passed to prevent its further use; but the stricter the prohibition, the greater was the avidity to obtain it; and instead of its being put down, it became so common, and its culture had increased to such an extent, that in the year 1644, the 25th of Charles I., an excise of twopence *per* gallon was put upon beer, and the brewers were forbidden to use any other bitter or drug, or any ingredient whatever except hops, for the impregnation of their sale worts.

Malt, however, had been an excisable article from the year 1367, when a tax of fourpence *per* quarter was put upon it by the same policy which passed the restraint upon men's appetites, the said quarter of malt being then equal in value to an ox, and six oxen to a tun of good wine. The fact was, that the people found by experience that all other herbs and flowers were very far inferior to the bloom of the hop, being generally coarse, rank, and less permanent. Indeed, no other substitute has yet been proposed at all likely to supersede the gratefulness of its fine aroma, to say nothing of the warm and cheering bitter peculiar to itself; though it cannot be denied that gentian, quassia, chamomile, and perhaps chirayetta, may be advantageously used *with* the hops in times of scarcity and consequent dearth, such as the failure of a season or two might and would occasion; for at such times the price, or the supply at any price, precludes their exclusive use in the brewery throughout the year, particularly in the manufacture of "*India ale*," for which see more at large in Chapter XVIII.

In case of such a climax as this, though forbidden by strict law, men would be justified by reason and common sense, in resorting to expedients such as satisfied their forefathers. Under other circumstances, any deviation from the established alliance between malt and hops, would be unjustifiable in a pecuniary as well as a moral sense; for brewers have been brought to know, that though "more powerful bitters than hops may perhaps be found," yet "the bitter can be of no use without the preservative property." Gentian and quassia, as observed many years since, "may be wholesome and useful when taken as medicines, but if introduced in beer, they would not fail to cause a rapid decrease in the sale," because they do not possess either the fine rich aroma, or the preservative excellence peculiar to the hop; and the author will be candid enough to admit the old principle, founded on experience, without recourse to law, that "the entire stock in trade of any druggist, although the value of it may amount to £20,000, is not worth the cost of a shilling to any brewer for the purpose of improving the flavour, or in any way contributing to the strength, of malt liquor; otherwise than as the articles may be *saccharine*:" an argument which the uninitiated will find more fully discussed in the 17th chapter of this treatise.

In old dictionaries we find new ale called *mustum*, which is a general term for a drink not brought to maturity; as Pliny calls honey that has not purified itself by working, "*mellis musteus fructus*;" and the term goes farther, as the same author has "*caseus musteus*," for fresh cheese, and "*liber musteus*," a new book; the word *must*, therefore, very properly applies to wort in the state of fermentation, or to any kind of liquor in an immature state. We also find, in the same fountains of information, "gill ale," described as "*cerevisia hederacea*;" but the *ivy* thus called *gill* is the *chamæcissus*, *hedera terrestris*, or *ground ivy*: a low creeping plant, called in Gloucestershire "*gill-go-by-the-hedge*," more viscous than hop, buckbean, or white briony, and found in vocabularies by the term *alehoof*; so that this seems to be the plant which distinguished ale from beer in the reign of Elizabeth, and with which is associated the word *gill*, a small measure of half a pint, or in London and some other places only a quarter; though it seems from the hoofs of the Saxon peg-tankards, that each man's gill in their day was a half pint. At one time it contained a sextary, or a twelfth part of a gallon, to which the Romans had an equivalent measure, by Plautus and Quinctilian called a *hemina*, holding a twelfth of their *congius*, which rather exceeded our gallon.

In a few years after the introduction of the hop, people found out a method of keeping their beer longer; for in less than a century it had attained such celebrity in the upper classes of society, that even bishops, ever fond of good doings, as before shewn, were enamoured with its charms, like the Bavarian ladies of the present generation, who drink it regularly out of tall glasses, as French gentlemen did champagne; and so delicious is its flavour in that region, that the tables of the rich are daily furnished with it in preference to wine.

The great variety of hops brought into the market arises from many causes, of which the principal are soil, situation, culture, method of picking, drying, and general management; but the most precarious of all is the season. Each sort is distinguished by a name, such as the county or district in which it grew, and some are named after celebrated growers or dealers. Richardson found that the North Clays, so called from the stiff land in Nottinghamshire where they grew, were the rankest in taste, and fetched a better price with a certain class of buyers than those from Kent, though not generally so high as the Farnham samples; but to persons unaccustomed to North Clays, their rankness approaches to nauseousness, particularly while the beer is new, and remains for a considerable time, unless the accompanying extract from malt has great strength to cover it; therefore they appear fitter for strong beers brewed to keep long, than for any others.

Farnhams are in high repute, though not worth the price to the brewer that is usually given for them, unless the proximity of his residence be a consideration in their favour; and the county of Kent at large, though pre-eminent both for strength and flavour in a general way, differs in its produce according to soil and season, the one being sometimes suitable to the other, and sometimes quite the contrary. Those grown in the neighbourhood of Canterbury have been much prized for their superiority, but that is not invariable. The Wealds are celebrated in some of the southern and midland counties; but in the more northerly, as Cheshire, Lancashire, &c., Worcesters are preferred for their mildness, and for the grateful sensation which they yield to the palate; some use a few Sussex or Kents with them, but the generality of brewers in those counties reject the growth of Kent as unpleasing to their customers. Sussex is truly a hop county, and its produce is in great request in some districts; whereas in others they are guarded against with vigilant caution, from having, according to the local taste of those parts, an intolerable smatch, which is a property distinct from the absolute bitter. Persons accustomed to the Worcesters, and accordingly to mild ale, usually designate such as is brewed with Kents by the term *porter ale;* but it must be remarked, that the stronger and purer the clear native bitter of the hop, the better will it withstand the casualties of site and season. Kent produces more than all the rest of England, which proves them to be most in demand; and, as already observed, those from the east are often preferred for their more pleasant flavour; but the preference is far from uniform. For example, in 1844, those called Mid-Kents were considered the best grown, and consequently were worth the most money, notwithstanding how often the reverse happens. Nothing but a knowledge founded on direct observation each season, will enable a brewer to purchase profitably and judiciously.

As quality differs, so also does quantity, not only with regard to relative strength and relish, but also from variations of season; but to attempt to define the exact quantity for each distinct month of the year, or the quality best suited to any approaching season, would be ridiculous, even if the taste of the consumer had been previously ascertained by study; but generally speaking, the small delicate leaf of the Goldings, the Kents, and the Worcesters, has its share of admirers; but the more durable, either in malt liquors or out of them, are those that are full-grown, as ripe as possible, and with a strong thick leaf, which retains its virtues longer than a thin one. The portions called "choice," which are every year picked early while pleasant and young, and brought to market in an unripe state, to make a show and please the fastidious gentlemen, are deficient both in flavour and in quality, which renders them quite unfit for the purpose of any establishment conducted as a common sale brewery by an experienced man, though they may captivate butlers, and keep well enough in the cool vaults of an old English mansion. Hops do not possess all other good properties in proportion to their strength; and under this consideration the author engages the palest and mildest for light fresh ales, the strongest and most aromatic for the stronger pale descriptions, and the carefully picked Farnhams for exportation and for country imitation of the London ales; whilst those Kents of darker colour and more pungency or sting, which perhaps are likewise a little astringent, suit his idea the best when preparing for porter or long keeping. The brewers in the hop counties prefer the growth of their own locality, though not always with perfect wisdom; and many of the best of their samples are sent to the London market, where they are bought with avidity when in good condition, by the more liberal, enlightened, and scientific portion of the extensive merchants and brewers; for the Scotch and other country traders have of late either taught the Londoners by their example, or have stimulated them by competition, to produce the very best and most splendid pale beers any where now to be found; though they cannot deny that the quality and flavour of London porter has gradually fallen off, from a cause fully explained in our chapter on "*Porter*."

Some brewers attend too much to the colour and too little to the odour of the hop, and thus expose themselves to the fraudulent practices of the growers, thereby perpetuating the evil. According to Lance, whose "Hop Farmer" is one of the best written and most scientific books ever yet published in relation to the culture of this plant, and the management of its offspring, Lord Kenyon convicted a dealer so far back as 1795, in a penalty of *five pounds*, for scenting or adding some species of drug to his hops, by which their natural colour and odour had been altered; and notwithstanding the liability that exists at the present time as it did then, the growers in certain districts vie with each other in their several efforts to consume the largest quantity of brimstone with the greatest success in the drying of their hops, that they may give them an artificial good colour, their own hue being too often in accordance with the nature of the fuel burnt, or the matter evaporated by it under the drying oast: thus a green tinge is imparted by burning charcoal, aided by the fumes of sulphur and saltpetre, partially coating the original brown of the blossom with a yellow bright in proportion to the fraudulent skill and charge exerted to give to decayed age the hale bloom of youth, thereby seeking to provoke a repetition of that vengeance which induced the government under Henry VIII. to attempt at the abolition of the plant from within his territories.

Few hops, except the best and most carefully picked Farnhams, come to market in their natural state of colour, and particularly of those sold to grocers for domestic consumption; and some that are accounted the best Farnhams, are commonly picked too early, for the mere prizability of colour; by which means the perfection and permanency of the natural fluid bitter, are sacrificed to delicacy in the appearance of the aroma. Good and uniformly ripe hops are generally injured by the gilding and bleaching extortion, particularly when they are designed for keeping, the sulphur being constantly disengaging itself, and extracting the oil and essence of the hop; and the fraud is further deepened by an enhancement of price in consequence of the green-yellow colour which it gives to the flowers; yet who can morally blame the grower for thus cajoling the brewer and conforming to his taste, when the latter insists upon it, and *pays him* for committing the deception?

No hop should be gathered till nature has matured the seed; for with it the juices and solids constituting its essential aromatic and bitter properties will also be ripe; and when in this perfected state, the nectarium or pollen will be in larger particles, and of a brighter yellow than is usually seen; the seed hard and brown, and the edges and tips of many of the blossoms tinged brown also; and then it is that when rubbed in the palm of the hand, they appear to dissolve into a resinous and oily, or rather a viscous matter, and emit a pungent and gratifying scent. An unbleached sample of this description is of real service to the brewer, and would be equally profitable to the grower if he would be honest, because of the additional weight consequent to its fulness of maturity.

Besides the characteristics of hops already noticed, a plenitude of seed is a very good criterion of their quality; not for the sake of the seed itself so much, as for the quantity and quality of the farina consequent on the existence of the seed, which contains within itself a bitter pungent fluid; for it is well known that the interior of the seed is not available in the brewer's copper, the boiling being insufficient to break its hard though brittle shell. The extraordinary facts, that the seeds which have ripened within the influence of the male plant, will often vegetate after the severe treatment of boiling, and even after having passed through any animal that has fed upon them; evidently prove that it is advisable to bruise the seed, if we wish to extract its virtue.

Botanists agree that nature has designed the nectarium, and deposited it at the base of the petals of all flowers, for the consumption and completion of their seeds; and here a question might arise, whether the reduction of the nectarium by the ripening seed, added to the cost of this weighty and at present useless matter, is compensated in any way, so as to induce the brewer to give preference to samples abundantly supplied with this first of criteria—seed. Upon reflection, comparison, and experience, the answer is at once affirmative, because—

Firstly, the supply of farina is healthy, and more abundant than the seed requires for its completion, and the farina of the male probably aids the perfecting process.

Secondly, the globules of lupuline of each blossom, when inoculated with the farina of the male plant, and sufficiently ripe (for these are the principal necessary conditions), are larger, and their contents are more pungent, oily, and resinous, all arising from their perfected nature.

Thirdly, a smaller quantity will suffice in the application, since it is richer in the bitter and aromatic principles, and the profit of the farmer is increased by the additional weight of such accompaniments.

It is further observable, that the growth of so many seeds in each blossom tends to expand the leaves and weaken their hold on the strig or strombile, in which state they are the more likely to break off the petals and become wasted in high winds, or during the process of picking, removing, drying, or bagging. To this remark only one objection appears applicable, which is, that the attentive and diligent grower will avoid such waste by every means within his reach; for as his interest is here at stake, he will gather his hops before they reach this extreme.

In order to mitigate the great loss usually attendant on the practice of keeping hops from one season to another, many futile schemes have been devised. Amongst the best, it has been proposed to prevent the formation of a "wind-cake," or dry brown exterior, and for their better preservation generally, to subject the pockets to a reduction of one-half, or at least one-third of their bulk, by means of the hydraulic press, or of levers and screws, and to smear them on the outside with some gelatinous substance, or to paste or glue brown paper over the whole exterior of each pocket, which would amply repay those brewers who make it a practice, in certain states of the market, to purchase two or three years' consumption; and in general, when the price does not exceed 4*l.* or 5*l.* *per* cwt., the speculation answers well.

Chemists have a general practice, and perhaps the only process to which they have recourse, that when an essence is to be obtained, such as of roses or violets, or the like, to *distil* the article in alcohol; and that which evaporates and is again condensed, is the desired aromatic liquid. Now brewers distil their malt and hops in a similar manner, but do not take the precaution to preserve their volatile oils, &c., by means of a condenser, and the extract suffers in consequence. This waste was made evident a few years ago, and the dome copper was introduced for its preservation; but the scheme turned out to be a failure, except that the use of its pan effects a slight saving in fuel. Donovan discovered its inefficiency, and has well explained it, where he observes, that through the loss of heat and the dissipation of the aromatic oil of the hop by continued boiling, the brewers employed an apparatus to arrest them in their flight, by adding a copper pan charged with water at the top of the boiler, constructed in such a manner that the tube which allows the steam and oily vapour to escape, transmits both into this water, and heats and impregnates it with the oil at the same time, and the water thus qualified with volatile oil is used in the next mash; but he found that nothing was thereby gained, because the oil had already left the boiling wort, which was the evil to be prevented; and what is less favourable still, is the fact, that when this impregnated water comes again to the boiler in the new wort, it again evaporates, is expelled, and is received in other fresh water as before; so that the oil, though always in circulation, "*is never found where it ought to be.*"

Thomson, in his Vegetable Chemistry, treats on the lupuline of the hop and of its examination by Payen and Chevallier, and says they found that it contained 13 *per cent.* of the cones in weight, 4 of which were foreign matter, so that the genuine lupuline was only 9 *per cent.*, and that when distilled in water, it yielded a colourless volatile oil, amounting to about 2 *per cent.* of its weight; which oil will dissolve in water in considerable quantity, and is the principle to which hops owe their peculiar smell. This volatile oil, then, which contains the active principle of the plant, as diastase does that of malt, is partly consumed by the act of boiling, and a bitter and griping nuisance is substituted in its stead. Surely something ought long since to have been devised to get rid of an evil, the virulence of which is increased by the boiling process.

But we must not overlook another oil, equally volatile, which is the resin of malt noticed in Chapter III., page 88, and now melted. Some of our indifferently rectified spirits possess a superabundance of this oil. That the copper evaporates both this and the oil of hops is quite clear; and that the aromatic virtue chiefly resides in those essential oils, and emanates from them, is evident from that inherent principle of both plants which entitles them to selection, and is identical with their maturity and vital essence ; and it is this essence that greatly contributes to the preservation of the spirit.

Having, then, pointed out one or two of the evils of boiling hops, the next question that naturally arises is, how to prevent such havoc; and how, above all things, to preserve their virtue and flavour. The remedy is simple, practical, and effectual:—this is

The Hop-Convertor.

This humble and unassuming invention, which is a part of the patent apparatus, lays the foundation of the economy which fermentation in its province perfects. The plan here proposed not only prevents an extreme evaporation of the aromatic and preservative particles, but extracts every atom of them, and efficiently incorporates them with the worts, while it rejects the coarse astringent matter that lies in the grosser husks and fibres of the hops. As the underback, according to the new system, will no longer be exclusively serviceable as such, the bottom part of it may be converted into a hop-back, such as is now wanted, by merely inserting a perforated floor above the old bottom; and in many breweries, the old hop-back plates can be transferred to the underback for this purpose. Upon the solid bottom of this new hop-back, or above it, but beneath the perforated plates, a coil or two of metal tubing must be placed, provided with a stop-cock, and made to communicate with the steam boiler.

The hops having been completely broken up and well divided, are to be laid evenly upon the perforated floor of the Hop-convertor, and at about four hours before setting tap, sufficient boiling water is to be run amongst the hops from an upper liquor copper or hot-liquor back, when it must be turned off. The hops are to remain in this state abont an hour, within which time their pores will be greatly opened, and the whole steeping will become thoroughly saturated with water. Recourse is then had to the steam apparatus before mentioned; the steam tap must be turned on, and the steam will then impart its caloric through the medium of the metal, till the liquor is raised to the heat of 200°, at which temperature it ought to be kept during three hours longer. This time will be quite sufficient to release the oil, the pollen, and the more soluble but less caustic portion of the tannin, without losing the aroma, becanse very little vapour has ascended, the heat having been kept at the 12° below the boiling point.

The steam-cock having accordingly been turned off, and the time having now arrived for setting tap, a few barrels of wort must be run into the Hop-convertor or underback; and when it stands at the depth of about six inches above the perforated floor, which depth should be constantly preserved throughont the time of extraction, the wort-pump, which formerly pumped the worts into the copper, must be put in motion, unless the underback is planted to command the coolers; and in that case, the hop-liquor, &c., will gravitate and fall upon the coolers. The first few lifts of the pump in the one case, and a short running in the other, will immediately convey this liquor directly to its destination to be cooled, leaving the hops in the possession of the gravitating worts, which worts will now pass through the hops, and receive their remaining essence and virtue in the transit, and will then travel with the hop-liquor through the perforated bottom, and through the pump or tap to the coolers. As the mash-tun tap needs not to be turned off, the flow of water from the hot-liquor back through the sparger, the mash, and the Hop-convertor, to the coolers, will be continuous, washing and floating the whole of the pollen, or nectareous farina, out of its native flower, away into the wort upon the coolers.

By thus impregnating the wort with the preservative parts of the hop, we not only effect a saving of that article, but likewise avoid the carbonisation or charring of the worts, besides an empyreumatic flavour, with the deep colour more or less consequent on boiling hops and wort in the usual manner; and it has been demonstrated that these evils have been increased where dome coppers have been used, because the worts have been exposed to greater heat by the pressure of the miscalled safety-valve.

Notwithstanding that the most valuable properties, and nearly all that are useful in the hops, are now incorporated with the wort that has passed through them, in order to ensure a complete extraction, it may be advisable, especially when porter and light ales are made, to retain the last few barrels that drain from the mash-tun after sparsion, within the Hop-convertor, amongst the hops, and to boil them a certain short time by means of the steam-pipe; for the rankest bitter will then be either of little consequence, or will be disguised by the quantity of extract. This practice will be found very convenient, and in some cases even necessary; and the plan is in perfect conformity to the theory here propounded, because all the fine principles of both malt and hop are already secured on the coolers, and the density of the last extract is but little removed from water, if taken from the old plan; so that this partial retention of the boiling system may serve as an experiment, and must make the Hop-convertor acceptable, even to the most dubious.

By the plan of steaming hops through the use of the

Convertor, coppers, underbacks, hop-backs, wort-pumps, and shifting the hops, may be totally dispensed with, the new utensil being so located and provided, that the purposes of each may be accomplished by it with economy of materials, fuel, labour, and time; and we may further observe, that the Hop-convertor may be made, as a matter of course, to act the part of a copper or boiler; for worts may be boiled as effectually, and as long, if necessary, by steam as by the furnace.

Steaming Worts.—As the requisite quantity of steam may be a question to some minds, and the mode of conveying it a difficulty to others, the Author has here to observe, that the steam ought to pass as rapidly as possible from the generator to the boiling tubes, and through them, that little or none of the heat may be lost by radiation during its transit; for which object, the main from which the branches diverge, should be near the boiler or generator, and the latter as near its work as convenient. When the steam has a long way to travel, the conveying pipe should be surrounded by some non-conducting substance, to prevent a waste of its caloric. As the quantity of heating surface should be in proportion to the liquor to be heated or boiled, and to the pressure of the steam engaged, some idea of this subject may be formed from the fact, that 150 feet of two-inch copper pipe, in the form of a coil or distiller's worm, will heat 30 barrels of wort from 140° to 212°, in half an hour, at a pressure of about 40 lbs. to the square inch; and the same rule will hold good in other positions, so long as the same surface incloses the same space; and since circumferences are as their diameters, the surface heat will be inversely as the enlargement or contraction of the calibre. The rate of evaporation is the same as with the furnace, if kept in the same state of ebullition. This improvement and substitute for the old costly copper is now made of oak, or of cast iron, naked or coated with pure zinc.

In boiling by means of steam, not a particle of caloric needs be lost. The steam may make its way directly to the liquor-back of the sparging apparatus or of the barrel-washing liquor, and be condensed in either of them. By this contrivance the author has for several years conducted the practical department of his business without the aid of furnace heat, except of that under the engine boiler, which is the only fire in or near the brewhouse: thus the furnaces of three coppers have been dispensed with, as well as their stokers, at a saving of at least one-half in fuel, besides the wages. These are not all the advantages of an economical nature; for the very expensive wear and tear of brickwork, furnace bars, and coppers, are entirely avoided; and of the effects which the plan produces on the articles brewed, sufficient experience proves that it is incomparably preferable to direct furnace heat, both as regards colour and flavour, besides securing the permanency of the beer; but, like other innovations, no matter whether beneficial or not, it has to meet the opposition of certain interested parties, such as coppersmiths and the like, who know that this is a heavy blow at the most profitable part of their business, and have not hesitated to misrepresent the effects of steam-boiling in the grossest manner, alike ignorant and barefaced, as it is insulting to men of sense and unbiassed perception.

Some few really intelligent persons have been led to doubt the efficacy of steam as a substitute for furnaces in the brewery. They have an indistinct idea that a proper effect is not produced on the worts by the heating powers of steam. To remove such apprehensions as arise from misconception and misrepresentation, we must here remark, that when all resistance, except the atmospheric, is removed from the surface of a boiling fluid, as brewers' wort in an open copper, for example, such fluids never attain a higher temperature than 212° or 213°, notwithstanding that the furnace imparts caloric of more than triple the intensity indicated by the thermometer when immersed in the boiling liquid, because all surplus heat above those 212° or 213°, flies off into the atmosphere. On the other hand, when water is exposed to furnace heat, and excluded from atmospheric pressure, as in the instance of a steam boiler, it will imbibe and retain caloric as long as the boiler resists its accumulating heat, and consequent increasing pressure. Hence steam is composed of fire and water in an intimate state of combination, which arises from compression, the heat of which bears a certain variable proportion to the resistance made to its escape into the atmosphere by the safety-valve. The intensity of the caloric imparted to worts by steam may then be ascertained by the thermometer, the safety-valve, or the mercurial gauge, all of which the brewer should provide, and particularly proper boilers for steam boiling and general purposes.

The following tables on the pressure and elasticity of steam, compiled from Luke Hebert's Encyclopædia, will be of service to practical men who adopt the system:—

TABLE I.

Temperature by Fahrenheit.	Pressure of steam, or the force which it will exert to enter into a vacuous space.			Pressure of the steam against the atmosphere when the barometer is at 30°, or force exerted to escape from closed vessel.		
	Column of Mercury. Inches.	Column of Water. Ft. In.	Pressure per sq. in. lbs. oz.	Column of Mercury. Inches.	Column of Water. Ft. In.	Pressure per sq. in. lbs. oz.
212	30·	33 11	14 11	steam.	equal to	atmosph.
220	35·	39 6	17 1	5·	5 7	2 7
230	41·75	47 2	20 7	11·75	13 4	5 13
240	49·67	56 1	24 4	19·67	22 3	9 10
250	58·21	65 9	28 8	28·21	31 11	13 14
260	67·73	76 6	33 2	37·73	42 8	18 8
270	77·85	87 11	38 1	47 85	54 1	23 7
280	88·75	100 3	43 7	58·75	67 5	28 13
290	100·12	113 1	49 0	70·12	79 3	34 6
300	111·81	126 4	54 12	81·81	92 6	40 2
310	123·53	139 6	60 8	93·53	105 8	45 14
320	135·	152 6	66 1	105·	116 5	51 7

TABLE II.

Elasticity in Atmospheres.	Height of Mercury in inches.	Temperature by Fahrenheit.	Pressure per square inch in lbs. Avoird.
1	29·92	212·	14·61
1½	44 88	234·	21·92
2	59·84	251·6	29·23
3	89·76	275·	43·84
4	119 69	293·4	58·46
5	149·61	309·2	73 07
6	179·53	322·7	81·69
7	209·45	334·4	102·30
8	239·37	343·4	116·92

The following suggestion, taken from Lance's Hop Farmer, page 18, has led to an improvement very likely to be of great service to the country, and will bring the use of a copper to a nullity, and that of the Hop-convertor to a very simple operation, when allowed to be acted upon. "When there is a greater quantity of hops grown for several years than are likely to be used while they are good, it would be well to devise a plan for consuming them in those overstocked years. For the use of bittering beer, an extract may be made, and all the fine qualities of the hop retained in a liquid state, or the bittering principle concentrated in a dry state of powder, and thus preserved, may be sent on board ship for exportation, or conveyed to any part of England in air-tight vessels: this would be the means of saving much room on shipboard, or in warehousing a stock. The quality of bark for medicinal purposes is now concentrated into a small compass, as *quinine;* and why not the bitter principle of hops? Instead of one pound of hops to a bushel of malt, part of an ounce of extract would then be sufficient, particularly if the extract was made with spirits of wine. A tincture of hops may be made with part water and part spirits of wine, and subjected to a gentle heat for a few days in an air-tight vessel: the full virtue of the hop will be thus extracted, and the virtue of several hundreds weight be concentrated in a gallon of liquor: this would be the tincture of lupuline, and would act as a medicine, or might be used for flavouring beer." Such are the pursuit and spread of literature and art in the present age, and the facility and rapidity of intercourse between and among nations, that no sooner is an idea started in one country, than it is scrutinised in another, and if worth any thing, is immediately seized and acted upon; and accordingly, within the course of two years, Mr. Lance's opinion travelled into France, received an impetus there, and having been tested, was put into practical operation, patented, sent home again, and obtained a patent in

England. The following translation speaks how cleverly and expeditiously this was done:

"An important problem relating to the cultivation and commerce of the hop, and to brewing, has been solved by the discovery of *humuline*, for which the house of Heck & Co., at Bischville (Lower Rhine), and at Nancy (Meurthe), have just taken out a patent for ten years.

"Humuline is the active principle of the hop, separated from all its inert matter; this product consequently represents the hop, with all its properties, in its natural and unadulterated state.

"It is *destined* to take the place of the hop in commerce and in brewing, for it possesses over the natural plant very great advantages, of which the following are the principal:—

"The hop loses its good qualities from year to year, and in the course of two or three years becomes unsaleable: humuline, on the contrary, prepared according to the patent, will keep for many years without expense, and without the least alteration.

"The hop is a bulky article, requiring extensive warehouses, and to be protected from the weather: humuline, on the contrary, takes up but little space, and is preserved without loss in any warehouse or cellaring.

The hop, if sent to a great distance, is often liable to injury from heat or wet: nothing of the sort is to be feared for the humuline, which may be easily carried in any weather, and at much less expense.

"The proportion of the active principles which the hop contains, varies every year and in every country, to such a degree that the brewer is never sure of the result that may be obtained from the first brewing made with any particular sort: by substituting humuline, he is certain of the result being always the same, and constantly favourable. Hundreds of brewings already made in many places, and by numerous brewers, have effectually proved it. The beer from humuline is shewn invariably to be superior to that made from hop.

"The small space which the humuline occupies in the boiler, increases the quantity of the beer, and lessens the firing. In a word, brewing, usually so complicated and so uncertain, becomes with humuline an operation simple, sure, and of easy execution.

"One kilogramme of humuline is equal to three kilogrammes of hops of the best quality; and in that proportion the humuline must be used by the brewer.

"We offer to merchants and brewers the humuline obtained from the hops of Spalta, Bohemia, Germany, Alsace, Lorraine, &c. &c., with scarcely any increase of prices above the hop from the same places. We guarantee besides, to the brewers, complete success in the trials with humuline, if they will attend to the simple directions with which we will furnish them.

"It must be observed, that our humuline may be used for the making of every kind of beer, whether Strasbourg, Lyons, Paris, English, &c. &c., and there will be a remarkable saving of time in each brewing.

"HECK & Co."

"*Directions for using the Humuline.*

"Take one kilo. of humuline instead of three kilo. of hops, add it to the wort about 30 or 40 minutes before drawing it off from the boiler, allowing it to boil gently, and keeping the boiler covered. After this the brewing is done in the usual way.

"According to the capacity of the boiler you may add one-half, or one or two kilo. of hops. This small quantity is to attract the little flakes floating in the beer, and that it may run quite clear to the cooler.

"Brewers wishing more information, address Messrs. Heck & Co., Bischville, Bas Rhine."

In the Mechanics' Magazine, No. 943, p. 206, notice is taken of an extension of the French patent to England, granting it to William Edward Newton, of Chancery-lane, London. Mr. Newton dries his hops at a temperature of 86° F., till they become brittle and assume a pulverulent character, when he runs them through a coarse sieve; he next places the powder in a close cylinder, covers it with alcohol an inch and a half deep, presses it close for 24 hours, and then draws off the alcoholic tincture into a tub, and the powdered hops are washed till no extract is left within them. The essential oil is thus combined with the tincture, and being placed in a warm bath, the alcohol is driven off, leaving the oil, which resembles a yellow resin, covered with a lutean aqueous liquor, and the extract and watery solution are evaporated together over an open fire till they become syrup, which is removed to the water bath, and farther evaporated till it is nearly solid, which he unites with the resinous matter of the alcoholic tincture while warm, and these form humuline, one pound of which is equal to three of hops.

As regards the process, it appears at sight to be chemically correct, and that the matter so produced will answer the brewer's purpose admirably, because of its economy, and the facility with which it will dissolve in the worts, and unite with them; and for these reasons the author inclines to the idea, that where a little astringency is not of consequence, as in porter, vatted ales, &c., it may be expected to rival the Hop-convertor.

All that is necessary for the preparation of the humuline, seems to be nothing more than a little moisture and heat, in order to add it to either the raw or the fermented wort with ease and accuracy; thus we have another, and perhaps a cheaper method of impregnating the worts with the essentials of the hop, and also another substitute for boiling and spoiling the extract of malt.

If humuline were manufactured from English hops under the eye of the excise, and marked by them as the produce of hops which have paid the duty, or are charged with it; and if it were *permitted* by them like other exciseable commodities; the officers of the revenue could not have cause for interference, notwithstanding any "rusty act of parliament" which designers might rake up; and at all events, they cannot obtrude upon private individuals; for if the object of any interposition on their part be to exact a second duty, or a penalty in lieu, it is austere and intolerant; but if it is to be otherwise prepared than as here pointed out, there is no safety in guaranteeing a plan to prevent adulteration. The excise would at once mark the locality of the manufacture upon the packages, and would seal them; so that the brewer would know whether he was buying Kents or Worcesters, Sussex or North Clay, and consequently whether he was to use 3 lbs. or 4 lbs. to a wort of given density and gravity; and besides, they would also mark the date of stowage, and having ensured the maintenance of the desirable qualities of new hops, the deceitful practice of returning old ones to be mixed with them would be abolished; indeed, old hops and bagging might be superseded altogether by this plan, and the usual consequent deterioration would be avoided through concentrating and preserving new essence only. The humuline may likewise contain the extract of the bruised seeds, which will materially alter its taste; and the "hop-dust" which is found to have escaped from the leaves and to be deposited under the drying oast, may be concentrated within it, if parties are so disposed; all which things ought to be known and understood; and another question arises, though we have no right to anticipate adulterations, aware as we are of their common occurrence; for some men are born to stratagem and finesse, move how and where they may. But will it banish for ever the fraud of smoking the hops with brimstone? Will it prevent infusions of cockle, (*agrostemma githago,*) darnel, grains of paradise, and savine or juniper? Will it abolish wormwood, southernwood, yarrow, buckbean, chamomile, centaury, broom, or gill? Will it prohibit the importation of gentian-root, quassia, tobacco, chirayetta, or ginseng? Quassia, certainly, might be introduced, tinctured a little with gentian (for of itself it is too stale and inodorous), when hops could not be obtained, and then only as an inevitable expedient; and in that extremity chirayetta might be tried, subject to the connivance or relaxation of the law, which in such an emergency ought in reason to be suspended for public accommodation in a definite degree.

In buying samples of hops, a little boiling water may be poured over an ounce or so, in a vessel with a close lid, and left to stand a few hours; and the same may be done with various samples at once, and at the end of that time they will distinguish themselves by the mere difference in the taste and scent of each:—may humuline stand the same test, and be free from adulteration! Unfortunately, the present state of the excise laws precludes its introduction into the British brewery; and though a company of speculators in London, with Dr. Ure at their head, lately essayed to form a large capital to trade in the "concentrated essence of malt and hop," they have soon experienced the complete failure of their speculation.

CHAPTER IX.

BOILING.

REFLECTIONS—THREE GREAT PRINCIPLES—EVIDENCE OF LOSS—ECONOMY—NEW LONDON MODE—THE FLAKES EXAMINED—THEIR COMPOSITION AND VALUE—EVILS OF BOILING—INUTILITY OF DOME COPPERS — DESTRUCTION OF DIASTASE — ANTI-BOILING — YIELDING OPINIONS—PRACTICE—PRESERVATION OF ALCOHOL—IMPROVEMENT OF FLAVOUR — LOSSES BY IMBIBITION AVOIDED — ADVICE ON BOILING.

Objections and animosities, like candidates and proffered stock, need the test of examination before we yield our confidence or prepossess them by adoption. We should not, in common reason, raise objections to a novelty merely because it is new, lest it should prove to be old or valuable; but endeavour to see some cause for the restraint of criticism, and pause before we condemn, thereby to shew that we are not more censorious than politic. Society contains certain men who value no person's opinion, however fully matured, so highly as their own, although their ideas be useless and obsolete; for ignorance is ever unconscious of being ignorant, and long-conceived notions grow into habitual prejudices. Were our ancestors to return to our cities, and behold the splendour of the gas-lights that illuminate them; or into our fields and roads, and there witness the rapidity of the steam-propelled trains; they would indeed wonder at the impudent moonshine produced from coal smoke, in imitation of that which in their day was a child's trick, and at the stupendous innovations that have grown out of a simple experiment with a tea-kettle spout, or the pressure of a pair of bellows! In the same retrospective light may be viewed some of the notions that have been entertained with respect to aërostation, vaccination, geology, and many other inventions and discoveries, and especially in almost every instance, those advancements in the arts and sciences for which letters patent have been obtained (whatever pecuniary and mental expense, without hope of remuneration, may have attended their completion), in order to stimulate industry; to economise time, labour, and fuel; to determine, regulate, and exemplify the powers of genius; to expand the views of experimental science; and to beautify the niceties and remove the intricacies of art: in short, to throw open the doors of philosophy to all who choose to enter, to improve and impart knowledge. If the inventor of the air-balloon was called a "wild goose," the discoverer of the vaccine lymph a "calf-head," the projector of the locomotive engine, a "hair-brain," and the practical propounder of carburetted hydrogen gas as a light, a "lunatic," scarcely can the founder of a matter so simple as the theory of brewing the national beverage without boiling it, however beneficial to society his product may be, expect to escape the opprobrium of some visionary epithet, and particularly from traders wedded by antiquity to an old state of trade, quite uncongenial to those who would march forward in the high road of sweeping improvement: he has, however, as he perceives from a little experience, his open abettors, who declare their conviction; and if he can be fortunate enough to demonstrate to the ordinary capacity of man, by proofs at once clear, uncompromising, irrefragable, and permanent, that he is guided by cool reason and thoughtful solicitude; that, in fact, he is right, and the customary practice wrong (upon which point he yet stakes his reputation as a brewer), he will be pleased and satisfied at the gratifying idea of having inserted his little tenacious link in the interminable chain of intellectual expansion, and contributed his mite towards regulating the equipoise between the scales of commercial justice.

The grosser portions of gluten and albumen are retained in the grains, because they will not pass through the filter: their finer parts, however, which are considerable, are dissolved, and are so far blended, and in a measure identified, with the sugar, that their separation from it, while in that state, is impracticable by ordinary means; and this shews the necessity of their conversion or of their removal from the body of the beer; and nothing but a cool and slow fermentation can afford time for their disengagement, and prevent their effecting a wrong species of decomposition of the sugar or its produce; and again, as the finest flavour is obtained from the most delicate parts of the materials, and as these are the richest, the most subtile, and the most liable to evaporate. even from the first; the warmer the circumambient air, the more greedily it absorbs in its thirst those delicate and volatile constituents, which, from these causes, it is essentially necessary to preserve through the intermediate stage of incorporation with the hop.

Though the new mode of impregnating the worts with the aromatic and preservative principle of the hop, differs from the usual, and indeed the universal plan of boiling pursued in the English brewery, the anti-boiling system is not entirely new; nor is the manner of extracting and preparing the essence of the hop, though the united process be novel, speedy, and economical; for like the former operations, described as parts of the inventor's scheme, its necessity has been seen and felt: the why has been in some measure accounted for; but the how has been wanting; and when discovered, it is found to carry out the great principles of—

I. Economy in Fuel;
II. The security of the Alcohol; and
III. The improvement of the Flavour.

I. Economy in Fuel.

In the first place, then, by dispensing with the boiling system, the fuel saved by the use of the Mashing Attemperator and the Hop-convertor, is a consideration so important in a pecuniary point of view, that this saving alone ought to weigh well with those whose capital has been expended in support of a process which has caused it to evaporate—the principal in the coal mine to produce fire, and the interest in the atmosphere in the state of smoke, inflicting injury upon their neighbours, without any benefit to themselves.

The avowed reasons, or rather the excuses, which are given in favour of boiling, are vague, contradictory, irrational, and unscientific; and to those who seriously reflect on its consequences, it is a matter of real surprise that the practice, with all its disadvantages, has continued so long; yet the mode of extraction and fermentation hitherto pursued, may have, to a certain extent, urged its necessity. It is, as the author knows and will prove, wasteful and pernicious, both to the extract of the malt and to that of the hop; for when the worts are heated to the boiling point, they undergo great agitation, and their ebullition causes the escape of much superfluous heat, accompanied with particles of the liquor, and the finest portion of the malt and hop. This great loss must be evident to the olfactory and other senses of all who pass within a few hundreds of yards of the brewery at any time, or within the extent of half a mile to the leeward of the copper when the operation is going on, as its fine aroma, the great essential of flavour, passes through their nostrils and over their palates. This is rendered still more strikingly evident when equal quantities of boiled and unboiled worts of the same specific gravity, are completely attenuated by a correspondent process of fermentation, and are afterwards subjected to distillation. This experiment, at the same time, again shews that the saccharometer does not at all times detect and correctly indicate the amount of *all* the fermentable matter present in either raw or boiled worts ; for the fruits of much seemingly disguised matter in impure worts, are developed by the still, and alone made apparent by the hydrometer.

Although some persons will be so bold as to contend that nothing flies off except watery particles, and that no loss accrues to the fermentable matter, but that boiling is necessary for dispelling the air ; if such persons would only take the trouble to put their assertions to an unbiassed and fairly-conducted trial, as before alluded to, they would assuredly find that a considerable portion of the fermentable extract of the malt is lost by boiling the usual time ; and let it be remembered, that the loss is more severe, because the most delicate and valuable of the aromatic particles of the two principal materials are thus lost and annihilated by dissipation and carbonisation. As to the secondary object, the expulsion of the air, it has not yet been shewn that a wort deprived of its native air, ferments more kindly, or makes better ale in any respect, than one which possesses a moderate quantity of air, such as is usually found in water. On the contrary, it would be highly advantageous in low fermentations, or where it is desirable to pitch at low heats, and make full-bodied and finely-flavoured ales; for such malt liquors would ferment the more readily, and continue in the fermenting state the more vigorously, at any temperature, because not deprived of their constitutional strength. At the desirable low heats especially, while other less aërated worts would scarcely evince a motion at many degrees higher, this advantage is decidedly manifest.

Perhaps, though neither much good nor any very considerable harm is done in this respect by boiling worts or liquor at certain periods of the year; that is, when they lie upon the coolers just long enough to absorb as much air as has been lost by boiling; this compensatory effect is uncertain, and cannot at any time be relied on; since at one season, during cold weather, the worts would regain but little: and at the opposite extreme of summer, they would draw in considerably too much, especially when the temperature of such worts is down at 80°, or perhaps at 90°; for the imbibed air always contains more oxygen than was expelled; and hence arise spontaneous fermentation, the fox, premature acidity, and many other evils. The writer would remark, too, that the boiling of either water or wort, causes a deposition of saline compounds, principally consisting of carbonate or sulphate of lime, thus wasting a most valuable anti-acid, the excellence of which is established above, in Chap. IV., p. 114, &c. Why should the country be ransacked in search of barley, hops, and water, all containing this and other kindred salts, for the sake of their preservative goodness, to have it hurried away in the copper?

Again, referring to Einhof's analysis of barley-meal, and setting aside the little niceties of distinction made by analysts among the different phosphates and other salts, arising, perhaps, from differences in the quality of the land and manure in which the corn had grown; as the meal in the experiment was just $\frac{7}{10}$ths of the whole bulk, and 2690 parts of it, produced from 3840 of barley, gave as follows:—Volatile matter additional 252, albumen 30·8, saccharum 140, mucilage 123·2, phosphate of lime, &c., 6·3, gluten 95·5, husk additional 182, starch to make saccharum 1806, loss 53·2, fractions, chiefly starch, 1; total 2690. This reduces the whole of the first barley, after the second separation, to (*per cent.*)

Volatile matter	17·76	Gluten	2·5
Starch and saccharum	50·68	Phosphates, &c	0·16
Albumen, about	0·81	Husk	23·49
Mucilage	3·2	Loss	1·4

Thus, by the simple act of crushing before the test, we have, on a very particular examination, 14 *per cent.* more saccharum, or of starch fit for saccharisation, than Proust, in his analysis of crude barley, though 20 *per cent.* less than when barley, but probably not the same, is malted, which is 16 less than in Thomson's result; the gluten, which Proust gives at 3 in barley and 1 in malt, Einhof finds to be 2·5 in the middle state; but the mucilage, which appears to increase from 4 to 15 in malting, is, with the albumen, only 3 *per cent.*; yet then, we have here no less than nearly 18 *per cent.* of rich "volatile matter," subject to flight or injury the first time that it is heated beyond the ordinary endurance: a certain proof that too much fire is a dangerous thing in a brewhouse.

Grain distillers do not boil their worts; yet their method and object in the mash-tun is similar to that of brewers; still the extreme perfection of their fermentation is here worthy of remark. They can easily attenuate to the lowest point, even to the specific gravity of water, because they have not removed the necessary agents by boiling; their high fermenting heat being merely to facilitate the process; the flavour of the saccharum not being with them a consideration, since they attenuate all the saccharum, and nearly all the vegetable matter.

Neither do cider makers boil their must, and yet it ferments well, is clear and sparkling, and keeps well if properly managed. The author had a conversation with one of the most conversant of the practical London brewers in which this topic was discussed; but he has been so long accustomed to boiling, that he cannot see how to dispense with it, though he candidly admits that "too much boiling does harm;" and it may be somewhat worthy of remark, that the same gentleman has ventured to abolish the use of the copper, and to boil his worts by steam, in a back erected for that purpose, according to the manner explained in the foregoing chapter; which plan is now followed by other brewers in the metropolis and elsewhere. Whether they will next run their first worts upon the coolers unboiled, as a second tardy step towards the plan adopted in the mind of the patentee, and successfully carried out, he does not attempt to predict, though many have become aware of the existence of a vital evil, and yet are unwilling to break through the trammels of habit, but rather,

> "To hint a fault and hesitate dislike,
> Willing to wound and yet afraid to strike."

For why is wort boiled at all? To extract the bitter, most assuredly; and this is now done by means of the Hop-convertor, without any risk of losing the prime materials.

The experienced person above mentioned, in objection to the introduction of an anti-boiling system, reasons upon the practice of country ladies, who in their household economy, contend that their *preserves* will not keep in a sound condition unless they are boiled. Neither, be it observed, would those prepared with honey by the women of the 13th century, nor are we any where informed that their ale was boiled more than their mead or metheglin; but in order to remove any prejudice that may be formed on such an inference, we must reflect that the fixed air and the vigorous gluten, &c., of the unboiled fruit extract, is prone to the acetous fermentation, and hence its unsoundness. Boiling, in that case, will retard the decomposition, by expelling the fixed air and its superfluity of water, and by crippling the decaying energies of the albumen and other native matter that constitutes its ferment; therefore, we may grant that such will be the effect on substances containing similar properties, in proportion to the caloric they imbibe, though whether boiling, even if adequate in this instance, be a desirable means, remains to be proved. As a simile, it is not a good one, because boiling is no preservative of fruit unless *sugar* be added; and because there is an additional and extraordinary property latent in the brewer's wort which was never intended to exist in the preserve, and a purposed fermentation is essential to its existence, wherever it be produced: that property is alcohol. Besides, the remaining ferment and the vegetable matter are reduced in quantity and power by the fermentation; and even before boiling, were considerably less in proportion to the bulk of the several articles containing them, or rather, in proportion to their specific gravity; and the alcohol is itself a well-known preservative to the remaining extract; whereas in the preserve no fermentation is intended, nor is any defensive alcohol provided. The gentleman admits that boiling is not necessary for the impregnation of the wort with the hop; and as the mode of converting hops by steaming the liquor will answer quite as well, or better, for what purpose is wort then boiled? He says that unboiled worts will not keep, having tried them. The author has no desire to contradict the affirmation, not being acquainted with his process of treatment in the mash and fermenting tuns, or out of them; but he can truly assert, on his own part, that his duly attempered worts keep much better, as all azotised ingredients are ultimately removed, than any boiled gyles on which he has ever acted; and he has tested them most rigidly and carefully.

II. The Security of Alcohol.

Amongst other objections which it is possible to raise against the novel conversion of the hop, as a great innovation on the habitual and long-continued practice of boiling worts,—one, perhaps the most general, is, that the effects of boiling are *seen* in the flakes or flocks that are produced by the coagulation of some vegetable substance contained in the malt or the hops, or both; and that by their appearance the quality of the extract is tested and ascertained; but it has not been satisfactorily shewn by any writer on the subject, that an increase of their number or size is advantageous, or yet that their production is desirable; for in all probability the question has never been fully investigated, nor do chemists seem to have decided what they are; and much less satisfactorily, therefore, can they discuss the mode of treatment and determine upon it. At all events, they consist of coagulated substance; but whether it is gum, or mucilage, or gluten, or albumen, or whatever else it may be called by way of speculation, beyond what is herein seen on the authority of philosophers, but all aiding in the solution of the same question, they assuredly are the effect of excessive heat. If their accumulation be a high merit in the art and mystery of brewing, they may easily be produced without either overboiling or legerdemain; for it is now many years since the author discovered, without study, that one ounce of powdered quicklime *per* barrel, added to the wort when ebullient or *hot*, caused ten times more flocks to form in ten minutes, than three hours' boiling could produce. He is well convinced, too, that a very great majority of these flakes or flocks escape with the wort through the hop-back; and as it parts with its caloric on the cooler, so do they again partially dissolve, and cause that turbidity so discernible in cold worts, notwithstanding their great transparency when hot. Were it possible for this to be a mistake, it cannot then be denied that they find their way into the fermenting tun, and are never afterwards seen in their pristine state; for being of a vegetable nature, and highly charged with nitrogen and sugar, they submit to the influence of the fermenting mass in which they float, and undergo decomposition, one of the products of which change must necessarily be alcohol; for the agitated particles and constant commotion of escaping gases, will not allow such very light matter to subside, unless under peculiar circumstances.

One author, after advising a gentle first setting of the tap in order to obtain bright worts, finds it necessary to suspend a bag made of horse-hair or thin canvas, filled with hops, in the under-back, as an effectual preventive to acidity taking place in the wort, which is a common occurrence in hot weather, and will sometimes happen in a moderate season; but whether brewers boil their hops in suspended nets, whether they rouse the hop-back, as recommended by another, or whether they use backs without false bottoms, plugs, or taps, as done by a third, or whether recourse be had to any other of the expedients usually practised, their system re-dissolves the flakes with the watery parts of the wort, so that they fall into a state similar to that in which they were before boiling, but with the exception that they are injured in quality, partially carbonised, and deprived of some of their useful air, and consequently they will be longer in decomposing. Combrune was aware of some of these consequences, and therefore boiled his worts without the excuse of ignorance, for his words are not a little remarkable:—" Those who continue boiling the first wort a long time, do so in order to be satisfied that the fire has had its due effect, and that the hops have yielded the whole of their virtue. They judge of this by the wort curdling and depositing flakes like snow. If a quantity of this sediment is collected, it will be found to the taste both sweet and bitter; and if boiled again in water, the decoction will ferment when cold, and yield a vinous liquor. The flakes, therefore, contain a part of the strength of the wort; they consist of the first and choicest principles of the malt and hops, and by their subsiding, become of little or no use." Here, then, is one who wrote with his eyes open; and who, rather than lose the gratification of knowing that the fire had taken its " due effect," was content to sacrifice the "first and choicest principles," until they became " of little or no use." Glorious inconsistency! not of the man, but of the school.

From the great quantity of matter partaking of the flaky form, and which brewers delight to " see curdle," the idea of its being all gluten seems to be contradicted by analogy, since Proust's experiments give only one part of it in a hundred in the whole corn before mashing, and still less after a further change effecting a saccharisation of starch, &c. Of what, then, do these flakes consist, that they can be so readily obtained, and in such abundance? Not of mucilage, from the clearness of the fact that it will not coagulate under such circumstances. Chemists certainly are inconclusive upon this point; but as Einhof's analysis of barley and barley-meal has led to the detection of albumen, and to its introduction among us in its true character by Thomson, this may help to make up the apparent anomaly, which we shall the more clearly see on referring to the second chapter of the present treatise, and especially to *gum* and *albumen*.

Now if it be wished to coagulate the albumen by way of experiment, in order to expel it out of the body of any certain wort, let the heat of the mash be increased to 190° or 200° just before setting tap, and the after-process will filter the wort at once, and render it tolerably free from this or other flocculent matter; but another subject for enquiry is, what good will their expulsion effect at this stage? If they do not consist of albumen, then they must contain some other constituent of gluten, or be compounded of more than one, with such grosser portion of the essential virtue as the ebullient force of heat could not evaporate, and which necessarily, from their lightness, must find their way to the surface during the agitation by which they are loosened from their hold when boiling; but albumen has been shewn to contain the prime motive principle, gluten to possess the nitrogen of vegetables, and the oils to hold the odour and much of the richness of the substance that contains it, and to unite freely with sugar; and moreover, from what has been advanced, the elements of albumen are in some cases due to the diastase which inhabits it, and which is the prime agent and central principle of its existence, and of life and motion in the whole mass, whether maltine or lupuline; and hence the absurdity of boiling it away! But the subject may be otherwise cleared up, thus:

We glean from Biot, Persoz, Pelouse, and other continental chemists, the part which diastase performs when in communication with starch, as already rather fully detailed, with some little assistance in accounting for such large bodies of flakes; and they also describe to us some little utility in a diastatic or mash-tun Attemperator; telling us of that valuable discovery, which shews that the starch of malt exists in numerous globules, which its action speedily dissolves; but whether or not we may attribute the accumulation of these flakes and their value to some action in the brewer's copper, must depend upon some solution of our own, as must the whole theory of destructibility by the process of boiling. Let us, therefore, proceed to examine the proximate principles again, in their application to this subject.

1. *Gluten* contains nitrogen, which is lighter than atmospheric air; for the air, according to the best philosophy, is thus compounded:

77	parts of nitrogen,	each	·297	of a grain=	22·87	grains.
22	ditto	oxygen, each	·338	ditto	7·43	do.
1	ditto	carbonic acid	·465	ditto	0·46	do.
100	ditto	atmospheric air	·3076	ditto	30·76	do.

Consequently, this last proximate compound, whenever or however decomposed, must necessarily liberate the nitrogen, and suffer it to escape.

2. *Starch*, if any remain unconverted, is only soluble at a temperature a little below boiling heat; but forms

with boiling water a kind of jelly, so that boiling prevents its conversion, and it becomes inert and useless.

3. *Mucilage.* As this is the last constituent in the extract which decomposes under ordinary circumstances, and as it is desirable that it should be the first to ferment rather than the last, its propensity to exist in malt liquors *as mucilage* is encouraged, and its continuance is perpetuated by the carbonisation, to which the inimical practice of over-boiling hardens it.

4. *Albumen* will coagulate at 52° below the boiling heat; so that boiling partly destroys the vigour and original nature of this great principle.

5. *The phosphates and other salts*, which originally depended on the soil, though not consisting of more than a 400th part of the whole, are nevertheless worthy of consideration, being deliquescent and accommodating. From the known nature of the action of heat upon liquid salts in general, we cannot but see that they are safer when the liquor is not boiled than when it is. Their great usefulness has been clearly shewn, and yet how soon will heat remove them!

Hence the whole chemical investigation determines that much boiling impedes the solution of the starch, discolours the saccharum, and especially if done by means of a furnace, retains the mucilage in its unconverted state, hardens the albumen, and expels the salts, or irrecoverably impoverishes each of these constituents; in short, does every thing that can destroy the ingredient mass, *ex parte* or *in toto*, but nothing to restore animation or to recover flavour. Practically speaking, it tears asunder the integumental amylin and hardens it, and so far the action of heat rudely supersedes the natural operation of the diastase, which would have done its work in the mash-tun by gradual insinuation, had it been kept patiently and at a proper temperature; but this bursting of the sphericles by force, proves that some of them have escaped laceration by the diastase when in the mash-tun, or, in other words, that its power has been impeded by imprudent haste or improper heat.

The experiments of Payen and Persoz, chemists of high standing, stand already recorded in this work, as do those of other chemists, to whom may be added Thomson, who takes 10 parts of ground malt to 100 of flour, and when he wishes to realise a syrup, he keeps the temperature between 158° and 167° during three hours; but if he works to obtain dextrine, "*with as little sugar as possible*," he raises his temperature to the boiling point, which in his own words "puts an end to the action of the diastase." This proves what is most important to the brewer, that boiling disables the natural powers which otherwise would protect his gyle.

But soluble starch, being released in the copper, retains its original consistence in defiance of the effects of heat, until it is subjected to fermentation, because the violence that broke its shell, and set it free, was too high for its saccharisation, and would be so, did all other circumstances agree; but they do not, for the action of the diastase, both on the shell and on its contents, is purely chemical in the mash-tun, whereas that of boiling heat on the shell alone, is merely mechanical; and the idea, chemically considered as above, that these flakes or flocks consist of the shells of starch, some albumen, and perhaps some other portion of the gluten, is supported by their apparent increase, as boiling, the cause of their production, is continued; and we may add the evidence of their solubility in water, their extraordinary expansibility by heat, their susceptibility of fermentation, their colour, and their concomitant testimony. Their subsequent submission to the vinous fermentation proves that they possess an innate virtue, which they would have dispersed to the surrounding elements if left to pursue their natural course; and that under extreme coercion they hold together, and sturdily defy the power of boiling, till they sacrifice their vitality in the resistance which they offer to the tyrannical sway of fire; therefore boiling is injurious, and excessive boiling is irrational.

With respect to dome coppers, one London brewer, of great eminence in his profession, thinks that if worts were boiled, or more properly simmered, *in vacuo*, at 160° or 170°, similarly to the plan followed by sugar refiners, the mode would be preferable to the old system, as a means of preserving the aroma, and securing soundness; but if it could be done at so low a heat, we might thence infer that the whole secret lay in the act of ebullition, well knowing that it could not take place in an ordinary copper under a temperature of 212°; yet the air-pump and dome could be dispensed with, if nothing more than commotion were necessary; because the heat could easily be kept up at 160° or 170°, and a rouser might be used, which would act within the wort like the flies of a churn, and thus keep the whole mass in motion; but the author is fully persuaded that such an expedient would not be productive of advantage, whether manual, pecuniary, or otherwise; because temperature is the agent, and not motion, except as regards the hop; the latter being the effect, but the former the cause, which is another instance of the error, common among superficial observers, of mistaking the one for the other.

III. Improvement of the Flavour.

In the third place, which becomes a matter of course, boiling destroys the flavour of wort. There has been an object in boiling, and sometimes in long boiling, which has aimed at the reduction of a great length, in order to increase the density of the extract; but on that subject a free opinion has been expressed in Chapter V., page 154; yet will any one presume to say that this has not been done at the expense of its flavour, which is its most valuable property? By the new system of extraction by means of the Attemperator, little above half the usual quantity of original liquor is used, so that the worts are made too strong, and require dilution with water, which can be added advantageously at any period; even in the fermenting-tun, which may excite some surprise, and yet the practice is correct. Another objection will perhaps be, that the boiling also blends the whole of the soluble parts of both malt and hop into one homogeneous mass, so that the distinct flavours cannot be discerned: granted that this is done, the previous aroma must, however, be omitted, because it has evaporated! and certain parts have coagulated; and, with all due submission to those philosophists who uphold such a practice, the patentee of the Hop-convertor, invented as a substitute for that operation, or a greater part of it, boldly and positively asserts that the next,—the forthcoming process,—that of fermentation, is a thousand times more powerful in this particular than any boiling, or any other imaginable application of fire.

Worts, when in fermentation, are in constant motion, and gentle effervescence, emitting gases in a manner somewhat similar to the mechanical operation by ebullition, and the emission of the steam caused by boiling;

but here the analogy ceases, because the other effects produced by the two processes are diametrically opposite; as continued boiling, by the mere expulsion of gas, renders the worts flat; whereas fermentation imbibes one gas while it emits another or two, and is thereby kept lively and healthy. Boiling, by increasing the density, makes the worts more clammy; but the active heat of fermentation decomposes and re-arranges every vegetable principle, attenuates every particle, and reduces the specific gravity of the mass. In short, the remains of the original properties in fermented worts, are much more intimately blended with those that are newly acquired, than in such as have been boiled, as is evident from the greater difficulty that attends the analysis of the former. The author is not singular in his opinion; for that of Baverstock was published in his "*Hydrometrical Observations*" as early as 1785; and Dr. Shannon, a great advocate for *short boiling*, whose large work on brewing appeared early in the present century, says, at page 235, that the vast injury which the worts sustain by long boiling, may be avoided with convenience by short liquors and stiff mashes, because there is less to evaporate, or reduce to a standard gravity by boiling down, and consequently that less of the volatile principle of the materials will be dissipated, "to the *annoyance*" of the neighbourhood, and the brewer's loss in stock and fuel. He thought, however, that short boiling required greater rapidity, and that if a wort had boiled *an hour* when "the criterion" appeared, it might then be turned out of the copper in a few minutes; but, be it cautiously spoken, the annoyance in the atmosphere, which some esteem as *deliciousness*, would be less "if the criterion" were done away with, and never attained more. The doctor thought that boiling the wort before the hops were added, was a bad practice; therefore he recommended simmering while the first wort waited for the second. "It is from over-boiling, and under attenuation," says he, "that strong beers and ales owe their gluey rawness and glutinous fulness, that passes with some for body and strength. In the application of these rules, the abuse of over-boiling is further pointed out."

Not only to England and Ireland, but to Scotland also, has the same kind of opinion and advice extended; for the "Scottish Ale-brewer" informs us, that though various opinions prevail on the subject of boiling, he can safely assert that his countrymen generally boil for shorter periods than the English, varying from an hour to an hour and a half; but that he is no advocate for long boilings, since, if the time exceeds an hour, the coarse flavour of the hop is extracted by it, and the fine aroma, being evanescent, flies away with the vapour, and "*may be sensibly felt*" by those who approach the brewery; which evils, with others that are consequent on boiling too long, he is desirous to prevent; and he considers that the flavour of the ale depends very much on careful attention to these particulars; but, like all the others, he advocates *some* boiling as a means of extracting the aromatic flavour, and of coagulating the "gluten!" as he calls it, into flakes. One of these objects is now accomplished through the Hop-convertor, and it would be more to the brewer's interest were the other not to be mentioned.

It seems clear, then, for what purpose these advocates have advanced their arguments, while in principle they objected to the practice, which Hayman designates an "erroneous one," and contends that where the hops are put to the first strong wort, without undergoing some preparatory process, the richness of the wort clogs their pores, thereby increasing the difficulty of extraction, and consequently diminishing their preservative quality within the body of the wort; besides which, he considers that if these hops be afterwards put to small wort, its thinness unsheathes their pores, and it is made too bitter. To remedy this loss and inconvenience, he has had recourse to a contrivance of his own, approximating in its character to that of the Hop-convertor, though at a great distance as an invention. "My plan has always been to soak the hops in warm liquor, previous to their addition to the strong-beer wort, in the following manner: — Closely adjoining the mouth of my copper, I had a small back erected, called a steeping-back, into which I put my hops before I turned my second liquor over the goods. As soon as this liquor was heated to about 165 or 170 degrees, I sprinkled my hops well with it, turning them repeatedly, until every particle was thoroughly damped; and I have found this method, from experience, create a saving of one pound in ten, which needs only trial to be confirmed." Here, then, in decrying the boiling system, is a principle advanced, though by no means so searching and efficacious as the plan now pursued.

Levesque also recommends short boiling, and strongly condemns the common practice of bestowing two hours on a first wort, in "dissipating those fine qualities which it was the brewer's intention to preserve, under the idea that the beer will not keep without, which is an error in judgment." He thinks *fifteen minutes* a sufficient time for the interstices of the wort to become transparent enough to betoken the "union or combination" of the particles of the two extracts, the *farinaceous* parts of which he supposes to coagulate into flakes. Thus one imputes that to farina, which another ascribes to gluten, and a third, Wigney, assigns to *mucilage.* Enough to say, that none of them is correct in his estimate, though all repudiate long boiling as a dangerous practice, of which some of them likewise see that the expense is formidable. But here is a writer carrying out the principle of innovation, so far as to endanger the safety of his wort for only a quarter of an hour; but the question is, why endanger it at all? Had he, or any of the authors whose opinions have been cited, possessed the idea of applying the steam apparatus, and a correct system of fermentation, the patentee is almost convinced by their language that they would have abolished boiling *in toto*, as a friend in Buckinghamshire has done, who finds the plan of non-boiling so satisfactory, that he has conducted ALL his brewings on that system for some years, in very hot weather as well as cold, and is persuaded that it is a decided improvement. Common modes of conducting the fermentation undoubtedly require common boiling; but there is now an *uncommon* mode which may be relied on; and in addition to the saving of one pound in ten, suggested by Mr. Hayman's mode of sprinkling, another and still more important benefit will be found to arise from the use of the Hop-convertor, by a second saving in the wort, equal to the quantity hitherto consumed in the absorption by the hops in the hop-back, which is generally lost; for, notwithstanding that the hop-press has for many years been introduced to the trade, it has been found more prudent to waste what wort they retain, than to use the very nauseous, bitter, and often acid fluid that exudes from the vessels and tendrils, unavoidably crushed by such violent means as the screwing operation.

For the information of persons not in the trade, the author has subjoined part of a table shewing the quantity of wort imbibed by different weights of hops while boiling, and after the usual drainage in the hop-back. The correctness of this table, which was drawn up by the veteran Richardson to accompany his saccharometrical observations, has never been disputed; but, on the contrary, is universally admitted by the trade to be an admirable standard of truth. (See Roberts, p. 102; and Levesque, p. 95, who gives the quantities in quarts instead of barrels, as 10 lbs., 24 quarts; 20 lbs., 48 quarts, &c., being always half a gallon to the pound or more; and whatever be the quality or strength of the wort last brewed, or last drained through the hops, this certain quantity of wort is imbibed by them, at the rate of a barrel to every 60 lbs. consumed.)

Hops used.	Wort imbibed.	Hops used.	Wort imbibed.	Hops used.	Wort imbibed.	Hops used.	Wort imbibed.
lbs.	barrels.	lbs.	barrels.	lbs.	barrels.	lbs.	barrels.
10	0·16	15	0 24	20	0·33	70	1·16
11	0·17	16	0·26	30	0·50	80	1·33
12	0·19	17	0·27	40	0·66	90	1·50
13	0·21	18	0·29	50	0·83	100	1·66
14	0·22	19	0·31	60	1·00	200	3·33

When return worts, or beers of 16 or 18 lbs. gravity *per* barrel, are the last liquors retained, the loss is not of such great consequence as that sustained by a single brewing of strong ale; but it amounts to something worth saving in the aggregate; and though by the new system, the last worts are certainly retained, the loss is considerably less than by the practice sought to be abolished; for, under the new mode of treatment, the hops will not retain worts with such tenacity as boiled ones possess over those that are designed for conveyance from the copper to the coolers; but they merely keep the last few barrels that leave the mash-tun, and that consequently consist of the *weakest portion of the whole extract*, and which do not exceed the specific gravity of water: such is the effectiveness of the Hop-convertor; besides the great saving in coppers, coals, and labour, and the greater cleanliness which attends the operation; so that, in fact, *none* of the frightful waste by boiling, as exhibited by brewers and authors, can be sustained where the principles of these inventions are truly carried into practice.

To conclude: if the general object of boiling be to cripple the natural energy exerted in the ferment of the grain, which is the albuminous gluten, that object is undoubtedly attained in proportion to the time and hardness of the boiling. The juice of the sugar-cane is boiled immediately after its expressure for the same purpose, and its ferment is skimmed off and decomposed with molasses for rum; because the high temperature of the climate in which it is produced, would cause the juice to ferment before the process of granulation could conveniently take place. Now, the constitution of cane juice is not widely dissimilar, in many respects, to that of malt, except that the latter is much less fermentable than the other; and as long boilings have been found to injure the fermentation, there is reason to believe that the exciting cause is greatly weakened by violence in the copper; but this could not have been the original object of boiling by the brewer, or why add the same quantity, or a greater, of ferment or yeast to the boiled worts again at pitching? Surely it would have been more economical and rational to make the best use of its *inherent* fermenting principle, than to attempt its destruction for the sake of employing an inferior and perhaps acetified substitute for the same purpose.

This chapter must be considered in the main as a theoretical illustration of the subject; yet the facts here noticed will not be lost on the young practical brewer who takes a pride in his profession, can reflect, and is ambitious of excellence. The attention of the general reader is now called to the following explanatory and conclusive remarks, by which it is hoped that the foregoing will be clearly understood.

All admit that the retentive character of the hop flower requires the application of very hot fluids, accompanied by some motion to remove the *whole* of the bitter property. Every description of bitter remaining in the partly-dissolved hop may be turned to advantage, and so also may the Hop-convertor, in all breweries, by boiling the hops in the last and weakest worts as long as may be required, and at the option of the managing brewer; yet he will allow, if master of his business, that the qualities of the hop so extracted, ought to be avoided in choice and expensive fresh ales; but few men are willing to acknowledge their own errors, though it was admitted by the most practical and skilful, sixty years ago, that the only motive which a brewer could have for boiling his worts, was that of extracting the necessary virtue and flavour of the hop flower, without the rank bitter of its leaves, stalks, or styles. Though non-boiling will, no doubt, be found advantageous under proper regulations, as soon as the prejudice of old-established custom can wear away, and has been proved to be preferable in many cases named to the author, besides any enumerated herein, yet the system is applicable only where the following circumstances exist, together or separately:—

1. Where the contents of the mash-tun can be heated to any temperature by which the necessary conversion, coagulation, and filtration, can be rendered subservient to the will of the operator.

2. Where the worts can be fermented at or below 52°, as described in Chapter XIV.

With the old existing system of extraction and fermentation, a moderate boiling is necessary, especially during the summer season, if only to weaken the decaying energies of the azotised matter, so as to facilitate its separation and ultimate removal; for that which remains in the body of the beer after racking, is, from its crippled state, inimical to further change. Upon this principle we may account for the keeping qualities of some beers, from the drying which their constituents endure, other circumstances being similar, and all extremes avoided.

CHAPTER X.

COOLING.

NATURAL WAY—NECESSITY OF CAUTION—LOCALITY OF UTENSILS—SCOTCH AND ENGLISH DIFFERENCES—OPIATES—BAVARIAN MODE—ANTI-FERMENTS—PITCHING HEATS—EFFECTS OF LOW TEMPERATURE—CAUSES OF PERFECTION—ATMOSPHERE—FOX TAINT AND CREAM—WOODEN COOLERS—EFFECTS OF METALS—GALVANISED WORTS—COATED UTENSILS.

THE second part or division of the Art of Brewing, is the important process of Fermentation, to which end *Cooling* is preparatory; and much as the beverage depends for flavour and quality upon the first consolidation of the extracts, on the incorporation of the whole of the nutritious and exhilarating properties, and on the rejection of all that is nauseous, hurtful, or otherwise objectionable, the great care of all is the production and preservation of the alcohol, and the retention of those wholesome principles in conjunction with it, commonly called *body*, which give to malt liquor its great character of maintaining strength in man; thereby placing it far above all distilled liquors in the scale of utility, though not of uniform profit, as an article of commerce.

To persons who have considered the subject with any degree of attention, the author scarcely has need to advance more than he has already observed in reference to the difficulties, whether natural or artificial, which beset the brewer in every stage of his progress. Perhaps no branch of manufacture is more uncertain in the result of its operations, or is less understood in its rature as a means, and especially this most important branch, Fermentation; for though the first chemists of every age have experimented and written on the subject in common with others, a great part of the practical effects of affinity evolved by it are still enwrapped in an obscurity almost oblivious. To reveal, by means of experience, the mysteries which modern chemistry tends to illustrate, is now the main matter in pursuit; for extensive as are the improvements that have taken place in almost every branch of our productive skill, from the flimsiest fabric of the cotton loom to the magnificent hardware of the vase and the chandelier, to say nothing of the safety-lamp which protects the life of the miner, upwards to the Bude light which preserves the vision of the senator; or yet of omnigraphs, electro-magnetic machines, galvanic apparatus, photogenic drawings, electrotypes, calculating automata, daguerreotypes, electric telegraphs, and fifty things more; still the critical and sublime art of fermentation, than which nothing can require greater vigilance and care, slumbers on much the same as in the days of our ancestors, the practice and the utensils being, with but few exceptions, intrinsically the same, though ill adapted to a purpose so very delicate and intricate; for though dependent on principles purely chemical, the subject has not been thought worthy of that peculiar and popular attention which its extreme nicety demands, in order that its conditions may be well understood, and its best effects duly appreciated. A few choice spirits there are who, to use the words of a friend, may be emulous to "place the art on its proper pedestal, and appropriate to it a niche in the Temple of Science," or who may look steadily to "that great end where the brewer reaps his *golden harvest*, meaning fermentation;" but such are thinly spread, and the harvest, be it golden or brazen, is to the cultivator and not to the gleaner. A stimulus, in fact, is wanting; for notwithstanding the progress which science has been making collaterally, we are surprised that the bulk of the men who have an interest above all others, do not take care to have every particular of the art investigated and perfected, so that they might place the brewery on an equal footing with other scientific establishments, but are the last to take it in hand; and we shall be the more astonished when we consider the uniformity which is desirable in the production, the respectability and wealth of the parties generally engaged in it, their extensive and every-day practice, with the competition which increases among them as mere traders; there being now 2460 breweries, 88,465 victuallers, and 38,002 beersellers, giving a total of 128,927 licences in the whole United Kingdom, according to the returns for 1848; and the vast consumption which they produce amounts to about thirteen millions of barrels annually. No class of traders are exposed to greater risks in their dealing practice; nor are there any whose profits and losses are consequently so fluctuating.

To attempt a scientific digest of the *modus operandi* of fermentation, is an undertaking which few brewers have had the courage to attempt; and perhaps a speculation as to the primary causes is as much as can be expected here, when the extensiveness of the subject, and the limits of the field are considered; but it will be necessary to explain the rudiments and effects of the system as at present understood, and to introduce some new views and proofs, in order to convey to the mind of the reader, should he not be a chemical brewer, an explanation of the reasons which have induced the writer to alter the practice pursued in this country in fermenting ales, and in preparing them for the change which they have therein to undergo; because, where the necessary preliminary of cooling has engendered the seeds of damage, the most careful fermentation cannot restore the beverage to its pristine goodness.

Cooling should take place with the greatest caution and care, and consequently no coolers should be used except such as are best calculated to assist in the attemperation, and to maintain the proper decreasing temperature without fluctuation, and without suffering any absorption which may injure the quality or taste of the wort before the constituents commence the work of decomposition, which is incidental to their reorganisation. The cooling utensils should be placed where the surrounding medium kindly aids the gradual diminution of the acquired heat; and the position which they occupy should also facilitate the transit of the worts, and, if possible, without pumping: it should be an intermediate state of locality in the road from the Hop-convertor to that place of uniform temperature to which hereafter they ought to be consigned for the work of fermentation.

The principal champion of the Scotch method observes, that it is usual for the English to set their worts as high as 75°, or even 80°, "according to some practical writers;" but the Scotchmen seldom or never exceed 58°, and sometimes cool down to as low as 44°; and he takes the average of the high range at 65°, and that of the low at 50°; but in a cool atmosphere of 42°, he supposes them to average about 53°. And why this variance? His answer is, that different heats require corresponding differences in the time required to complete the fermenting process, and that while in Scotland the gyle is not hurried through, but may remain 21 days, the English think it slow if it remain 6 days. The English, however, are not ALL as he describes them, and the author for one; nor is it fit that they should. One brewer in the South of England recommends pitching a wort of 45 lbs. gravity *per* barrel at 45°, "if the gyle tuns are in the ground," and this is the greatest strength which he can recommend. He would pitch a 6 lbs. wort of small beer at the same temperature, only altering the quantity of the yeast, putting $3\frac{3}{4}$ lbs. to the ale wort, and only $\frac{1}{2}$ lb. to the beer. He would never exceed $47\frac{1}{2}$° under any circumstances, and would then put 3·625 lbs. or 3 lbs. 10 oz. of yeast, which he would allow to ferment till his gyle rose $22\frac{1}{2}$° or to 70° for his cleansing point. But neither the practice of the one nor of the other, in their own particular breweries, can be any criterion for the guidance of others, since the *water* alone, in many places, would baffle both in attempting to work their principles into practice, and neither the heat, the yeast, nor the time, would correspond in many breweries.

Ales pitched at 80° or 90°, as attributed by the Scotchman to English brewers in general, are of this kind: pseudo-brewers have recourse to the practice, that the produce may attain early brightness when carefully attended to; but it is never *sound;* and its opiate and stupifying influence is its chief recommendation amongst its accustomed imbibers, which characteristic is exceedingly obnoxious and injurious to strangers, whom it enervates in a manner similar to opium.

The Englishman above noticed evidently advocates the best principle which distinguishes a *rapid* system of fermentation; and in carrying that principle into operation, his time is regulated according to his means. Very different from this is the practice of the Bavarians, the deliciousness and beauty of whose beer has been noticed in Chapter VIII., p. 220. The Regen Circle, or

Vale of the Danube, in the neighbourhood of Ratisbon, near the borders of the great woodland forest of Bohemia, is the district most particularly famed for this unparalleled cordial, and there the wort, as we are informed by Liebig, and after him by Ure, in his new Supplement, "after being treated with hops in the usual manner," is put to ferment in very wide flat vessels, having thus a large surface exposed to the air, at a temperature from 45° to 50°, and in this state the fermentation is continued from three to six weeks; Ure says three to four, and that it is placed in "cool *cellars*," but Liebig calls the fermenting rooms "*chambers*." The fact is, that Ratisbon or Regensberg, and with it the plain of the Danube, north and south, from Ingoldstadt to Donaustauf, as celebrated for its ale, as the more westerly circle is for the growth of the hops which assist in its production, is situated in the form of a large natural cooler, being so well sheltered by its elevations northward and collaterally, from the frigidity of winter; and by its absorbed and flowing waters and southern screen, the Alps, from the aridity of summer; that it bears out all the characteristic features of such a climate as is physically assigned to it in Bell's Geography; allowing that gentle fermentation to prevail which the French cannot effect above ground, and which, in our domestic economy, our householders produce in their cellars, when aware that the atmosphere will overcome all their efforts in an exposed situation. Thus, verily, the professor and his tyro account for the fact that English, French, and most of the German beers, will become vinegar when the air begins to act on them; but that Bavarian will keep through any length of time without acetifying or undergoing any change. The rest of Liebig's able exposition relates to Fermentation, and will be found explained in Chapter XIII.

He however asserts, and no doubt his authority is good, that "the great influence which a rational management of fermentation exercises over the quality of beer, is well known in several of the German states;" and he instances the grand duchy of Hesse, where a large premium is offered for the production of beer brewed upon the Bavarian principle, the prize to be awarded to any competitor who can prove that his beer has lain six months in the store-vats without becoming acid. Why cannot this be done in England, the queen of barleyed nations? That sites possessing eligibility, with advantages even superior to those thus generally described as existing in Bavaria, can be found in every part of Great Britain, by a judicious availment of which, the brewer's worts may, by proper cooling and a peculiar kind of fermentation, be converted into an almost imperishable and altogether delicious beverage, abundant evidence shall hereafter attest; and this eligibility, with the practicability of the principles to the fullest extent, shall be incontrovertibly proved; but, first, a necessary preliminary must be observed.

The difficulty of conducting the brewery in warm weather has been uniformly felt, and is exactly in case here. The Scotch and American brewers forego brewing ales during the hottest month or two in the year. Roberts tells us that till lately the *fox* was hardly known in Scotland, because the brewers of strong ale brewed only in the colder months, their coppers lying silent from May to October (which, by the by, is a long while to be lazy, or to punish the poor trout either). But, he avers, some of those who brewed *inferior* ales, ventured to brew throughout the summer, and ran the risk of this insidious disease, which therefore sometimes crept into their worts.

A few of the London brewers also relax their energies, and avail themselves of the dog-days for the repair of utensils and the like. To a warm atmosphere and neglect of the vessels, may be ascribed the disease called the *foul*, in wooden casks, &c. Hence the necessity of discontinuing vessels of wood in the various processes, as far as possible, and of devising some plan which may obviate the inconvenience of suspending business, throughout the best months of the year.

Wooden Coolers. It may now be proper to point out the inconvenience always attendant on keeping in order that erroneously constructed utensil, the wooden cooler, or " very wide flat vessel," of the British brewery. The ruinous consequences of its frail nature, its extreme porosity, and its liability to contraction, render the partial but constant application and removal of lime and water indispensable. It is generally admitted that the offensive flavour arising from the foxing of the worts, and its evil influence on the vinous fermentation, can always be detected, but never remedied; and besides the injury which the ale sustains by being in contact with a substance so perishable and ever-decaying as a vegetable cooler, ulterior consequences must not be forgotten, such as loss of reputation, and desertion by the best customers, which are matters of paramount importance.

The best cure for a wooden cooler is to burn it, and to substitute another of less precarious material, which may be the means of preventing its creaming by spontaneous fermentation, caused chiefly by the reception of too much oxygen; a principle which must be denounced as a bane; for although spontaneous fermentation may succeed at a mild and constant temperature, practice tells us, that it is far better to withhold the supply of air, than to overcharge with it; because the surplus attacks the alcohol, and the consequence is, that either the acetous fermentation is encouraged and excited, or that, at least, the vinous is suspended or diverted; and the whole or some of these disasters occur in proportion to the artificial surcharge: Dr. Henry discovered this in one instance, by his failure when, in preference to barm, he infused atmospheric air by Nooth's machine.

One thing that tends, to a very considerable extent, to hasten the decay of wooden coolers, and is perhaps the principal original cause, is the latitudinal friction arising from the alternate expansion and contraction of the planks, upon the reception and impartment of heat and moisture, in which respect they more or less resemble sponge, according to their compactness, by which reciprocation of toward and untoward motion, the fibres are made alternately to recede from each other, and again to approach; thus pulverising their own albumen, and grinding away the more solid substance; increasing also, by such attrition and other motion, the decomposition of all other matters absorbed by the pores, or within the sphere of their action.

The albumen of timber lies between the fibres, and is the first to loosen and perish; that nearest the outside either floats out of its cell, or exudes therefrom, and is swept away by the cleansing broom; the breach thus formed soon becomes deeper and wider, and ultimately affords easy ingress to the vegetable moisture, until the whole plank is saturated with principles that decay with greater rapidity than the displaced albumen itself; this ligneous substance in its turn decomposes, recedes, and makes way for the reception of new matter; so that the pores of the wood are so many fermenting vessels for every stage, from the vinous to the putrefactive. These places are never full, though always filling, with the solid matter of the wort, which, through this continuous but varying decomposition, forms an accumulation of starchy, glutinous, lupuline, and albuminous admixture, ever dying, but never extinct, thus rendering the timber so spongy and leaky, that the fibre, which began to perish from contagion at the onset, gives way; and the general consumption increases daily, until the employment of the back-maker becomes inevitable. During this work of destruction, the worts are absorbed and wasted, and become so permanently impregnated with acidity, that they not only irrecoverably lose their flavour, but a poison is imparted to them by this seemingly spontaneous, though unintentionally excited, vino-acetous or acetous fermentation of the worts, which daily increases.

Again:—the contraction and expansion of the boards creates a species of pump; for when the timber imbibes heat, as it does when the hot wort is on, the pores expand, a kind of vacuum is formed, and whatever is in contact, as wort necessarily is, instantly enters by virtue of atmospheric pressure: the wort, however, directly begins to impart its caloric to the surrounding media; and as this cooling proceeds, the timber contracts, the fibres assume a more compact position, the pores close, some air, ferment, &c., issue from them, and the foxing of the worts is natural and inevitable: for

> "One touch of nature makes the whole world akin."

Indeed, in all brewing vessels constructed of wood, liable as they are to excessive changes of heat and cold, siccity and moisture, a proneness to acidity must ever be prevalent.

Mash-tuns, fermenting-vessels, and store-vats, are generally made of oak, though coolers are almost universally constructed of Dantzic deal, or of pine, which, though of more hardy growth than oak, is nevertheless more porous and perishable; and we may here name a fact that cannot have escaped the notice of all persons engaged in brewing establishments, which is, that all wooden vessels that are treated with the hottest liquor, are the most durable; such, for instance, as the hop-back, which receives the wort in nearly a boiling state; and next to it, the cooler which is built the nearest, which lasts twice as long as that which is farthest from the hop-back, because the liquor which flows over this last, is cooled in its transit from the copper and intermediate vessels. The greater preservation of certain utensils may be owing to some partial consolidation of the albumen of the wood, or to its preservation of its fibre, or both, by the great heat of the liquors, much in the same manner as the effect of the bichloride of mercury in Kyan's patent, or the sulphate of copper or iron, the pure chloride of sodium, the acetate of lead, &c., used by others. Another durable vessel in the brewery, and which is generally made of oak, except that in London some squares are of red deal, and some few tinned copper rounds exist, is the fermenting-tun, notwithstanding that the heat of the contents of these vessels seldom exceeds 80°; but this is more attributable to the spirit or alcohol of the fermenting wort, acting in a similar manner to that performed by heat on the other vessels described above. The great and novel object of the present apparatus, is the arrangement of the fermenting liquors, so as to encourage a perfect and equable fermentation of that principle which alone produces spirit and odour or flavour, which is more certainly done by avoiding contamination; and what can be more detrimental than the solution of taints that emanate from these vessels of wood? It must be clear, therefore, that the farther beer is kept from wood, the better it will keep.

These objections to wood in the construction of coolers, will also apply to it, in a minor degree, when used for gyle-tuns, barrels, &c., and especially those vessels in which the fermentation has to be conducted, or which have been otherwise subjected to the influence of change in the temperature of the atmosphere, notwithstanding all the effects of scalding, which, like a quack medicine, only alleviates present suffering, to increase the future virulence of the malady.

One great requisite of a cooler is, that it shall be a good conductor of caloric, not only by receiving it from the heated liquid, but by its speedy conveyance elsewhere; though the heaviest and least porous woods happen to be the worst conductors, as the following extracts from Meyer's tables will shew:—

Wood, compared with water.	Conducting power.	Specific gravity.	Wood, compared with water.	Conducting power.	Specific gravity.
Water	10·	1000	Oak	32·1	668
Ebony	21·7	1054	Ash	30·8	631
Apple	27·4	639	Pine	39·	408
Beech	32·6	692	Scotch Fir .	38·6	408

But these specific gravities differ a little from those given by Ure, though the ratios are much the same.

Metallic Coolers.—Richardson's experiments led him to conceive that the decrements of temperature in a given time, might be considered to mark the difference of their conducting powers, which he found to be in these proportions:—Lead 25, tin 17, iron 11, copper 10, and brass 10, which two last also contain the greatest *retentive* power; but he eventually concluded that the increments and decrements of the bodies on which he experimented, were not in the inverse ratio of their density, their hardness, their cohesion, or any ratio compounded of them. That they bear no proportion to their specific gravity, is clear on comparing them with

Ure's tables, which give lead specific gravity 11,350, tin 7,291, cast iron 7,248, copper 8,900, and brass 8,000.

Another great objection to metallic coolers, especially those containing sheet zinc, lead, or other thin rolled metal, is, that though smooth and clean at first, they soon become wrinkled and rough and present ridges, dents, blisters, and furrows, all caused by their repeated expansion and contraction; for when these metals are exposed to hot liquors from 150° to 200° or so, their contraction at cooling is never equal to their former expansion, and they gradually lose their contractile powers; and the longer they are exposed, the higher those hillocks become, until at last the expansive and contractive power is altogether lost, the surface is rendered uneven, and the wear on the projections makes them thin, till they untimely crack in those thin places, and the unevenness is again increased by the repairing solder; and besides, such metals are backed by a non-conducting substance, so that they imbibe the heat only to return it to the wort again, as it cools by evaporation. All these metals have the character of "very good conductors of heat and electricity;" so that they are great absorbents and famous agitators, but bad coolers. Cast-iron might perhaps answer better, had it not a strong predisposition to rust; though we must admit that great progress has of late years been made in the purification of that metal, through the agency of smelting furnaces. For instance, a metropolitan brewer, who erected some iron fermenting squares in 1833, was obliged to take them down again; and yet the author, in walking through one of the large London breweries in 1842, was particularly struck with the elegance of a large range of new iron coolers. Iron, however, has a great affinity for oxygen, and is a conductor of electricity in the highest degree, the pure metal being no where found in its raw state, except in masses supposed to be of meteoric origin. In short, making all allowances for the progress of art, the general intrinsic character of metals at large, militates against them as utensils to be employed in a brewery; for their relation to oxygen is accounted the most interesting quality, though it is general to all metals; but the brewer cannot afford those contaminations to which his worts must become subject when in contact with them, and particularly in fermenting vessels.

That the interior of all cast-iron vessels which contain hot saccharine liquors, and the cast portions of the mashing machines, perforated bottoms, coolers, and other utensils brought into contact with those fluids, gradually become black, smooth, and hard, is a remarkable coincidence, too important to pass unnoticed. In reality, the iron is thereby case-hardened, that is, its exterior is converted into a peculiar chalybeate substance resembling plumbago, disinclining it from oxidation; whence a conclusion may be surmised, that the metal absorbs the carbon of the sugar, or exchanges a portion of its oxygen for such carbonic accession. The hardness increases in depth and strength as long as the cause continues, and it is not afterwards so prone to oxidate as common steel. This singular property is but slightly acquired by wrought iron, nor by any other vessel in the brewery than those that are repeatedly in touch as aforesaid. Prior to this converting process, however, and for a little while at its commencement, the wort in juxtaposition suffers in respect to colour and soundness; but of course this twofold deterioration is not so perceptible in porter and very strong ales, as in a light, pale article.

From these observations, the author has been induced to recommend cast-iron to the trade, for the purposes here named, with the precaution, when it is to be used naked, to have each segment well boiled in a dense saccharine liquid, some ten or twelve hours, before the pieces are bolted together. If they were alternately boiled and cooled at intervals of an hour between each immersion and removal, the result would probably induce a preference to that plan. This having been done, no danger of rust or troublesome oxidation can arise, provided the vessels are appropriately used, *kept dry*, and not misapplied after they have been used. For instance, a cooler thus prepared should be merely swept down or rubbed, but not washed with cold water until a few minutes before "turning out:" that is, in untechnical language, not before the time has nearly approached for laying on the succeeding, or first wort, to cool.

Further experience also convinces those who have rightly tested the principle, that zinc, when alone and properly applied, is as harmless as copper; and that cast-iron, covered with this metal in a molten state, is an excellent and a cleanly substitute for wood, in all brewers' vessels situated above the fermenting vessels. The experiment has succeeded wonderfully in cast-iron mash-tuns, mashing machines, perforated bottoms, coolers, and minor utensils.

According to the usual practice of the old school, the worts cooled gradually by the winds are suffered to lie from *seven* to *nine* hours, except in very cold weather; and in that time they imbibe a vast quantity of atmospheric air in an undecomposed state, from which they abstract oxygen as the after-process goes on. Men thought formerly that a greater duration of time would cause a greater *expulsion* of an unknown something, which they conceived to be inimical, not being aware that the reverse doctrine of absorption was impregnating the wort with evil all the while. It is also probable, that in most cases when rapid cooling began to be practised by artificial means, the operators pitched at the same low temperature as before, and boiled longer to make up for the deficient evaporation on account of the speedy refrigeration, thereby causing disappointment through a slow and languid fermentation, especially in strong worts, after the attenuation was two-thirds or three-fourths completed, instead of attributing it to the absence of the theretofore wonted quantity of air, and without seeing the necessity of a higher pitching heat, or a little more patience, under the altered circumstances; while another class of objectors ascribed their imperfect fermentations to some galvanic action of the metals of which the cooling instrument was made. This suspicion may not be unfounded, particularly where sulphuric or muriatic acids abound in the water; or where zinc, by forming *a part* of the cooling machine, becomes injurious.

Metals having different conducting powers, the selection of those that are the most suitable in that respect, has induced many to prefer copper; and in numerous instances a thin substance has been chosen before one more substantial, particularly as a *refrigerating* medium, from an impression that the lighter its fabric, the more rapidly it would receive and carry off the heat; but experiment will soon convince that caloric is transmitted through very strong plates as readily as the cold water can absorb it; therefore the cooling process is not at all accelerated by using dangerously thin metal; and such should accordingly be avoided, because the want of substantiality prevents its being durable, and thereby increases expense in the wear of the utensils, without affording any advantage to compensate for it.

CHAPTER XI.

REFRIGERATION.

THE BOILING POINT—THEOREMS—BRITISH TEMPERATURE—THERMOMETRIC SCALES—REMARKS ON CLIMATE—FANS AND PIPES—REQUISITE PROPERTIES—THE CATHARINE REFRIGERATOR.

PRESUMING that the brewer has now embraced the best mode of cooling wort, as far as the natural process enables him, his next consideration is to find the best access that can be had to artificial assistance when the natural means fail, which, in a country like the British islands, affected by great changes of temperature, will frequently happen, and sometimes when least expected.

A gradual and steady reduction of temperature in the worts while upon the coolers, as the practice has been conducted, has always been advisable when it could be done within the limits of security, or in about *four* hours; but after this period, more speedy means of refrigeration have usually been sought. The majority of brewers now advocate rapid cooling, and they that have refrigerators use them directly after the worts reach the coolers; though when these instruments were first introduced, several abandoned them, from an opinion that they produced mischief.

Some practical hands wish to retain the worts simply as they are cooled by nature, deferring the use of a refrigerating machine till the issuing vapour has begun to disappear above them, notwithstanding that this subsidence is regulated more by the state of the atmosphere than by the heat of the worts, so that the criterion is good only in warm weather. It is then seldom visible after the extract has cooled down to 95°, whereas at other times, and especially in the winter season, when refrigerators are not needed, it is perceptible 20° or 30° lower; and hence no fixed rule can be introduced to regulate a temperature indicated by an appearance at once so uncertain and deceptive. It would be much safer to use the refrigerator according to sound thermometrical rules, and to introduce it at a certain statutory degree of heat. Where plenty of spring water can be had, the use of a long range of wide coolers may be economised; but where this essential is scarce, one cooler at least is necessary to assist in the economy of water. On the other hand, nearly all the modern breweries erected by skilful men, are provided with steam pipes to warm the tun-rooms in winter, and their fermenting vessels are lined with tinned copper tubing, supported on brackets, at 12 or 18 inches from the sides, through which pipes they pass hot or cold water at pleasure. Light portable attemperators are now preferred by many for their comparative cheapness, and for the facility with which they may be lowered to the bottom, or brought to affect any part of the gyle, as occasion may require; when, for instance, cold water is run through them, they will be near the surface of the fermenting wort, but when hot is used, they will lie near the bottom. This contrivance is most valuable in winter, though it still leaves its approvers at a loss in summer, the pipes being seldom sufficiently effective, particularly in large establishments, to reduce the heat in due time: with all his advantages, then, the brewer who cools above ground, can never compete with the subterrane artist, because of the hot air absorbed by the worts of the former in the summer brewings.

A great deal, therefore, depends upon the state of the atmosphere, and its consequent pressure, which affects even the boiling point. "The grand secret of the Munich brewers," says Dr. Ure, "is to conduct the fermentation of the wort at too low a temperature to permit of the acetification of the alcohol;" and it happens there, as in England, that "it is only in March and October that the good store beer is begun to be made in Bavaria." In Griffith's lectures, published at page 30 of the "Forceps," he observes, that though 212° by Fahrenheit is considered to be the boiling point of water, other circumstances must be considered in connexion with it; for at Geneva, which is 1200 feet above the level of the sea, and where the atmospheric pressure is accordingly less, it becomes ebullient at 209°; and at Quito, 10,000 feet above the sea, it will boil at 194°; and if a vessel of water of 178° temperature be placed under the receiver of an air-pump, and the receiver be immediately exhausted, that water will then boil; the pressure at which this would take place, as indicated by the barometer, being equal to half the ordinary weight of the air, or 7½ lbs. to the square inch. Munich, the capital of Bavaria, stands upon a plain 1920 feet above the level of the sea, and consequently water will there boil at about 207°, the diminution being about one degree in each 400 feet of elevation in the lower altitudes, and one in 600 on rising higher; and if such is the variation in boiling heat, a like change will also influence liquids heated only in part.

One of our English writers, like the Bavarians, depends more upon October brewings for future quality, than upon any other, because he says, that as the cold then gradually comes on, a too rapid fermentation is thereby prevented, which enables the attenuated beer better to withstand the heat of the following summer; but this rule cannot apply to March brewings, because the weather is then becoming warmer. The same author, who recommends that all brewings intended for keeping should be made before the close of the year, thinks that beers for present use may be brewed at all other seasons except in June, July, and August; but he is wrong in this exception, and a good refrigerator will soon widen his error. This old-established but fallacious notion will explode on reasoning over the following facts, deduced from the state of the thermometer kept at the Royal Military College at Sandhurst, in latitude 51° 20′, and which were expressly computed for this work from the Gentleman's Diary for 1812 to 1836, inclusively.

1. Some of the days in February, 1816, were only $\frac{1}{7}$th of the mean temperature of 1819, and not so high a fraction of that of 1818.

2. In 1821, the mean temperature of October was higher than that of June by 4°; and the thermometer was 12° lower in the summer than in the winter month, and on three of its days by 25°; also the 15th of November was 20° hotter than the longest day.

3. The year 1817 presents a contrast to 1821, inasmuch as the thermometer sank in October as low as 35°; whereas in June it was up at 72°, being an excess more than double.

4. The 12th of October, 1819, was hotter than the first of the corresponding month of 1817 by 43°, being 8° above double; and October, 1818, was 33° above the same October *minimum* of 1817, and 34° above that of 1829. The 1st of October, 1831, was hotter than the 8th in 1829 by 28°, and 18° hotter than the 7th of June; and the 20th of October, 1829, was 20° higher

than the 8th of the same month. In 1822, the last day of October was 10° higher than the last day of June; but in October, 1831, the average temperature for two whole days was 6° below the freezing point.

5. In July and August, 1835, were forty-four days in which the temperature varied between 60° and 71°, being an average of 30° above the latter end of October; but in 1831, five of the October days were hotter by 10° than the 7th of July.

6. The 15th of January, 1818, and several days in January, 1819, though 46° higher than the 9th of February, 1816, were not so hot as the 12th of October, 1819, by 24°; which day averaged nearly ten times the positive heat of the said 9th of February.

7. The heat in 1818 and 1820 was greater by about 20° than in any part of the years 1813, 15, 27, 28, 29, 33, or 35; and the heat on the 9th of May, 1819, exceeded that of any part of 1813, 15, 16, 17, 27, 28, 29, 30, 31, 33, or 35; and the preceding day, May 8th, was colder than the 9th, but was equal to the highest temperature in 1817 or 31, and these were higher than the other years here named.

8. The 18th of September, 1822, was hotter than any day in the above-named eleven years, or in 1812, 14, 23, 26, 34, or 36; being 79°, which none of those years ever reached.

9. October 8, 1829, came within 2°, and October, 1828, within 3° of the freezing point; in 1836, the 29th of October was 2° below the point, and the 13th and 31st were 6° below freezing; but in 1830, the anniversary of the battle of Trafalgar, (Oct. 21st), was hotter than that of Waterloo, (June 18th), by 9°, though on the whole, June was warmer than October by a mean rate of 6°.

10. Lastly, the heat in this country is not so high in

some summers as in others by 20°, nor so low in some winters as in others by 30°.

The subjoined remarkable observations were made by the author on his own thermometers at the Nine Elms brewery, near Vauxhall, in June, 1842 and 1843, and very clearly shew the precariousness of seasons in England; the situations of the two instruments, and the times of observation being the same:

Year.	June 12.		June 13.	
	Sun.	Shade.	Sun.	Shade.
1842	120½°	84°	110°	79°
1843	82½°	59°	56°	53°
Difference ..	38°	25°	54°	26°

The following is more recent and still more remarkable: on the morning of the longest day of 1844, many ponds of water, in the eastern parts of England, were covered with ice; but on the morning of the shortest day, the thermometer stood at 50°, or at least 28° higher than on the longest.

If these variations are not sufficient to perplex any man who is obliged to work in the middle of them, he must have a remarkably comprehensive understanding; but to complain of them is not to remove the cause of complaint, nor yet to remedy the evil effects produced. In reference to these heats, and to all others herein named, the reader must know that unless something is specified to the contrary, they are all taken according to Fahrenheit's scale; and it may be useful to some that a few words be said upon the principles adopted by others, when put in comparison with this standard.

Thermometry. Know, then, for the information of persons unacquainted with the history of the Thermometer, and for the prevention of any mistakes in the application of instruments differently graduated; that the invention, or rather the improvement made on former instruments, by Daniel Gabriel Fahrenheit, a philosopher from Dantzic, resident at Amsterdam, is generally used in Holland, Britain, and North America; that of Reaumur, or Roëmer, another celebrated philosopher of Dantzic, before Fahrenheit's time, was the only one used in France prior to the Revolution, and is still employed in Spain and other southern European nations; but the French under Buonaparte adopted the scale introduced by Celsius, professor of philosophy at Upsal, in Sweden, called the *centigrade* regulation, which is now general in France, the French dependencies, and most of the countries of middle and northern Europe. Their difference is, that Fahrenheit fixed his *zero* or *nothing* at the most frigid point which had been observed in Iceland, being 32° below the *zero* of Amontons, adopted by Reaumur, which is the point of temperature where water begins to freeze, or above which ice melts, which is also the *zero* of Celsius; but 4° on Fahrenheit's scale are equal to 9° on Reaumur's, and 5° of Fahrenheit's to 9° of the centigrade; so that for the conversion or reconversion of Fahrenheit, or the English thermometer, to or from either of the others, these theorems must be used:

$$F=\frac{9C}{5}+32=\frac{9R}{4}+32;\ \text{and conversely, } C=\frac{5(F-32)}{9},\ \text{and } R=\frac{4(F-32)}{9};$$

and hence the boiling point of water, which is 180° above the freezing point, according to Fahrenheit, is at 100° of the centigrade, whence its name, and at 80° on Reaumur's scale. This is the reason why English authors do not commonly speak of *the thermometer* in their productions, but of F., or Fahrenheit's scale, as the species of thermometric index which they employ.

The temperature of our fermentations has hitherto been either above or below that of the air, which varies as much as 60° or 80° F. within the course of a year; therefore such workings, even where artificial means are employed, are affected more or less by the changes that have been described; and their productions vary in flavour and virtue, as much according to the changeable gradations of the external influence, as to the internal constitution of the worts themselves. Thus, by the common hurrying and uncertain process of fermenting malt liquors, the heat is seldom so low as 58°, and often ranges to 80°, while at the same time the atmospheric temperature may decrease from 80° to 50°, or perhaps from 50° to 20°, so uncertain are the changes of weather! From these excessive variations, for which no efficient provision has been made, and from the coercive force exerted over the worts to prevent the consequences of a diminution of temperature, but which sometimes has the opposite effect when a sudden increase of heat unexpectedly takes place in the atmosphere, arise many of those hyperbolical vicissitudes to which the worts in their fermentation are liable, and which they assuredly suffer, to the great destruction of the alcoholic principle; for it often happens that when the process is over, a large quantity of gluten and gum remain undissolved in the ale. Liebig tells us that free oxygen and gluten are the *conditions* on which alcohol becomes acetic acid, because they determine its eremacausis; but that the capability of exerting their influence does not obtain at low temperatures; hence, then, the necessity of artificial cooling where a fixed temperature is requisite, and the natural course fails through conflicting causes.

Dr. Shaw's view of decomposition, which is beautifully philosophical, will very aptly apply here: "The intention or tendency of nature is to proceed from the very beginning of vinous fermentation, directly in one continued series to putrefaction, and thence again to a new generation; which appears to be the grand circle wherein all natural things are moved, and all the physical or rather chemical phenomena of the globe are produced." The brewer does not wish, however, to avail himself of this whole circle of change, but to secure the advantages of the first ascendant quadrant, and then to allay the decremental motion in his fluids at a certain *punctum summum*, or highest beneficial attainment, before the second sets in; by which means he hopes to preserve his alcohol and a portion of his sweet, which properties, if duly secured by a process as nearly allied to nature as possible, furnish spirituosity, flavour, and briskness; for if he would act as a physician, he must understand the kind and cause of the disease, lest he should mistake the character of the balsam which he intends to apply. Is it the Bavarian, or is it his atmosphere, that makes him more expert than we? The question is one that needs solution.

Ratisbon stands in latitude 49° 2′ N., and in longitude 12° 5′ E. from London; so that, in point of geographical temperature, as connected with its distance from the equator, it cannot differ much from London, the latitude of which is 51° 31′ N.; but Munich presents a contrast to this, though situate in latitude 48° 55′ N., or only 7′ nearer the equator, being much elevated, as we have seen, and is nearer to the large lakes and northern declivities of the Alps, and is therefore subject to greater changes of temperature. Hence, notwithstanding the encomia bestowed on the Munichians by Ure, he confesses thus: "In my several journeys into Germany, I have met with much spurious or ill-made Bavarian beer. The best contains, when brought to England, a little acid, but no perceptible gluten on the addition of ammonia in excess." And moreover, "the brewers of Hessia and Prussia, who wished to *make* Bavarian beer, found it more to their interest to send for the article from *Wurtzburg* or *Bamberg*, in Bavaria, than to prepare it themselves." (Mech. Mag. vol. xli., p. 471-2.) Not from Munich.

But, say they who are unwilling to improve for fear of the trouble it might happen to cause, we have neither Alps nor Andes in England, nor shall we go to the city of Quito to look for a brewery or a brewing site. True; neither have we Hungarian plains or Libyan deserts, nor can we travel here as Buonaparte marched with his army, as far as from Paris to Moscow, and scarcely see a hill all the way; but this is the grand question. We have thousands of hills and dales with gentle declivities, and hundreds of Alpine precipices in miniature; and above all things, this exceedingly variable and uncertain climate; and we have every reason to believe that the least level districts of England are the most noted for native beer; for we are accustomed to work upon larger mashes than they who inhabit those extensive territories have ever seen, and to whom the intrinsic value of British beverage is neither known nor understood; therefore it is that the author adopts the language of the Mantuan shepherd, saying:

"*Sic parvis componere magna solebam.*"

Who is there that has not read of, and perhaps seen, Ben Nevis, Ben Lomond, the Middletons, the Ochies, Fanna, and Blackhall? Helvellyn and Skiddaw, the Peak and the Peak beyond, the Cotswolds, the Mendips, Longmynd and Stiperstones, the Wrekin, the

Clees, and Malvern? Snowdon Wyddffa, Plinlimmon, Cader Idris, Cader Frewyn, Arran Fowddy, and the Cradle? The Carberries, Iveragh, Derryveach, Slieu Bloraers, and Slieu Denard? Valleys and caves abound on the banks of the Clyde and the Findhorn; at Clifton, in Somersetshire, on the Avon; and at Iron-bridge and Bridgnorth, in Shropshire, on the Severn; all rocks with rivers flowing through ravines deep between. Need we tell of Fingal's Cave, the Giant's Causeway, or the romantic scenery in North and South Wales, Cornwall, Derbyshire, or among the Westmerian and Cumbrian lakes, or under the edge of Ingleborough and "Stainmore's wintry waste?" In Devon, Dorset, Hants, and many places round the southern, and indeed all the other coasts (for all are hilly), sites so eligible might be chosen for our business, that much artificial refrigeration could scarcely be needed, unless the brewings were very large. The defiles through which the Severn runs, are in many places peculiarly suited to the purpose, from the facility of exportation afforded by the navigable river, and from the proximity of all essentials requisite to carry on the trade, such as hop-gardens, coal-mines, good water, and the best of barley; in short, nothing can be wanting to make such a district outvie Bavaria in all respects; besides which, England is now almost every where supplied with canals and railways. If, then, Burton and Edinburgh derive a good menstruum from the neighbouring hills, and afford facilities for its conversion and transport to all parts of the world, why not other places likewise? But the brewer has not yet arrived at that stage in his progress and practice, which will require him to examine subterraneous places; not having disposed of all the interruptions which annoy him in the cooling department, and which are principally contained under four heads, namely, severe boiling, a hot or variable atmosphere, the influence of climate, and the bad selection of utensils. The philosophy of climate shews to him the uncertainty of atmospheric action where it varies so exceedingly as in England, under all the influences of

1. Sun;	4. Aspect;	7. Cultivation;
2. Elevation;	5. Mountains;	8. Wind; and
3. Sea;	6. Soil;	9. Time of year;

and points out to him the eligibility of certain localities in producing coolness, but excluding cold; determining the situations in which the desirable medium of temperature can be obtained with the least trouble and expense, his business here being not merely to cool, but to cool properly, so that ultimate perfection may follow the attenuating process. Of these nine influences more might be said, if want of space did not urge the compression of the subject, to make room for observations which are more directly practical; therefore to be brief:—

1. The Sun.—The influence of this great luminary over physical climate and season, must be universally acknowledged, and the cessation of labour in the brewery during the hot months, affords proof of it. We read that in a part of Norway, at so high a latitude as 70°, the thermometer has been known to rise to 80° F., because the sun is a great while above the horizon; but that such heat is not generated in the dingles surrounding the Dofrafeld. In like manner in Bavaria, his horizontal rising and setting are prevented by the interposition of mountains; as in Great Britain, in the vicinity of Ben Lomond, and several others of the mountains named above, with many more, particularly those called pikes, near which, at certain seasons and in cer-

tain places, he rises or sets twice or oftener every day. Bouguer shews that the sun's rays have the greatest power when they act perpendicularly upon the earth's surface; and that when near the horizon, they merely glance along the ground, and many are absorbed and dispersed by the lower stratum of atmospheric media in which their passage lies; and that of 10,000 rays which fall on the earth's atmosphere, 8123 arrive at a given place if they fall perpendicularly, 7024 if the angle of direction is 50°, 2831 if but 7°, and only 5 if they come horizontally. This applies to Bavaria, where the meridian heat falls almost perpendicularly on the sloping hills, leaving the valleys cool; and where the evening and morning tangential rays are reflected from the points of their contact, and absorbed by the cooling waters. This precisely accords with our lake districts, as Loch Lomond, Ullswater, Coniston, and Winander Meres, Llyn Ceigin, Llyn Beris, and others, and with many snug creeks on our coasts, all noted for good home-brewed beverage.

2. Elevation.—The reason of this influence has become quite apparent since the discovery of isothermal lines, or distances of ascent to give equal heat, dependent on the quantity of level land, or of water covering the earth's surface, which causes the range of superficial heat to be regulated, in a secondary sense, by its distance from the shore. For instance, the curve of congelation formed by the position of the freezing point, which is every where said to be at 32° F. (though not correctly, as in the case of the boiling point, noticed at page 287), is said to touch the earth at the poles, but to be 3818 feet above the sea in latitude 60°, 6334 feet in 50°, 9001 in 40°, and 15,207 feet at the equator, taking the atmosphere at a mean temperature in each place. In the neighbourhood of Birmingham, or in latitude

$52\frac{1}{2}°$, if no local causes affected it, this curve of congelation would be at an altitude of 5705 feet; but there are days on which the thermometer, in exposed situations in that latitude, falls as low as 7°, or 25° below the said freezing point; whereas on other days it rises to nearly 90°, as has been shewn, which is higher than the mean temperature at the equatorial level; but these excesses do not appear to happen in the Bavarian brewing circle and season, whereas Englishmen like to be doing throughout the year.

3. The Sea—or continental position with respect to it.—This consideration is greatly in favour of the British climate, giving to certain localities a temperature deviating materially from the isothermal line. According to the researches of the great Humboldt, in the Hungarian interior of Europe, between 44° and 50° of latitude, where there is an extensive plain of 20,000 square miles, round which numbers of mountains rise from 5000 to 10,000 feet in altitude, the mean temperature for August is 76·6°; but at Dublin, and other places on the coast of Ireland, from 53° to 56° of latitude, it is 60·8°; yet in Hungary snow falls as early as September, and lies till June; and Ireland is remarkable for mild winters and green hills; and in Scotland, at Edinburgh, in latitude 56°, the winters are said to be as mild as those of Milan, in latitude $45\frac{1}{2}°$; and though the elevated terraces of land which lie along the Carpathians are accounted healthy, yet Hungary is termed "the grave of the Germans," from its inordinate and variable temperature; and Dublin and Edinburgh brew famous malt beverage, but Hungary does not.

4. Aspect.—The point towards which the country slopes, has a great influence on climate, of which the Bavarian northern inclination is a striking example; and "in the Vallais in Switzerland, the Alps are on the

one side covered with ice, while vineyards and orchards flourish on the other." (Phys. Geog., p. 35, Society's Treatise.) The climate of the vale of Kendal, which stretches to the sea on one side, and is screened from the northern blast by the snow-clad hills of Westmorland on the other, is more temperate and steady than that of London, with all her fires and tepifying inventions; and we seldom hear of good, bright, fresh ale in a flat and open country, like the Wiltshire Downs, or the fine luxuriant cider counties of Somerset, Gloucester, Devon, and Hereford, or in the plains round Leicester, Manchester, the Fens, or Dereham, unless imported or brewed by a more than ordinarily skilful workman; but Kendal ale has a high name.

5. Mountains.—It has already been shewn that acclivities affect climate in various important ways; in addition to which it may be useful to observe, that they attract the vapours of the atmosphere, condense them, and give rise to rain, which descends upon the valleys near their feet; and in the vicinity of lofty ranges is often violent; though in England this cannot happen to any very detrimental extent, but frequently, in dry seasons, is a local benefit; and they afford shelter from winds, which in our climate is a protection where the aspect is to the south-west especially. Much also depends upon the direction in which the chains run; for in narrow valleys, the sides of which reflect the sun's rays strongly in summer, the shelter from the breeze is injurious; but it is from this attraction of vapours, says Hogarth in the Physical Geography, that the chain of the Alps, running east and west, as many of our British ranges do, gives salubrity and fertility to the climate and soil of Italy.

The quantity of rain which falls in London annually, notwithstanding the fogs and damps which infest the place, is from 23 to 24 inches; and according to an elaborate investigation of the table of returns of the state of the thermometer at Sandhurst, on every day during 25 years, and before quoted, the mean temperature of the atmosphere is $51\frac{1}{2}°$ in $51\frac{1}{2}°$ of latitude; and it may seem strange that at Pekin, which has nearly the same mean temperature as Britain, the summer heat is greater than at Cairo, and the winter cold and severe as at Upsal, in latitude 60°; but Sweden is a mountainous and China an open country, and "rain is a very uncommon phenomenon in Egypt," as we have been taught from our school geography. At Kendal, under the southern prow of the Westmorland fells, in latitude $54\frac{1}{4}°$, the quantity of rain is 60 inches in a year; and at Liverpool, latitude $53\frac{1}{2}°$, the collection is 34 inches; yet Liverpool, like Kendal, from being situate near the coast, is fully as mild as London in winter, and much less arid in summer, when the more opulent residents of the south retire to those milder districts to recruit their health, vigour, and appetite. From this cause also, we may account for the length and coolness of the Alpine summer, and the oppressive heat of the Hungarian deserts, where good ales could not be brewed.

6. Soil.—On this subject, much has been said in our third chapter; and we may here add that its nature greatly affects climate. "One soil acquires heat, keeps it, when acquired, much longer, or reflects it more readily than another One which, from its porous character, allows the rain descending upon it to pass freely into the earth, will emit much fewer exhalations than one which retains the waters near the surface. Thus clayey or marshy grounds lower the temperature, and, especially in hot and humid climates, affect the atmosphere in a manner pernicious to health; on the other hand, those which are light, stony, or calcareous, tend to make the

atmosphere salubrious." (Phys. Geog., p. 36.) Now the Alpine apices are formed of granite; Bavaria is stony, and the plains of Hungary are sandy. Here again Kendal has a great advantage; for Kendal fell is a limestone rock, of a quality so pure, that portions of it have been converted into harmonical ranges, which, on being struck with a hard instrument, such as the mace of a dulcimer, form peals of the sweetest bell-music; and the soil which covers the limestone bed in the lower lands within a few miles of the town, produces some of the best barley in the world. But Kendal is not alone: look at Burton and its "plaster of Paris" soil; and at Dorchester and the chalk hills many miles thence, as far as Bedfordshire; at Much Wenlock and its Franchise; at Buxton and Poole's Cave, the Peak, &c.; at Roseberry Topping in Yorkshire; at the natural walls of Nottingham; or at any of the hilly districts of England, Scotland, Wales, or Ireland, which are not too fully stored with metals; and there we may find brewing sites in abundance, fit for carrying on the business wholesomely, safely, effectively, and profitably, without recourse to extraordinary refrigeration.

7. Cultivation. — The degree of improvement to which a country has been brought, is of material consequence: this may be very largely exemplified by the well-known fact, that the progress of agriculture has very greatly diminished the rigour of the American climate both in Canada and the inner United States. The slovenliness of the Bavarians, and the growth of their forests, help to keep the country cool; but though the proverbial industry of the British may tend to increase the brewer's perplexities, he can now avail himself of the recesses which afford channels for the mountain streams, and there harbour, like a fox, upon a large

scale, keeping himself warm in winter and cool in summer, and being profitably employed all the while.

8. Winds.—Such is the power of wind, that in Siberia, as far south as the 58th degree of latitude, M. Pallas found the temperature of the air to be at the freezing point of mercury, which is at 39° or 40° below *zero;* and at Melville Island, where Captain Parry wintered in 1820, the thermometer sank to 55° below *zero;* though the Norwegians of Attenguard, under the 70th parallel, "contrive to raise corn" in their valleys, where sheltered oats and barley vegetate at an elevation of from 1500 to 1800 feet; and in some parts of that region the corn is sown and reaped within the course of seven weeks; the extreme rigour on one hand being attributed to the constant prevalence of wind in one direction, and the extraordinary growth of corn in the other, to its total absence. It is also in the absence of wind, that in New South Wales the thermometer rises to 110°, and at Pekin to that or 115°; but in Africa, the continual current of a *hot wind* raises the temperature to 125°, as noticed by Major Denham at Balbeis. These excesses, it is true, do not take place in Britain; though here, as in all other countries, the temperature varies according to the quantity of wind that prevails; and though a good breeze may be thought serviceable to the brewer in summer, especially if his coolers are lofty and open, yet as he never knows how strongly it will blow, or from what quarter it will come, other means of refrigeration are preferable. Wind is not uncommonly accompanied by rain; though by a proper regulation of the louvres in favourable seasons, he may admit the one and exclude the other.

9. The Time of the Year.—The observations that have been made under the heads of *sun*, *aspect*, *moun-*

tains, and *soil*, very greatly affect this remaining influence; and the information given from the Gentleman's Diary and elsewhere, might lead some readers to infer that the difference between one season and another, was more a matter of chance than of actual disparity; but after all, there will be a winter and a summer to every year, the one very cold at times, and the other very often unendurably hot; and though some of the influences have a tendency to ameliorate towards a greater equality in certain places, the annoyance of a variable atmosphere will continue more or less in all; therefore as all are quite insufficient, together with a better selection of utensils, to secure any thing like uniformity in the pitching heat and fermentation of the worts, recourse must be had to such additional artificial auxiliary means, as the skill of the human mind can invent, care being taken to give preference to the best.

Cold water appears to be the best agent when properly managed, and ought to be the most easily available; and most of the prejudice that can exist against refrigerators in general, must arise from the ignorance of persons who either misapply them, or have not chosen the most efficient and suitable; or perhaps from the obstinacy of persons who use fans, merely because they have them, and are unwilling to go to any additional expense in acquiring improvement. Worts cooled by fans cannot be brought down to so low a heat, or yet so expeditiously, as by a good refrigerator, whose foundation is running water, and whose supply is copious and perpetual.

As winds and electricity often affect the vinous fermentation of malt liquors, the former by retarding and the latter by hastening them; and as in like manner they frequently injure the mash, as the worts undergo chemical decomposition and natural change, under the two excitements of saccharine transmutation and alcoholic conversion, which render them very susceptible of atmospheric contamination; so in the cooling process they must also have their share of natural action and influence, though the condensing worts conduce less to aid the affinity, the action on the coolers being more mechanical than when decomposing.

A good machine is undoubtedly an invaluable acquisition, and the great variety of Refrigerators which the ingenuity of man has introduced to the market, affords ample scope for choice in the selection. This is a delicate point in the process; and under circumstances such as occur, a wide difference is usually perceptible between summer brewed ales and such as are produced in cold seasons, if not brought about gradually; the best samples of the former being spirituous and light, but those of the latter full and rich, inferior qualities being less so, from the prevalence of electricity in the one case, and of wind and cold in the other.

Necessary Qualities of a Refrigerator.

1. *It should be composed wholly of tinned copper, or of as few and as tasteless metals as possible, every part being tinned on all sides to prevent contagion.*

2. *It should be so constructed as to be perfectly suited to the locality assigned to it, and so as to facilitate the radiation and absorption of caloric, by exposing the greatest surface of wort to the cooling medium, that can be done consistently with size and expedition;* and

3. *Its construction must be such as to afford easy access to the wort and water chambers, when they require cleaning.*

The attemperating application of a Refrigerator, where copious supplies of water are always at hand, is of inestimable service in a hot summer; for though constant and thorough agitation with fans, winds, ploughs, and the like contrivances, may sometimes prevent the tangible appearance of a spontaneous fermentation in the coolers, and may render its effects less evident by driving the foam and mouldy spots from the surface as they rise, yet they present no guarantee against the engenderment of the calamity; but, on the contrary, it appears reasonable, if we admit analogy, that by the numerous and gaping ripples and undulations which these implements cause, an enlarged and continuously new and changeable surface is exposed, as a temptation to the insinuating gases of the atmosphere. Different from this are the action and effect produced by a properly constructed Refrigerator.

Notwithstanding the importance of the above requisites, we have never had an implement really possessing them, and more especially the last, in any degree approaching to perfection. That most of them may be kept tolerably clean on the outside may be admitted; and that the wort passages in some of them can be partly cleaned within, is not to be denied; but their water compartments being invariably soldered up, or so closed otherwise as to require the occasional skill of the constructor, or of some other ingenious artificer, to open the machine for purification, and afterwards to reinstate the parts; much expense is thereby occasioned, and not a little delay, besides the rapid destruction of the instrument; because the hard crust which has arisen through a long accumulation of petrific particles, cannot be removed without force; whereas, if the passages had been kept open and duly washed, no such encrustation, and consequent deterioration, could have occurred.

The author has paid considerable attention to this difficult subject, having had the experience of working almost every species of Refrigerator introduced to the trade; and he may say that he is acquainted with the principles of every one of them; and though in compliment he may have eulogised some shining improvement, he has one general objection to the whole, in the particular of their complex and costly mechanism.

A strong natural affinity obtains between the metal of the apparatus and the metallic and earthy matter which invariably inhabits spring water; insomuch that the gathering of sediment becomes in time so thick and hard as to be immovable; and the abstraction of caloric is then so tardy, that ultimately the machine becomes valueless as a cooler. All tubular Refrigerators are open to this great objection; so that the truth is notorious to all who use narrow tubes encased by wider, that it is *cheaper* to stop up the ends of the pipes as they severally split or fracture, thus rendering them harmless and useless, than to attempt taking them out of the case to be repaired or renewed. In short, many of them are so enlarged in diameter, through the adhesion and petrifaction of lime and other substances brought in the water and left to cement on its withdrawal, that the task of abstracting such pipes through the holes in the end or side-plates, originally made to fit them, is unaccomplishable.

Although the defects of tubular machines stand acknowledged, still the use of them in the trade, in one curious mode of construction or other, is almost universal; therefore attempts have been made to substitute spiral chambers, or those of a flat and oblong form; but the latter have totally failed through deficiency of strength, and the former through want of simplicity, and of the necessary provisions for keeping them clean and sweet. These, notwithstanding, are more operative in their effect than those of any former contrivance, being designed on a better principle ; yet their progressively ascending and descending water and wort courses in the opposite direction to each other, materially militates against them in their capacity as economists of water and time ; for besides the impossibility of opening the water passages for purification, without the assistance of the coppersmith, they possess the fundamental demerit of depositing their coldest strata, and allowing the lightest and warmest to flow above them. This is the natural consequence in all fluids which pass horizontally ; and the deeper and more confined the stream is, the greater will be the difference in the temperature between its upper part and its lower confine. Whether these streams be altogether vertical, or deep and horizontal, another objection arises to either principle, that though neither of the currents is quiescent, yet the lower portion is stagnant in an *approximate* sense ; being retarded by its comparative density and by the friction created in the continuous impediments which have met it in its course, whilst rolling along the bottom and against the sides of the channels or other bounds. In all properly designed Refrigerators, the caloric of the hottest portion or end of the current of wort, will be imparted to that end of the abstracting water which has acquired the highest temperature, the two streams opposing each other in the continuity of direction throughout their progress, until the egress wort is as cold as the ingress water ; and the nearer it has been reduced to that degree, with the smaller consumption of water, the more perfect the apparatus and the greater the economy of time and labour. Sound worts, namely, those that are put to commence fermentation without containing a superfluity of oxygen, cannot be pitched in a British establishment of any magnitude, even with all the advantages of site which a judicious selection may secure, during some portion of the year, which generally includes the whole seven months between March and November, if permitted to cool gradually by simple exposure to the natural air; consequently nothing but rapid refrigeration can reduce them without danger and inconvenience: it remains, therefore, to mention the result of past experience in this department of the brewer's vocation, where its benefits have been the most strikingly realised. This is the invention of a Refrigerator which supersedes all former devices in simplicity and utility; being without their defects, and possessing qualities to which they never claimed any pretension.

The Catharine Refrigerator.

The interior of this instrument is composed of a series of spirals of tinned copper, with one end of each wort and water course closed, and the other open, and is clear all round from any obstruction, throughout the whole length and breadth of each coil. Both ends of the apparatus are fitted with covers, to close them water-tight; and being made secure, the machine is complete and fit for action. Its arrangement allows no pipes, tubes, horizontal channels, deposit of sediment, or cold stagnant fluids, to intercept the course of the currents; and consequently they move with equal rapidity throughout their whole range, so that it can never deviate in quantity or err in temperature; and besides this advantage, the facility with which it may be cleaned, will induce a monthly or quarterly examination, or as frequently as circumstances render an inspection desirable, and can therefore have any appearance of filth or crust removed from the interior, before it trespasses to any formidable extent.

The Catharine Refrigerator is so named from the well-known wheel employed in exhibitions of fireworks; but the origin is imputed to Maximin, Emperor of Rome, who having wooed the embraces of St. Kate, maid of Sinai, and met with repulsion, devised a wheel of four parts, armed with sharp piercers and blades, constructed so that the alternate parts should act in the direction contrary to the motion of the others, and sever her into pieces by cutting and piercing both ways. Catharine, albeit, escaped that horrible destruction to suffer a less ignoble martyrdom by decapitation (A.D. 236), and holds the peculiar honour of patroness over learning and eloquence, in return for which she is patronised by the salamanders of modern pyrotechny; and now, at a more remote and humble distance, in the Brewer's Refrigerator, by way of damping the fiery ordeal. The instrument acts much like its predecessors, and is placed in a position similar to that of the exploder of combustibility, supported on two trunnions, not very different in make from those upon which a cannon is mounted. On these it turns, at the pleasure of the operator, to give the ends or edges of the chambers a horizontal position, and to enable it to hold a quantity of water whenever it may be thought desirable to open and examine it, and to cleanse it when necessary. It may also be turned upside down, to drain out the wort and water left at the close of each refrigeration, or to remove the covers to be cleaned ready for the next brewing: indeed, the whole machine, however large its dimensions, may be turned over by a child, and handled as easily as an artificial globe, because it is balanced upon its centre.

Amongst the advantages attendant upon the employment of the Catharine Refrigerator, may be enumerated its cheapness, the simplicity of its construction, its compactness, strength, and cleanliness, its power and durability, its economy in the waste of water and time, and, to sum up, its singular adaptation of all the requisite philosophical principles. In recommending this splendid instrument to the trade, the author, who is likewise the inventor, as regards the circulation of the fluids with which he charges it, does not hesitate to say that he has spent twenty years in mental exercise and close practical observation, much of which he has devoted to the object of perfecting this machine; and will now be happy, if challenged to the necessity, to make comparison of its merits by testing it against any other mode extant, be its pretensions what they may.

The small area occupied by this Refrigerator is its lowest merit; for its power is so considerable, even when the refrigeration is commenced at a high temperature, and the quantity of cold water employed is comparatively so small, that the usual area of coolers may safely be reduced one-half, and consequently much space is gained, which may be applied to other purposes; and besides the great saving in the outlay for coolers, the waste of that wort which adheres to those coolers is wholly avoided. The great injury done to the worts by long exposure to atmospheric air, after being cooled down to a fermentable temperature, is also avoided. The apparatus may be applied at any heat under boiling; but as the natural cooling from the top heat down to 100° or 120° is so rapid, it is not advisable to refrigerate at any higher temperature.

CHAPTER XII.

FERMENTS.

GENERAL PRINCIPLES—CAUTION—YEAST—BARM—THE FERMENTING IMPETUS AND VEHICLE—BRANDE'S LECTURES—DOCTRINES OF PHILOSOPHERS—THE YEAST BITE—PROOF QUALITIES OF BARM—CURIOUS FACTS—BAVARIAN PROCESS—LYMPHINE FERMENTATION—FOWNES ON ARTIFICIAL FERMENTS—BOUCHARDAT'S NEW LIGHT.

Fermentation, as a philosophical subject, is exceedingly delicate and interesting; hence, in the pursuit of trade, it is intricate, requiring much thought and attention. Thomson says the term was first introduced into chemistry by Van Helmont, and that some suppose it to have had its origin in the intestine *motion* always perceptible during the decay of vegetable substances, whilst others derive it from the *heat* thereby generated; but that it is now generally applied to all changes which vegetable bodies spontaneously make, with reference to results: it appears, nevertheless, to come from the Latin *fermento*, to puff up, or render light; while its diminutive *fermentesco* represents the symptoms of rising or leavening.

Chemists differ in opinion upon the precise nature of this extraordinary process, and the number of its stages. In Chambers' Information for the People, Part XIII., p. 84, we are told that they reckon *five* distinct species, which are, the *saccharine*, which changes gum and starch into sugar; the *vinous*, which converts sugar into alcohol; the *acetous*, by which alcohol and other substances are turned into vinegar; the *mucilaginous*, producing slime from sugar, instead of alcohol; and the *putrid*, or decomposition of animal and vegetable substances. Of the first of these we have disposed already, and with the rest we have now to deal; and it becomes us to take care how we treat the subject, to secure the good and avoid the evil. There is, however, a sixth sort of fermentation, which does not concern the brewer except as to the disposal of his fermenting material, but is as old as the Levitical law: this is the *panary* process, by which the flour of corn is turned into dough for bread, when water and an exciting cause are added.

Thomson confines his term to *three* species, which he designates the *vinous*, the *acetous*, and the *putrefactive*; the first producing *spirit*, the second *vinegar*, and the third reducing the substance to *soil*. Liebig's denominations are similar, dividing his chemical transformations, by which " some of the elements decomposed are singly set at liberty," into *fermentation*, *putrefaction*, and *eremacausis* or *decay*; and says that they arise from a disturbance of the equilibrium, which causes the particles of the body moved to follow their natural attractions, or to obey other affinities. In this way he accounts for the progress of putrefaction and disease, whenever an affected particle touches those of the same species which are sane; and he conceives that in fermentation and putrefaction, the elements composing the organic substances separate themselves from the organism; and being exposed to the influence of *water* at a certain temperature, that they enter into new combinations in which the constituents of the water act: which kind of decomposition he terms a transformation; but that eremacausis (derivable from ερημοω, to separate, by καυσις, heat) requires an accession of *air*, from which the decaying body absorbs oxygen, and is a slow combustion, uniformly evolving heat, and sometimes light. It has been very judiciously observed by the intelligent, and amongst them by Thomson, that fermentation does not take place at a temperature under the freezing point, which is the basis of an obvious mode of *preventing* it; and that furthermore the kind of fermenting termed *acetous*, is an example in which the alcohol absorbs oxygen at a particular temperature, and thereby becomes vinegar. In short, we find throughout nature, that heat is one of the principal agents in dividing, dissolving, and decomposing animal, vegetable, and mineral matter, and that solids become liquid, and liquids vapour or gases, in proportion to the quantity of heat present, or to some law dependent upon it. This principle exerts a powerful influence in fermentation, breaking through all the affinities and cohesions, and preparing new arrangements, simple or compound, in liquids or solids so separated; and these effects are dependent on the amount of caloric present, the commanding influence of which is much felt by the brewer in every stage of brewing, and in every department of the brewery, but especially in the fermenting room and stores; how necessary, then, to counteract its ravages.

The worts, at a proper degree of heat, evince an immediate symptom of change in the composition of their sugar and water, especially when induced by the presence of a fermenting medium, whether applied upon the coolers, or in the gyle-tun or vat. The operator must now bear in mind that the ferment called *barm* possesses a very strong affinity for oxygen, because of its strong inclination to decay, during which change oxygen is indispensable as a decomposing power; but whether the first parts of this element, thus appropriated, have been derived from the sweet principle of the wort by the ferment, so that its equilibrium thereby becomes broken; or whether the ferment has previously imbibed enough from the air, and a similar state of decomposition has been entailed upon the sweet by the mere power of contagion, through transition to the contiguous fluid, is of little moment here. It is sufficient, that by the interposition of the ferment, the old affinities of the saccharine solution in contact are destroyed, and a speedy decomposition ensues, by which every original particle becomes affected. It is probable that, under ordinary circumstances, various processes of fermentation go on in a gyle at the same time, in a greater or less degree; the putrefactive being excited by the glutinous substances, the gluten immediately engaging with it to alter the albuminous property, and so on in due rotation, till the particles least susceptible of decay yield to their influence. The decomposition of the sugar follows, and next in succession the mucilage; and if a large amount of caloric be present, such atoms of starch, hordein, &c., as remain, become subject to a similar change; and the more vigorous appearance of the fermentation is made evident when each of these several constituents is engaged in the same simultaneous and universal ruin. No other part of the extract than that which is constitutionally sweet, or has become so by a saccharising conversion, can produce alcohol; and it is the transformation of the saccharum into alcohol which is termed vinous fermentation. The putrefactive is a dissolution of matter containing nitrogen, though the term is now rendered almost general, signifying the decomposition of all vegetable matter, in whatsoever form it happens. It shall be shewn that alcohol is the standard of qualification in vinous liquor, being, as it were, a fulcrum on which its perfection depends. Add hydrogen, and it leans to ether; but if oxygen preponderate only an atom, it inclines to aldehyde; give it another, then the equipoise is irrecoverably lost, and it falls into acidity.

During the fermenting process, large quantities of carbonic acid gas and some hydrogen gas are formed at the expense of the carbon of the sweet, and the oxygen of either the solid or the liquid, or both, attended by an intestine motion, a slight noise, and an increase of temperature, if not duly curbed; and it is quite probable that on the old plan, the atmospheric air which has been regained upon the coolers after boiling, is first exhausted by the decomposing mass; and that afterwards, as the process goes on, the water is attacked, and its oxygen, as well as that of the atmospheric supply, becomes engaged to the same purpose; while the hydrogen, which must thereby necessarily be set free, is either assisting it in the formation of spirit, or flies off with the carbonic acid gas.

The solutions of all vegetable substances partaking of sweetness, and not having nitrogen in their constitution, such as crystallised cane sugar, starch sugar, and converted mucilage, require the addition of a substance partially composed of that essential element, before they will undergo the alcoholic or vinous fermentation. It is sufficient if they are in contact with either animal matter, or such vegetable substances as are termed the most *animalised*, such as albumen, gluten, and the like; and although these or similar nitrogenised matters must be in a decomposing state to qualify them for the office of exciting fermentation in saccharine fluids, such a condition needs not be an object of ardent solicitude by the brewer, since his ferment, as it consists principally of the natural diastatic albumen, associated with the gluten of his grain, wants only oxygen, moisture, and an agreeable temperature, to proceed immediately to putrefaction.

Here be it observed, that *yeast* is not necessarily *barm*, or the *cerevisia fermentum*, but is an ancient English word, and takes its name from its property of *yearing*, or *working round* into its former condition; a property which those who have not inwardly *yearned* cannot duly appreciate. When, therefore, Ham emphatically says, "*Let no yeast be used*," he evidently only prohibits *barm* as a *species* of yeast; for to prohibit yeast in general, is to supersede working altogether. *Yeast*, no doubt, is from the same stock as ζεω, and is equally significant of agitation.

Though the author's experience teaches him to adopt Mr. Ham's advice to some extent, he is not quite so parsimonious as that writer, and much less is he so extravagant as Levesque, as he is satisfied that a careful accommodating *middle* course is the best. Under precautionary circumstances, that is, with duly attemperated worts, properly hopped and prudently cooled, and in a cave with plenty of square-room, or where the fermentation can be carried on above-ground in a steady atmosphere of from 40° to 50°, when spring-water is ready to be passed through attemperators about the like heat, not more than *four ounces per barrel* can be at all necessary as the *maximum* at pitching, and none will be afterwards required.

The vinous, acetous, and putrefactive processes require three distinct ferments, each imbued with a different power to effect its separate purpose; or, in other words, a wort will partake of that species of fermentation more or less, which exists in the fermenting vehicle employed, and according to the particular stage of decomposition at which the majority of its parts have arrived. When such or a similar condition is imparted to the wort, the ascendancy of any particular stage in the mass depends upon its purity, density, and heat, either to aid, retard, or neutralise the progress of that species of decay which may be paramount in the additional ferment at the time of pitching; yet the result too often proves that an improper selection has been made, or that the age or quality of the yeast has been overlooked. The correctness of such a theory is evinced by the spontaneous production of alcohol, acetic acid, and humus, simultaneously or consecutively, under ordinary circumstances, in the musts of both fruit and grain, where artificial ferment is required to be used; and may be found on inquiry into the constitution of the ferment universally employed by the common brewer, the distiller, and the vinegar-maker; and by also observing the peculiar properties, affinities, and productions of each constituent, during their decomposition and afterwards, as well as their influence when in contact with similar and even different elementary principles, in all their varied forms of arrangement.

The heterogeneous character of the excrementitious part of the brewer's wort, recognised as his ferment or barm, may be founded in Westrumb's analysis, reducing to the following *per centage:*—Water 88·509, gluten 3·125, saccharum 2·051, mucilage 1·562, alcohol 1·562, extractive 0·781, lime 0·449, malic acid 0·293, carbonic acid 0·098, potash 0·085, acetic acid 0·065, with traces of phosphoric acid and silica towards the 1·420 unaccounted for. This analysis argues that the mucilage of the malt had not all passed into a saccharine state, and that some of the minor ingredients were incidental to the soil; and the variety of acids shews that the analysed barm was not of the purest quality. Chemists do not consider all these ingredients to be essential; and Westrumb's experiments demonstrate that when this yeast is filtered, a matter containing the properties of gluten remains upon the filter; and that when this substance is removed, the yeast loses its property of exciting fermentation, but recovers its power when gluten is added: whence it becomes evident, that this glutinous substance is the essential constituent of the ferment. Also, when common barm is preserved for some time in cylindrical glass vessels, a white matter like curd disengages itself and floats on the surface; and when skimmed off, the barm loses its exciting power. This substance is like gluten in some of its properties, but not in others; its colour being whiter, its elasticity less, its particles not so adhesive, and its dissolution in acids readier. Thomson considers this to be "gluten somewhat altered, and much more disposed to decomposition;" that it is the real part of yeast which causes fermentation; that it existed in the raw grain; but that it was considerably modified by malting, and by other incidents which took place while the must was fermenting.

It appears from the above analysis, published in Crell's Annals in 1796, that the learned professor selected such yeast for his experiments as was destitute of the hop; or that he overlooked its resin and oil, which must have existed in proportions sufficient to fill the vacant space in his *per centage*. The white substance which separated itself from the gluten, and without which the latter would not act, was the albumen of the seed, and contained the diastase, which, unless boiled to nullity, was not only the "real ferment," but the original agitator; though its presence may not be necessary where *gluten* exists, which appears to be analogous to it, and yet not precisely identical, being of itself an all-sufficient agent, though not so peremptory as diastase; neither is any other substance composed of the same elements, however proportioned.

Boussingault found the gluten of wheat to be composed as follows (Ann. Chim. et de Phys. LXIII. 229. Thom. p. 684) :—

Carbon . .	$8\frac{1}{2}$ atoms	$=6{\cdot}375$, or *per cent.*	53·75
Hydrogen.	7	$=0{\cdot}875$	7·55
Oxygen . .	3	$=3{\cdot}000$	24·20
Azote . . .	1	$=1{\cdot}750$	14·50
	$19\frac{1}{2}$	12·	100·

The gluten of raw wheat, however, is not so active or so soluble before germination; or, in other words, is not so susceptible of putrefaction or decomposition, as that of germinated or malted wheat; and the same observation may be applied to that of other corn, as barley, for example. This important circumstance is attributable to the original decomposing power of vegetation on each constituent of the grain, during the first efforts of its reorganisation through the peculiar agency of the diastase, which owes its animation to the same cause, and is designed for this especial purpose, and also for stimulating and aiding the process of regeneration. Fabroni found that wheat gluten as a ferment, acted but imperfectly, but that its efficacy was much improved by adding tartar; and Thomson informs us that Bertholet repeated a like series of experiments with success, and ascribed the efficient power of the tartar, to its increasing the solubility of gluten.

In a lecture delivered by Professor Brande, at the Royal Institution, as recorded in the "Forceps," he demonstrated that the chemical action of fermentation could not take place in any body, unless its composition contained nitrogen; and shewed that, on mixing a small quantity of barm with a solution of sugar and water, a change would thus ensue: — as sugar consists of 3 atoms each of carbon, hydrogen, and oxygen, a proportion of this carbon will unite with the oxygen under the influence of the barm, and will form carbonic acid, and the remainder will be converted into alcohol. In manufacturing wine, he shewed that yeast is unnecessary, because the sugar in the grape contains the principle; yet the grapes may be dried into raisins without change, on account of the imperviousness of the skin of the grape to air. Even in drying, water can pass, but not air; therefore, allowing the air to enter but for a moment, fermentation will result from its admittance. Liebig introduced into a vessel containing a solution of sugar and water, a smaller one covered with muslin, having a false bottom; in which inner he placed some yeast, and shewed that fermentation had commenced here, but not in the larger; nor would it do so till the particles became sufficiently reduced to pass through the gauze, notwithstanding the free communication between them. Mr. Brande also proved that the presence of creosote or turpentine always stops the action of barm, and that boiling answers no other purpose than delaying this action, which after some time cannot be perceived.

According also to Liebig, a principal part of barm is "gluten, or the azotised matter of corn." He treats very lengthily on the subject, and admits it to be known that the formation of barm depends upon oxygen being accompanied by gluten in the act of decomposition, but that it has not been sufficiently ascertained whether this oxygen comes from the water, from the sugar, or from the gluten itself; nor whether it combines with the gluten in a direct capacity, or whether merely with its hydrogen, so as to form water. The first hypothesis he terms an oxidation of the gluten; and says that the transposition of the atoms of the sugar into alcohol and carbonic acid, necessarily attends this oxidation, so that if one of them is arrested, the other must likewise cease. He will not admit that the yeast which rises to the surface of the liquid in fermentation comes from complete decomposition, but is gluten oxidised, still capable of being transformed anew, by a transposition of its constituent elements; and that by virtne of this condition, it possesses the power of exciting fermentation in a solution of sugar; and if gluten be present, the decomposing sugar occasions its conversion into fresh yeast, which gives to the former yeast the appearance of reproducing itself. This is all oxidised gluten in a putrefactive state, by means of which a like transposition is induced among the elements of the sugar.

The same author again explains, with greater minuteness than before, on the authority of Colin, that *yeast* or *ferment* from possessing the power of causing fermentation in saccharine juices has all the characters of a nitrogenous compound in the state of putrefaction or eremacausis; and, according to Thenard, it emits carbonic and other gases when kept under water, which have an offensive smell; and is eventually turned into a substance like old cheese; and when its own putrefaction is complete, it loses the power of fermenting other bodies. To sustain its fermenting properties, he conceives that the presence of water is found necessary, and its power to excite fermentation is diminished by simple pressure, and is, he says, quite destroyed by drying; but the author's experience does not lead him to that conclusion; though the rest is true, that "the temperature of boiling water destroys its action, as do also alcohol, common salt, excess of sugar, sulphurous acid, volatile oils, and all antiseptic substances."

Wigney, in his philosophical treatise on brewing, attributes the fermenting principle of yeast, solely to its accompanying carbonic acid gas, and thinks that the glutinous substance is merely its vehicle. In his Cyclopædia, edited in 1838, we find him again professing the same opinion, and while admitting that this singular power belongs to the gluten of the yeast, he still asserts that the carbonic acid gas is indispensably requisite to commence the vinous fermentation: nay, he yet further assures his readers, that yeast deprived of this gas will not cause this kind of agitation, but will beget that of an acetous or a putrefactive character. Suffice it to say, that common practice and observation contradict this theory of his, as well as others of his doctrines, such as the *coagulation* of *mucilage* by boiling, before reverted to, and his ideas on water, on solution in the mash-tun, and the like, where he gives effects for causes, or confounds his ingredients.

Contrary to the assertions of some, common yeast will retain its decomposing quality a long while in a dry state, especially when the air is excluded; and it exercises the property of exciting the alcoholic fermentation after the evolution of *all* its carbonic acid gas by boiling, and even after the expulsion of its moisture by baking or roasting before the fire, because *its albumen, though much reduced, is not destroyed.* The acidity, bitterness, or putrescence of the yeast so treated, requires no test beyond the senses; and the quantity of water that evaporates during the drying process is astonishing: indeed it appears that the water is increased for a time, by the union of oxygen and hydrogen, evolved by the rapid decomposition of the yeast during its exposure to such high heats. When dry, its colour is deepened, and its smell becomes rather offensive, but the bitterness is predominant, and almost absolute.

The extreme bitter thus produced in the yeast, and the preservation of the decomposing power, led the author to reflect on the cause of the *yeast bite.* Yeast-bitten ales are seldom bright; which circumstance, and the cause of their very nauseous and rank flavour, have not been satisfactorily explained. It is seldom perceived till the attenuation is nearly over, and consequently till a large amount of alcohol is present. The extreme putrefaction of certain vegetable substances, as bruised and mouldy malt, for instance, or baked yeast, will produce an acrid bitterness. The most reasonable way to account for yeast-bitten beer, is to attribute it to a limited quantity of *emaciated yeast*, the bitter property of which is owing to its final decay and attendant high heats; and the bitterness is increased by the resin and tannin of the hop, operated upon by the alcohol and additional heat, which dissolve it with the humus-like gluten, and blend it with the beer. This bad and peculiar flavour is seldom if ever evinced by the distillers' wash, where hops are not used, although their heats are exceedingly high, and the quantity of yeast used during their fermentations is large, and often not of the freshest or soundest description. When this catastrophe takes place, not only are the heats higher than necessary, but the skimming has been neglected, and the head of the yeast has evidently fallen into the must, or has never stood well upon its surface; for had the must supported a deep head, it would also have borne up the light hop-resin that accompanied it. The attendant cloudiness is attributable to the solution of the yeasty particles by the acetic acid, which acid is ever copiously formed during high fermentations. But the bitter impregnation is not by any means an instantaneous operation, nor is it entirely dependent upon the presence of bad yeast or high heats, as before observed; for it will take place to a moderate extent, excepting the dull appearance, with the best of yeast, at a temperature as low as 70°. In this case the head will be very shallow from the beginning of the fermentation to the end, and the escape of gases towards the close of the process will be both copious and tumultuous, the natural and artificial products being incorporated and actively engaged with the whole body of the wort, instead of forming a hindrance to the free ingress of invited oxygen from the atmosphere, by covering its surface to an inconvenient depth; and here let it be noticed, that the deep and dense layer of carbonic acid gas does not appear in the least to impede its ingress. The attenuation will be much lower and more expeditious than usual, and will promptly supply the necessary amount of alcohol, and expose all the bitter principle of the hop to its influence; the whole of this latter process amounting to neither more nor less than an economical application of the hop, notwithstanding the apprehensions of the timid, and the mystifications of quackery in relation to this subject. By a right application of the attemperator, and a judicious selection of the ferment, that which is known as yeast-bitten beer can at all times be avoided, and the resin of the hop will be imparted to the article with considerable advantage.

The principal causes of a thin head of yeast, with large bubbles constantly forming and breaking on the surface of the fermenting wort, arise from the altered condition of the gluten, through improper mashing heats, and by the fire of the malt kiln, which has rendered the yeasty constituents less adhesive when surcharged and expanded by the rising carbonic acid gas. This objectionable character of fermentation may be prevented in future by the use of paler materials, or by adding a few quarters of pale malt to such grist as that which produced it; for the less malt is exposed to fire, the more tenacious and cohesive are its glutinous particles: this in a great measure accounts for the deep and accumulated head upon pale beer in an ordinary course of fermentation.

According to the constituents, as expounded by Westrumb above, all compound yeast placed in warmer situations than 52°, is liable to all the singular and complicated metamorphoses to which vegetable solutions are subject. The nitrogenised solids are the only part of the brewer's ferment that is really useful; and they are the most so during its purest and primitive state. When exposed to the atmosphere, oxygen is absorbed so rapidly, that such solids not only weaken and perish by exhaustion, but the accompanying alcohol is speedily converted into an acid; and in proportion as acids exist in the ferment, so do they exercise a contaminating and acidulating influence, on the principle of contagion, over the newly generated alcohol of the must, particularly when the vinous fermentation is retarded by an undue share of mucilage, and a degeneracy in the artificial ferment. In such destructive changes, the oxygen appears to be appropriated by the alcohol faster than by those principles of putrefaction, the glutinous compound, and the carbon of the saccharine matter. Writers may continue to call this an "acetous fermentation," but it appears more like an acetous *impregnation*, the motive power being vested in the putrefactive agent; therefore, by all means it is desirable to keep cool and stable.

When a brewer changes his locality, he will find that, as in the case of water, practice alone will put him right in the choice, quantity, and management of his yeast. The character of this stimulant varies as much as any thing in nature, depending on many circumstances, the most immediate of which are the time of its original production, its after-treatment, its situation, and its age. Yeast cannot be too pure, energetic, fresh, and solid, for the brewer's use. The best is obtained from pale gyles that undergo the skimming process: a system of management but little known or practised in the provinces. The yeast to which the author finds preference due, is that which accumulates on the surface of the musts at or near the close of their vinous fermentation. This owes the superiority of its nature to the period when it rises, and to being peculiarly exposed and yet in a protected situation, more than to any other combination of circumstances. It should be collected after the first or second skimming, and used as soon as possible, as much for its own unimpaired condition as for its perfect inability to impart too much of either oxygen or acid; and from the fact that this yeast and its fluids are less susceptible of the aceto-putrefactive decomposition, than that which preceded it, there is no doubt but that it is the last of its kind which separates from the mucilage during the close of the fermentation, and that it contains less of the old ferment and less albumen than any other; for the principal part of these either falls to the bottom or floats upwards before one-half of the attenuation is over: such yeast, then, is purer and more durable, glutinous, and energetic, because it has emanated from the last extract, and its desirability is enhanced by its freshness, and by the soundness insured by the constant imbibition of alcoholic and carbonaceous vapours imparted by its supporting parent, and amply remunerating this yeasty shield for its partial protection of the must from the air during the time of its accumulation. One pound of this yeast, if used in due time, will be equal to three or four pounds of such mixtures as are commonly used ; and if this important commodity were more carefully selected, kept less fluid, in colder situations, and in vessels with hydraulic covers, and for much shorter periods than are usual, not only would a smaller quantity suffice, but less acidity would be imparted to the must, the fermentations would be healthy and vigorous under low temperatures, and the dangerous and often futile practice of adding more yeast to stimulate the fermentation when near an imperfect close, would never be required.

This subject has derived exceedingly little elucidation, and not much attention, from the gentlemen who have hitherto contributed to the brewer's library : the author observes, nevertheless, one writer recommending the exposure of yeast to the atmosphere a certain time, previously to being used for pitching, in order that it may become sufficiently decomposed to effect a prompter influence over the worts ; but with due deference to such an opinion, we can safely assert, that such intentional exposure is not only unnecessary but dangerous, especially during the warmer months of the year, as has already been explained. The present author has actually known the alcohol of an unfinished gyle of 36 lbs. *per* barrel, acetified by the addition of barm that has been too thoroughly oxidised, and even at a temperature of 71° in an atmosphere of 75°, and the attenuation about 18 lbs., the fermentation having become languid, and appearing to require the aid of an additional stimulant. Inattention to this part of the process is frequently the main cause of the "out of order" state of some establishments in difficult seasons.

Yeast soon loses its power by repetition ; so much so, that Richardson compares it to seed sown in the same field, which by a succession of sowings produces worse crops ; and he relates the incident, that having one brewery at Hull and another at Beverley, he carried yeast from one to the other, when it would not work sufficiently in the place where it was produced ; a circumstance which he attributed to the quality of the waters, one brewery being supplied by a well, and the other from a river ; because when the malt was the same in both breweries, the potency of the barm could not diminish on that account. Many brewers of the present day entertain the like opinion, and frequently send from one brewery to others, to seek "a change of yeast," imagining, of course, that they can get from their neighbours some superior to their own ; but all this risk, trouble, and expense, may be safely avoided, and the degeneration of their own yeast will be prevented, by adopting the method of selecting the newly-developed yeast originating directly from the last extract, and by the air-tight and cool means here recommended for its preservation. Those brewers in the north who but partly ferment their ales on Mr. Bentley's system, often find that the greater part of the yeast derivable from such a process is unfit for fermentation, through the emaciated condition wrought by its repeated exposure to the air, and to its former peculiarly harassing vocation.

The quantity of ferment that may be requisite, depends upon a variety of circumstances, such as the quality of the water and of the grain, the pitching heat, the density, and other casualties ; but the judgment of the brewer, founded on experience, must be exercised in this respect, no general rule being applicable to all cases; yet at all events, the smaller the quantity that will efficaciously effect the purpose without exhaustion, the better for the produce. An idea of Liebig's may be interesting here: he says that the transformation of a certain quantity of sugar, requires a certain quantity of yeast to effect it; not because quantity acts in increasing any affinity, but because its influence entirely depends upon its presence alone, which presence is necessary till the last atom of the sugar is decomposed; so that when the quantity of ferment is less than adequately small, it will complete its own putrefaction before it can accomplish the transformation of all the sugar; but when the ferment predominates, a certain quantity of it remains as it was, when all the sugar has passed through the fermenting process; whence it will appear that the natural ferment is insufficient, though sparingly aided by the foreign supply. If, nevertheless, sufficient time could be allowed for carrying on the process under favourable circumstances, the constitutional ferment would be equal to the task; but this is generally impracticable in a wholesale establishment. Yet if we say that with all the skill that the advocates of barm and heat can command, the natural ferment is preferable in the abstract, to the most strictly available extent, our observation will be indubitably correct when applied to the calm process, where the consumption of the azotised matter does not surpass the ratio of decomposition in the saccharum.

A brief description of a different kind of barm is given by Liebig, who has discovered that the yeast which is formed by the fermentation of Bavarian beer, is oxidised gluten in decay; and that the decomposition of its constituents gives rise to a very protracted fermentation in the sugar. So far is the intensity of the action lessened, that the gluten still held in solution by the fluid, takes no part in it; for the fermenting sugar does not excite fermentation in the gluten, but the contact of the gluten or yeast already precipitated or decaying, produces an eremacausis of the gluten which the wort has dissolved, oxygen gas is drawn from the air, and all the gluten in solution is deposited as yeast, like a viscous sediment, on the bottom of the vessel. The carbonic acid gas which the fermentation evolves does not rise in large bubbles, as in the ordinary course, but in myriads of *glomeramina*, similar to such as escape from a liquid saturated by high pressure.

This is the principle which distinguishes the Bavarian process from the common English mode. In the latter, a large quantity of yeast forms a thick scum on the surface; for because part of the sugar is employed in converting the ferment into gluten, the carbonic acid generated during the process, attaches itself to the particles of the yeast, which thereby become specifically lighter than the liquid mass, and *rise to its surface.* Gluten in the act of oxidation, says the great chemist last named, comes in contact with the particles of sugar decomposing in the interior, on which the carbonic acid from the sugar, and the insoluble ferment from the gluten, are disengaged at the same time, and cohere to produce that effect; and as more gluten is employed than is necessary for the formation of alcohol, and has a strong disposition to attract oxygen, and thereby to anticipate its own decay, the great excess which remains undissolved in the fermented liquid when the transformation of the sugar has been completed, attacks the newly-formed alcohol and turns it into acetic acid. But—"it is plain that with the separation of the gluten and that of all other substances capable of attracting oxygen, the beer would lose the property of becoming acid." Here the perfection of experimental knowledge has led to the solution of a most beautiful problem in the theory of fermentation, through this desirable riddance being "completely attained in the process of fermentation adopted in Bavaria;" for though both kinds of beer are completely saturated with carbonic acid when the fermentation ends, yet in Bavaria the extraction of oxygen by the gluten from part of the sugar *within*, in its conversion into ferment, is avoided by the introduction of oxygen *from without;* and the eventual consequence is, that the action of the oxygen from the air, and the low temperature at which they ferment, cause the whole of the sugar to be transformed into alcohol; and this is especially the case whenever that transformation is unattended by the formation of ascending yeast: thus Bavarian beer contains more alcohol than that which is produced by ordinary fermentation, the quantities of malt being equal; for there the aërial oxygen does not unite with the alcohol, but with the gluten only, although it combines with both at higher temperatures, and forms acetic acid.

Dr. Ure, in the recently published Supplement to his Dictionary, remarks, that English, French, and most German beers "become gradually sour by contact of air," but that Bavarian may be preserved at pleasure, "without alteration in the air;" which quality is to be ascribed to the peculiar process termed by the Germans *untergährung*, or fermentation from below, who designate the superficial barm *oberhefe*, and the viscid sediment deposited at the bottom of the back by the Bavarian fermentation *unterhefe.* The top yeast being added to wort at a temperature from 46½° to 50° F., will produce a slow and quiet fermentation, accompanied by a "rising up" of the mass, while yeast collects both at the top and at the bottom; and if this deposit be removed for use in other operations, he observes that it gradually but slowly acquires the character of the *unterhefe*, and becomes incapable of exciting the phenomena of the "first fermentation" or *oberhefe*, causing only, at 59° F., those of the second or sedimentary fermentation. "The superficial yeast may be removed without stopping the fermentation, but the under-yeast cannot without arresting all the phenomena of disoxidation of the second period. These would immediately cease; and if the temperature were now raised, they would be succeeded by the phenomena of the first period. The deposit does not excite the phenomena of tumultuous fermentation, for which reason it is totally unfit for *panification*, while the superficial yeast alone is suitable to this purpose." He wishes it to be carefully observed, that the proper *unterhefe* is quite different from the precipitate in backs ordinarily fermented; and he urges the necessity of pains to obtain it genuine at the commencement, and in a proper condition for use. The Doctor compares the superficial yeast to vegetable matter putrefying in a marsh, and the sedimentary to the rotting of wood in *eremacausis*, which he calls "slow combustion;" but Liebig's comparison is much more elegant than this. Something more than art has led that distinguished analyst from an examination of the principles of fermentation, step by step, to contrast the two distinct modes of action and reproduction of ordinary and Bavarian yeast, or barm expelled into *oberhefe*, and yeast precipitated to become *unterhefe*; in the same manner that he would distinguish the contrary tantamount principles of small-pox virus and vaccine lymph. "Ordinary yeast and the virus of human small-pox effect a violent and tumultuous transformation;

the former in vegetable juices, the latter in blood, in both which fluids respectively their constituents are contained, and they are reproduced from those fluids with all their characteristic properties. The precipitated yeast of Bavarian beer, on the other hand, acts entirely upon the sugar of the fermenting liquid, and occasions a very protracted decomposition of it, in which the gluten takes no part; but the air exercises an influence upon the latter substance, and causes it to assume a new form and nature, in consequence of which this kind of yeast also is reproduced. The action of the virus of cow-pox is analogous to that of the low yeast; it communicates its own state of decompósition to a matter in the blood, and from a second matter is regenerated; but by a totally different mode of decomposition, the product possesses the mild form, and all the properties of the lymph of cow-pox." (P. 389, 2nd edit.) The following are the experiments and opinions of other talented chemists of the present day.

Artificial Ferments.—In the Mechanics' Magazine for August, 1844, is an excellent paper on this subject, by Dr. Fownes, who complains that bread raised by the old-fashioned dough "leaven" is always sour, and that a secret substitute is vended in the provinces; and he suggests, as a matter of great practical importance, the propriety of having the means to excite the vinous fermentation, when yeast of the ordinary kind cannot be obtained. He sees, with Berzelius, that though much barm may be reproduced from a little, to create it anew is a difficult task, and refers to certain extraordinary phenomena to which that philosopher has applied the term "catalysis," which Liebig has assumed to explain on the principle of *induced* chemical action, and which MM. Boutron and Frémy have carried out in their researches on the formation of lactic acid, which go far to solve the difficulty. Diastase, in addition to converting starch into sugar, turns the sugar into lactic acid, and causes that acid to excite the vinous fermentation, whether fresh from the germinated grain, or advanced more or less towards putrefaction; he therefore mixes wheat flour and water into a thick paste, which he exposes, slightly covered and in a warm situation, to spontaneous change, when it will undergo a series of transmutations resembling the several actions achieved by the diastase. About the third day of the exposure, he observes that it begins to emit a little gas, and to smell like stale milk; but this odour afterwards changes its character, the evolution of gas becomes much greater, and is attended by a new scent which is agreeably vinous. This, he says, will take place on the sixth or seventh day, "and the substance is then in a state to excite the alcoholic fermentation." The dough thus decomposed he mixes with a little tepid water, and applies it to a quantity of wort at 90° or 100° temperature, which he keeps up by placing the vessel in a warm situation, and in a few hours active fermentation begins, carbonic acid gas is disengaged in abundance, and when the action is complete, and the liquid clear, a quantity of excellent yeast is formed *underheft*, "well adapted to all purposes to which that substance is applicable."

In another experiment, he made a handful of flour into a thick paste with cold water, covered it with paper, and let it stand seven days on the mantelpiece of a room which had a fire all day, stirring the mixture occasionally; and at the end of that time he mashed three quarts of malt with two gallons of water, and added the paste as a ferment; the consequence of which was the production of a pint of thick barm, "which proved perfectly good for making bread," and a quantity of beer, "quite free from any unpleasant taste." These results led him to the conclusion, that common gluten of wheat resembles diastase in the manner of its decomposition, and runs like that substance through two successive dynamic stages, first into lactic acid, and next into alcoholic ferment; and he asks, in conclusion, whether it is too much to expect, that by proper means it might be detected in the third condition of a sugar ferment, acting like diastase itself as existing in malt. Diastase, he contends, has no more existence than yeast as a proximate principle; and his reasoning is just, as it is evident from the above that his paste undergoes a malting process, productive of the diastatic impetus: hence his argument that "its powers are purely dynamic, and that it is, in short, nothing more than the gluten of the seed in one of the earliest stages of its decomposition."

In recommending these experiments as models to country residents and colonial settlers, who wish to enjoy "the luxury of good bread," he suggests that they may manufacture a sufficiency of malt from any kind of grain, and that hops may *probably* be omitted when yeast alone is the required object. Of course they can, as the ferment is derived from the malt, and the bitter from the hop alone. Another part of his observation is worth recording, which is, that when wort, boiled and hopped, is set aside for spontaneous decomposition, its change is dependent on its strength, the weak requiring three or four days before any alteration is evinced, when a scum collects upon the surface, and precipitates a brown flocculent substance, incapable of exciting fermentation in sugar, the liquid emitting a flat offensive smell; whereas the strong becomes turbid from the separation of a yellow adhesive substance, emits gas slowly, creates alcohol, and deposits an active ferment to saccharine matter. He also notices, that in a moderately strong unboiled infusion of malt, and of course unhopped, acidity and turbidity suddenly commence after standing warm a few days; the progress in the change is rapid, carbonic acid is copiously evolved, and a thick insoluble whitish matter settles down, which readily excites fermentation in a dilute solution of sugar, the supernatant liquid containing alcohol and acetic and lactic acids. He conceives that here, as before, the lactic acid is first formed, and that subsequently the vinous and acetous fermentations go on together.

New Light on the Globules of Ferments.—M. Bouchardat, in a "Memoir on Alcoholic Ferments," published in the "Chemist," for September, 1844, distinguishes them as three separate species, which he terms *beer yeast*, *dregs yeast*, and *black yeast;* the first being collected in ordinary beer, the second in very strong, and the third in a deposit of white wine; and observes that each requires two kinds of nourishment to sustain it, namely, sugar, to produce heat by its "*dedoublement*," and nitrogenous matter, to furnish the elements appropriate for its assimilation and reproduction. He has elucidated, by means of the microscope, that the globules of all three are analogous to the nervous globules of superior animals; and that when "in definite conditions," they ramify and become transposed into vegetable infusoria, losing their character as ferments, from the spores of the new vegetation not possessing the property of decomposing the solution of sugar; but that their active nature, while unexhausted, resembles that of certain animal substances, and produces the same effects; as in the experiments by Colin, which proved the albumen of the egg to be an alcoholic ferment; and M. Bouchardat's own results shew that albumen, in contact with a saccharine solution at 92° F., converts into a ferment, the action of which is weak at the end of three weeks, but that the brains of a man become an energetic alcoholic ferment in 48 hours; and it is remarkable that similar conditions apply to the three vegetable ferments before us, and that the substance composing the brain is formed by the union of globules of different kinds, of which the albuminous are among the most important, and these proteic globules are formed, like those of ferment, of an envelope insoluble in acidulated water, and of an enclosed albuminous matter soluble in such water, which is precisely the case with the globules of the vegetable ferments. Singularly enough, the brain of a young animal does not excite alcoholic fermentation, but is transformed into mucus, when put into a solution of sugar, and exposed to a temperature of 77°, because the envelopes have not sufficient resistance; and in like manner, though the "beer yeast" will determine a brisk fermentation at a temperature varying between 50° and 84°, it terminates in a very few days, not being capable of exertion in liquors containing much alcohol, and consequently being speedily destroyed by the brisk fermentation; whereas the two other species determine slow fermentation at the same heat, the "dregs yeast" acting three or four months on liquors containing alcohol to the amount of 16 *per cent.*, without being sensibly destroyed, and the "black yeast" working six months under the same circumstances, and with the like result; all which experiments conduce to establish the natural fact, that as strength requires strength, so weakness can only be effectual when applied to weakness; which fact merits the brewer's observation.

The three ferments, though alike in some particulars, as in being albuminous compounds, containing oxygen, sulphur, and phosphorus; in being equally accessible to the removal of their lactic and phosphoric acids by alcohol, and of a fat liquid matter containing oleine, stearine, and an oil containing phosphorus, by ether; and in being insoluble in pure water, or in water containing 0·001 of hydrochloric acid, though soluble in the latter after being bruised a long time with grains of silica, which is exactly the case with the adult brain; yet they differ from each other in form, colour, dimensions, and the contents of their globules, those of the *fermentum cerevisiæ* being seldom spherical, but generally spheroidal, like the albuminous globules of the brain; those of the *fermentum fæcis* more generally spherical, but sometimes ovoid; and those of the *fermentum nigrum* perfectly globular. The colour of the two first is uniformly whitish grey, but the globule of the third presents a very distinct black circle to the microscope, and the colour of the mass is uniformly a blackish grey. The diameter of the first species of and the greater number are well isolated asunder, though some have a smaller globule on the side, proceeding from the larger, and dependent on it, and some-globules M. B. estimates at $\frac{1}{91}$ to $\frac{1}{150}$ of a millemetre; times united to it by an elongation; the diameter of the second species varies from $\frac{1}{214}$ to $\frac{1}{228}$ of a millemetre; almost all its globules are isolated, though some few have smaller dependents proceeding from the larger, in the same manner as the first: and the dimension of the third is $\frac{1}{228}$ to $\frac{1}{250}$ of a millemetre, and are all entirely isolated; for when they are collected, or have small globules attached, they are transformed, and lose their fermenting power; and note, 305 millemetres are an English foot. The contents of the first are granular, and those of the second lobulous; but the third are void, or at least they have no distinguishable interior parts.

The following are some of M. Bouchardat's experiments, with which this topic shall conclude:—

I. He took 25 grammes of a man's brain, weighing 14·1 drams avoirdupois, which he put into a quart of water, and added 250 grammes of sugar at a temperature of 77°, and in 48 hours the fermentation began and continued with regularity.

II. He dissolved the whites of four eggs and one kilogramme (2·206 lbs. avoirdupois) in four quarts of water, containing 0·001 of hydrochloric acid, filtered the liquors carefully, and put them in equal quantities into two flasks, adding an equally limpid solution of 10 grains of tannin in 100 grammes of water to the one, but nothing to the other. An abundant precipitate was immediately formed in the first, which, on exposure of 48 hours to a temperature of 77°, was partly converted into globules of $\frac{1}{400}$ millemetre, acting absolutely with the sugar, just like the *dreg* ferment; but the latter stood two months at temperatures varying from 59° to 77° F., without any manifestation of alcoholic change or of fermentation.

III. He took of sugar 1 kilogramme, water 4 quarts, yeast 50 grammes, white of egg, dissolved in water with the usual accompaniment of hydrochloric acid, 200 grammes, and maintained a temperature of 68°. The fermentation was promptly established, and continued regularly four days, when becoming slower, he collected his ferment, and found it to weigh $50\frac{1}{2}$ grammes. He then repeated this experiment, substituting 100 grammes of fresh gluten for the albumen of the eggs; the fermentation went on four days as before, and only $49\frac{1}{5}$ grammes of ferment could be collected. From these results he concludes, that "the globules of the ferment do not assimilate more of the solution of sugar than the solutions of albumen and gluten;" and asks, in conclusion, "Does it not follow that, if we find in the brewer's vat 7 of ferment, when only 1 has been put in, it must be owing to this 1 part of ferment having met with proteic substances, which being placed in a fermenting medium, are proper for giving rise spontaneously to globules of ferment; the same as in the must of grape, *without* having added ferment, we find a considerable quantity of it?"

CHAPTER XIII.

RAPID FERMENTATION.

CONTRARY EFFECTS—ALDEHYDE ANALYTICALLY CONSIDERED—ACETIC ACID AND ALEGAR—OPINIONS AND TESTS—MORE ILL EFFECTS OF HEAT—ALCOHOL ANNIHILATED—ATOMS OF SPIRITUOSITY—COMPARISON OF CHEMICAL SYSTEMS—THE DEMON OF THE CELLAR—FOREIGN CUSTOMS—BRITISH MALT CORDIALS AND WINES—STINGO.

We proceed to examine the species of fermentation commonly termed acetous, and to ascertain the causes of its production, in order to avert its consequences. Vatted ales and new wines, which have been fine in the winter, often undergo a secondary and more expeditious fermentation on the approach of summer, through an increased action, because the fermentation, if properly conducted, has, in fact, never entirely ceased; and hence the cloudiness of beer at certain points of its progress that have occurred, under the most favourable circumstances, even as now conducted; hence, too, the incorporation of its lees throughout the whole mass, and the freedom with which it "ages," or becomes hard and afterwards sour, which changes are the sure effects of heat, aided by the restlessness of the unsubdued ferment in its now exhausted and expiring extremity; but in ales that are removed from their depuration during the cold season, such atmospheric changes are not so perceptible, nor is the acidity so intense; which shews that heat is productive of acidity when a rapidly oxidisable substance is presented to its influence.

Dr. Thomson states, that when beer is deprived of its glutinous matter *in toto*, whether by spontaneous deposition or by clarification, it will not submit to the acetous fermentation, unless some *mucilaginous* matter be mixed with it; and here the author must explicitly observe, that the case differs in ale in which the mucilage has been converted into saccharum. In the Annales de Chimie, XXXVI. 245, Chaptal shews that he exposed old wine, freed of its mucilage, in uncorked bottles, to the greatest heat of Montpelier, during 40 days, and that it did not turn by the exposure, though on adding vine leaves to it, containing mucilage, it then became sour in a few days; and it shall be shewn in the sequel, that British beer may be found which will stand at least an approximate test. This, by the way, is old beer, brewed temperately for long storage; hence, as mucilage is such a powerful and universal agent in producing acidity, when acted upon by a little heat, the supereminent utility of the mashing attemperator to nurse that constituent into sugar, as directed in Chapter V., is unquestionable. The production of acetic acid does not rely on one condition, but on an union of causes, aiding the transformation. Alcohol, at any temperature between 80° and 100°, will absorb a large accession of oxygen, and becomes acidulous where mucilage exists, without the presence of gluten; but if both those agents accompany the alcohol, the formation of acid is more rapid, and a putrefactive odour attends the acetous formation; and if the gluten be in excess, the putrefactive decay will be the more evident, particularly when the antiseptic properties of the alcohol and the hop are removed; oxygen in either case being the direct agent; though it will not enter without a warm amylaceous invitatant.

Heat is produced in various ways, as by the union of alcohol with water, or by chemical action in the conversion of sugar into alcohol, which is a fermentative because a generative process. Some have supposed that the increased heat within the tuns was caused by attrition or friction among the contents: but Pictet has demonstrated that solids are the only substances which can produce heat by friction, and that no elevation of temperature whatever takes place from the mere agitation of fluids or their particles one with another. The primary supporter of heat and combustion of oxygen, is feelingly described by Booth in the Society's Treatise, p. 28, where he says, "The formation of vinegar, like other fermentations, proceeds more rapidly where it has a *nidus* or incipient acidity from which to begin. In the aërial theory, that *nidus* is oxygen, and to destroy or counteract this oxygen in the outset, is to *strangle the demon* in the moment of its birth;" which moment may be either within the period of mashing, or at any subsequent stage; but he seems particularly to charge the act of "*blinking*" in the newly-drawn worts with being the mother of the demon, and "*improper heats in the mash-tun*" as its sire. That the imbibition of too much of this element is fatally productive of acidity, enough has been said herein, whether its vehicle be unconverted mucilage, or alcohol accompanied by mucilage, or an incurable aërial blink, all of which contain hydrogen in superabundance. A certain degree of heat is requisite to oxidise alcohol; but to effect this, a sufficiency of oxygen must be supplied from the air through the nitrogenous agency of some substance in decomposition, its decay causing not only an influx of oxygen in excess, but when a certain amount of caloric is present, the subtraction of a portion of hydrogen from the alcohol; and if its atomic weight is thereby diminished one 23rd part, a substitution of oxygen annihilates its water, and again commonly adds to its elementary constituency one-sixth *per* atom of its former alcoholic weight; for the atomic weight of alcohol, where oxygen is unity, is 5·75; that of aldehyde, its first transformation, only 5·5; but that of acetic acid 6·375.

But the atomic weight of a particle in composition, is distinguished from its absolute or specific gravity, inasmuch as atoms differ in magnitude: œnanthic ether, for instance, which gives odour to wine, has a specific gravity of 862, with an atomic weight of 18·75; whereas an atom of alcohol of a specific gravity varying from 813 to 863, is not equal to one-third of the former, as before seen. In the transmutations before us, however, the disparity is not eccentric, as aldehyde has a specific gravity of 790, which is one 23rd less than 826, or a mediate gravity of alcohol; but the specific gravity of acetic acid is 1060, which shews that the atomic increase is not equivalent to that of its specific gravity, entitling it only to 915·7; this, however, is the same as given in the table above, and is absolute or "highly concentrated." The constitution of aldehyde will be found in Chapter XVI., and what it really is in nature we are told by Liebig, who found that it could be obtained from either alcohol or ether, and describes it to be a colourless volatile liquid, limpid like water, combining with it in all proportions, the combination evolving heat. Thus alcohol becomes aldehyde at a low temperature unless properly restrained, and the latter spontaneously works its own destruction by latent caloric, though "its volatility is much diminished when it is combined with water or alcohol," and though "it takes fire readily, and burns with a pale flame which emits a good deal of light."

Now that the composition of aldehyde is known, as

Thomson truly argues, we can easily ascertain the truth of the facility with which oxygen converts it into acetic acid; for

Acetic acid is . . . . $C.^4\ H.^3\ O.^3$ and
Aldehyde is . . . . . $C.^4\ H.^4\ O.^2$

So that if oxygen combines with one of the atoms of hydrogen and turns it into water, and if another atom of oxygen at the same time replaces the hydrogen, the aldehyde will obviously be converted into acetic acid, and that alcohol and aldehyde differ between themselves only from the former containing two atoms more hydrogen than the latter, is equally obvious; for as shewn above, at page 392,

Alcohol is . . . . . $C.^4\ H.^6\ O.^2$ and
Aldehyde is . . . . $C.^4\ H.^4\ O.^2$

How easy, then, is each dangerous transition, and how carefully ought favouring heats to be avoided! And moreover, the fermenter may fall into another dilemma; for "an atom of aldehyde, to be converted into *aldehydic acid*, requires to combine with one atom of oxygen. Hence aldehydic acid is composed of $C.^4\ H.^4\ O.^3$, differing from acetic acid merely by containing an additional atom of hydrogen." So far Thomson in pursuing Liebig; so that it is intermediate to the two; and according as the management is good or bad, we have the following products in succession:

Ether	$C.^4\ H.^5\ O.$ atomic weight	4·625
Alcohol . . .	$C.^4\ H.^6\ O.^2$	5·75
Aldehyde . .	$C.^4\ H.^4\ O.^2$	5·5
Aldehydic acid .	$C.^4\ H.^4\ O.^3$	6·5
Acetic acid . .	$C.^4\ H.^3\ O.^3$	6·375.

From the volatility and limpidity of aldehyde, it is presumed that old bottled beer which rapidly effervesces when unstopped, is of an aldehydinous character, and that the acidity which speedily ensues is aldehydic acid, the subsidence of the effervescent action having removed its suffocating influence; and so nearly is it allied to acetic acid, that the flavour of the one can hardly be determined by the palate from that of the other, though aldehydic acid, were it to remain such, would be the sharper and more spirituous alegar of the two: not *vinegar*, for *that* is made from *wine*. *Gar* is Saxon, and signifies *sharpness*.

The variable conditions and the tendency of our malt liquors to decompose, originate chiefly with the commencement of the fermentation; for then it is, if not earlier, that the seeds of acidity are sown, and their development becomes more conspicuous as heat, their *primum mobile*, increases. During the first part of the fermentation, some of the most soluble of the ferment becomes blended with the water or the alcohol, or both; and the acetic acid first formed aids the solution and incorporation, the latter often originating from a surcharge of oxygen on the coolers, and being frequently the primitive cause of early acidity where the mash has escaped free, especially in summer-brewed beer: a circumstance to which those who use refrigerators, with a plentiful supply of cold water, are far from being so liable.

Thus we see that our malt liquors which are brewed and stored under those that are deemed the most auspicious circumstances that can attend the current system, if an unsystematic process can be so termed, where we suppose that the heat has not at any time exceeded 60°, are liable to become acid, all the destructive agencies being thereby induced, retained, and active, till the very alcohol, whose nature it is to preserve the richer parts and to impart strength, is subject to change and become alegar, the intermediate stages being imperceptibly hurried over. This spoliation is too well and too sorrowfully known both to the producer and to the consumer, and how to avoid it is the anxious enquiry of all; for as no effectual remedy has yet been provided, the work of destruction still goes on; though its course, according to the sanguine hope entertained in common by the author and his friends, is nearly run, and will terminate as soon as the public can be persuaded to dissipate old-fashioned prejudice, and listen to the plain language of reason and experience.

Gluten being a vegetable organ, almost like albumen in its nature, and as such, being exceedingly subject to change, its transition is attended with most disastrous consequences to the vital property of every thing around it, particularly the alcohol, provided this alcohol be at a temperature which will submit it to the influence, namely, at any heat above 52°, as indeed it almost always is after the fermentation commences; so that as the sugar transmutes into alcohol, the gluten assists in converting it into acid, and as the heat advances, so is this acidifying process accelerated. Hence we cannot do otherwise than infer, that if the fermentation be commenced above 52°, the first drop of spirit is liable to the attack of the oxygen presented to it by the decaying yeast or gluten, or otherwise; and that such is actually the case shall presently be most satisfactorily proved. Let the least sceptical put his worts to the following simple and fair chemical trial.

Just before pitching a wort, if it have been expeditiously cooled, as soon as it is down at 70° or below, dip a bit of blue litmus paper into it, and if the colour of the paper remain unchanged, no acid is present. After the same wort has been pitched, and when the fermentation has commenced, the same test may be applied again, when the acid then being formed, will tinge it with spots and streaks of red, and as the fermentation proceeds, the more will the attenuated liquor redden the test-paper; indeed, the natural carbonic acid will slightly affect it, but not so much as when acetification has set in. Thus any person can easily detect the presence of acids, and the period at which they are formed, and so convince himself that by the existing mode of fermentation, the two distinct processes of vinous and acetous working are going on in the vessel at the same time. That the precious alcohol is the victim of this turbulence, the following conclusion from Donovan's treatise in Lardner's Cyclopædia, may tend to shew, though not coincident with fact:—

"With regard to the theory of acetous fermentation, and the formation of vinegar, or acetic acid as it is called, in its pure form, it is almost exclusively the alcohol of the fermented liquor, which is changed into vinegar, and the question is, what is the nature of the change? Lavoisier, finding that the oxygen is absorbed during acetification, concludes that its presence and absorption are indispensably necessary; that the oxygen enters into the composition of acetic acid; that acetic acid is *plus* oxygen; and that the change effected by the acetous fermentation does not enter into combination with the alcohol, but acts the very different part of abstracting some of its carbon, combining with it, and thus forming carbonic acid, which then remains a separate compound, either exhaling or remaining mechanically mixed with the resulting liquor. From the facts ascertained by Saussure, it might be supposed that nothing happens in the acetous fermentation, except the abstraction of carbon, and that acetic acid is alcohol *minus* carbon. But that this is the case, a very little consideration will suffice to shew." This certainly accounts for the utter destruction of the alcohol, though not on correct principles; for instead of abstracting carbon, we have shewn from the more modern and minute discovery of Liebig, that this element remains unchanged throughout the several transitions, and that the abstraction is of hydrogen in interchange for oxygen. The learned Irishman proceeds to give the following, which are here arranged tabularly, that they may be the more readily seen and compared.

Primary elements.	Acetic acid.		Alcohol.
	Gay Lussac.	Berzelius.	Saussure.
Carbon	50·22	46·83	51·98
Oxygen	44 15	46·82	34·32
Hydrogen	5·63	6·35	13·7
Total	100·	100·	100·

He then takes Berzelius's analysis of the acid, which contains the smaller quantity of carbon, and compares it with the alcohol, which thus gives 5·15 as the decrease of carbon obtained by the change; and says, "*Supposing* the oxygen absorbed by the fermentation, which turned the alcohol into acetic acid, to have combined with and carried off 5·15 parts, the result would be, C. 49·362, O. 36·183, H. 14·442," which, he asserts, "is very different from the composition of *acetous* acid, as represented by Berzelius." But at all events, Berzelius's carbon agrees, and the remainder of the oxygen in excess is made up from the hydrogen, which also appears to be the case, and to a greater extent, in Gay Lussac's analysis. Saussure's is almost identical with that by Liebig, as given in our 16th chapter; but any carbon which they obtained must have come from a portion of the sweet which had not transmuted into alcohol. Gay Lussac's diminution of carbon is exceedingly small, so that the Doctor has made some mistake in his calculations, and doubtlessly from a wrong impression; and it is rather strange that he should not have seen his error, and examined his figures, when he admits at the same moment that "Vauquelin conceived that *the ferment* takes both hydrogen and carbon from the alcohol, leaving therefore an increased ratio of oxygen, and thus converting it into acetic acid, while ammonia and an oily substance are formed; but the production of these two compounds seems not to have been ascertained." In these several analyses something depends upon the purity of the alcohol, as we find Doebereiner employing it at a sp. gr. of 863 in preparing *acetal*, and Pelletier as low as 815 in various experiments on quinine. Our analysis of *absolute* alcohol, at page 391, very nearly agrees with Berzelius again; and there aldehyde is shewn to contain $7\frac{1}{2}$ *per cent.* more carbon than here exhibited, and ether nearly 18 *per cent.* from the same four atoms; and why? Because there we had fewer atoms of the weighty element, oxygen, in proportion, which accordingly gave the carbon a greater comparative preponderance, and consequently the *per centage* may alter without any abstraction of carbon whatever; a circumstance which has not struck the learned Doctor of the Cyclopædia; therefore, after much reasoning, he is satisfied with saying that, "in the absence of facts, hypothesis may be substituted," and that on consideration, he feels inclined to the following explanation: "*Perhaps* it is near the truth to suppose, that in the formation of vinegar, the constitution of the alcohol is subverted; that the elements of the latter re-combine in such a ratio as to produce vinegar; and that the residual quantities of the elements not required for the vinegar, unite and form some other compound." On a hypothesis thus vaguely conceived, he elaborately proceeds to build a series of new conjectures, one upon another, and at length comes to the final determination, that "oxygen is not necessary to acetification;" and that "therefore an explanation of acetification need not to be embarrassed by accounting for a phenomenon which is not a part of the process to be explained." The editor of Chambers' Information, Part XIII., has been better informed on this subject, having alcohol C. 51·98, O. 34·32, H. 13·7, or to mere fractions of the *quanta* given by the eminent analysts above named, and quoting Saussure.

The formation of the carbonic acid, which becomes gas, is thus otherwise accounted for in Thomson, who says, in his Chem. Org. Bod., p. 8, where he treats on the theory of ethers, that a discussion respecting the constitution of ethers had then been carried on between Liebig and Dumas, with much animation on both sides; that, according to the former, the radical is $C.^4\ H.^5$; but, in the view of the latter, $C.^4\ H.^4$; and that, "of the two," he is inclined to prefer Liebig's doctrine as the simpler, and more agreeable to the phenomena. He then follows that philosopher in resolving sugar as follows, only we halve his double atom to simplify the result:—

"Common sugar is	$C.^6\ H.^5\ O.^5$

Now it is resolvable into

1 atom ether	$C.^4\ H.^5\ O.$
2 atoms carbonic acid . . .	$C.^2\ \ \ O.^4$
	$C.^6\ H.^5\ O.^5$"

Which shews at once the dissipation of all the carbon that disappears, and the fountain and creation of the carbonic acid gas and ether, prior to the formation of alcohol from the latter, or from the body. The elements, therefore, reduced to a table, are thus disposed:—

Primary elements.	Sugar.			Ether.			Carbonic acid.		
	Atoms.	Equivalents.	Per cent.	Atoms.	Equivalents.	Per cent.	Atoms.	Equivalents.	Per cent.
Carbon ..	6	4·5	44·44	4	3·0	64·87	2	1·5	27·27
Hydrogen.	5	0·625	6·17	5	0·625	13·51	–	—	—
Oxygen ..	5	5·0	49·39	1	1·0	21·62	4	4·	72·72
Total ..	16	10·125	100·	10	4·625	100·	6	5 5	100·

That is, considering each as a compound consisting of 100 parts *in se*; but taking the acid and ether as mere components abstracted from the sugar, and filling its volume between them, the result is, that 22·63 *per cent.* of carbon remains in the ether, ready to form alcohol, and 14·82 *per cent.*, or just half as much, supports the acid, and is carried off in gas; that the whole of the hydrogen, or 6·17 *per cent.*, lapses into ether, and is insufficient to support the after-change into alcohol; and that no more than 9·87 *per cent.* of oxygen passes into the ether, whereas 39½ *per cent.* of that element gives way to the carbonic acidity; that alcohol requires a fresh supply of as much more as ether, and that the ethereal quantity is tripled before the acetic acid assumes its birth and sovereignty. Who, then, can say that oxygen is not an essential supporter of acidity? This is a studious subject, but is very serious in its consequences; and Booth's *demon* is a real being, to be dreaded and guarded against.

Furthermore, the elementary exposition of alcohol already given, as deduced from Liebig, agrees to a fraction with that observed by Saussure; and we are bound to consider that the nicety of the analysis is subject to the height of rectification to which the spirit has been brought; and on comparing the sugar here with the acetic acid of Gay Lussac, that farther and final transmutation, and the supposition that both are correct, would appear to have had the effect of completely interchanging the carbon and the oxygen, were it not that now we see the *ultimatum* of the former; the hydrogen acquired by the conversion into alcohol being transferred from its duteous connexion, to assist in forming the acid, thereby entertaining a species of fermentation in many respects diametrically contrary in its action to that vinosity which it conquers and destroys.

Acetic acid, in common with alcohol and their parent sugar, has its different degrees of perfection, and each is dependent on concomitant accident, as well as direct lineal derivation; for as great a difference may obtain between acetic acid formed from alcohol in its intermediate state, and that obtained directly from the root of sugar, as Berzelius's and Gay Lussac's analyses exhibit, and even more, aërial and elementary contagion and temperature being especially considered in the computation: in fact, anhydrous acetic acid may be as low as 1010, according to Liebig and Gregory's Turner.

That alcohol, therefore, is convertible into vinegar, and is propense to the change, no doubt can longer remain in the experienced mind. Several French chemists recommend that it be applied to vinegar by persons desirous to improve its acid strength. Thomson has a remark, that the presence of an acid was formerly supposed to be essential to fermentation, but that it does not *seem* to be the case. It is true, indeed, that an acid *usually* makes its appearance in fermentation, he continues, but its formation *has been* attributed to the action of the yeast upon the starchy and mucilaginous parts of the wort; though from what he believes through Fourcroy and Vauquelin, it does not fail to appear where yeast is not used in the process. This, then, to him is all conjecture; but the following is more decisive, and applies at once to the point at issue:—"The gas which comes over consists of half carbonic acid and half hydrogen; but at a lower temperature pure malt wort does not yield any inflammable gas." (Chem. vol. iv. p. 379.) Who, then, would keep up the temperature of the wort to destroy its spirit? We have seen and proved that the abstraction of hydrogen annihilates the alcohol.

Thus we every where see that a cool fermentation is slow and vinous, causing the yeast to subside to the bottom of the vat, and the body of the beer to retain the gases which produce the exhilarating power and future briskness, and that they lie dormant till called into action; but that, on the contrary, heat drives the musts to ferment rapidly, to exhaust their stimulus by over-exertion, and to float over the tops of the vessels, to be used for any other purpose than that of preserving the beer; and that consequently the alcohol really furnished in support of the saccharine nutriment, becomes an immediate prey to the first invading foe, and all the good that we have been striving to accomplish, is liable to be dissipated and rendered null.

Let us now consider the old prime beverage called "stingo," which flows so freely in the halls of many who deserve the title of "fine old English gentlemen," and there we shall find it in perfection, not because it has been attenuated by force and chemical skill, but because it has been fermented carefully, and stored in the best, the deepest, and the coolest cellaring that the builders of the mansions could devise; and this is of itself a guarantee, without any recourse to hypothesis, which is too speculative for conviction, that British beer thus prepared, be it of the ale or porter species, will withstand the baneful influence of the atmosphere during a whole age, provided that it have been well matured in the cool vault. Of this kind were the "Morocco," at Levens in Westmorland, particularised in a former edition, which was never tapped under twenty years old; and the "Mum," twice named by Booth, which our ancestors brewed from oat malt, and tapped after standing two years, but which, as he observes, is "now unknown in England:" this beer was never hopped, or impregnated with any bitter. It appears somewhat strange that Dr. Ure, who has undoubtedly read the Diffusion of Knowledge Society's Treatise, and swallowed many of its contents, should leave out of his catalogue of German beers that of Augsburg, "which is so famous *throughout* Germany," in which, when stored, the dried roots of the common hedge-plant Avens or Herb Benet, "highly extolled all over the continent," used to be suspended sliced in a thin linen-bag, and to impart a peculiarly pleasant odour to the beer, which when "so managed *never* becomes acid." This, however, seems to be a preservative rather than a restorative; and if we admit the justness of the proverb, that "it is easier to prevent an evil than to cure it," we must go to some cool calculating butler to a British nobleman or gentleman, who brews at the birth of his master's heir, in the hope of having the felicity to broach his own bunging on the day when the said heir shall attain his majority of twenty-one.

Stuff like this outvies that celebrated British wine which the yore Romans took home with them as a kind of trophy, and exhibited before the senators as a captured treasure, "superior to all the wines of Rome:" the argument in its favour is the *cool* truth that it will *keep*, and that it suits every constitution not pampered by luxury or medicine, or broken by disease.

CHAPTER XIV.

GENTLE FERMENTATION.

SKIMMING PROCESS—RECLUSE FERMENTING—REQUISITES—TUN-ROOM ATTEMPERATORS — NORTHERN BREWERS — CORRECTIVES — FLATTENING—WASTE—WHEN AND HOW TO USE ATTEMPERATORS.

As all the most exquisite and marvellous productions are, so is gentle fermentation, a calm and gradual process, producing natural consequences in perfection, and then subsiding into quiescence. Though called an oxidation according to the phraseology of the modern school, it is progressive, not by making an oxide of the alcohol, because that cannot be done under the conditions, but it is an oxidation of part of the raw worts; and this is an invariable preliminary, inasmuch as it is self-agent, or the wort could not undergo the necessary decomposition to which it quietly approaches with certainty and precision. The *gluten* of Saussure, or *kleber* of Einhof, which is the principal nitrogenous matter of the native gluten, being actuated by an innate and sleepless propensity, is among the first constituents to decompose, by absorbing a surcharge of oxygen from the atmosphere, or from the sugar, as the constituency may allow, and to commence decaying. This species of fermentation produces a very protractive decomposition of the sugar, mild and gentle in character; and the accompanying gluten, which only is decaying, takes no part in the vinous fermentation of the sweet principle;

nor can the action of the decomposing sugar alter the peculiar species of change which the gluten and yeast are now undergoing; thus, while the nitrogenous matter is appropriating to itself the oxygen which assists in its subversion, the saccharum is dependent on the progress of decay in the glutinous compound. By this novel commotion and contagion, which it spreads every where in its existing course, the *kleber* is made to assume the diastatic property, and to act as though in concert with it throughout the vinous fermentation, forming alcohol, yeast, and carbonic acid, as before explained, the first being intimately united with the water, the second precipitated to the bottom of the vessel, and the last flowing away with the running stream.

The material on which the brewer has to depend for the production of a fermentation purely vinous in its nature, is his saccharum, no other being capable of the conversion; and this remarkable fact is a good argument in favour of either preserving the diastase from destruction by fire after it leaves the mash-tun, or of making the most of it there; for we have before shewn that it does something more than merely break the amylin and set the amidin free; and notwithstanding that a species of saccharising fermentation precedes the vinous in the gyle as well as in the mash-tun, the alcoholic production from sugar so formed, and apparently so prematurely decomposed, is not so copious, or of so fine a quality, as that made from ripe, well-matured, and perfect saccharum.

Although the remarks now further offered on this head might be generally extended to the extracts of grapes and other fruit that contain the essential constituent, and are, upon decomposition, subject to the same or similar laws, and will bring forth kindred issues, it will be more convenient and consistent with the object sought, to confine the observations that arise, chiefly to the produce of malt and hops, as used in the brewery, particularly as a mental view of this matter will easily transfer the idea to any kindred object.

The materials considered requisite for establishing a correctly vinous fermentation are four: sugar, water, modified heat, and a little yeast. The first of these, accompanied by gluten, and too frequently by large quantities of unconverted starch and starch gum, is plenteously and variably supplied from the mash; the second by the necessary means of dilution therein; the third, under certain limitations, puts all the particles in motion when induced by the fourth, which is the ferment itself, posited within its appropriate sphere. Thus constituted, the *new* mode of fermentation very closely resembles the Bavarian process, so clearly and scientifically described by Professor Liebig, with the exception that in lieu of exigencies and contingencies, we establish definite and fixed principles. The British public ought to feel bound in gratitude to this eminent chemist for the information his labours have elicited; and in justice to that public, as well as in support of the present author's own peculiar views, he gives that philosopher's investigations and opinions as an act of grateful duty. Bouchardat's experiments will be found to confirm his testimony, where he lays down the doctrine already referred to, that when common yeast is put to wort of 40° to 45° temperature, a tranquil fermentation takes place, depositing at the bottom of the vessel a substance which will excite new fermentation; and that when repeated several times successively, the ordinary fermentation graduates into the process which alone forms precipitated ferment; the yeast so deposited having lost the property of exciting fermentation in the common way, but producing that other process even at 50° F.

In order to facilitate a comparatively vigorous fermentation in saccharine liquors at extremely low temperatures, such as from a multiplicity of obvious reasons have been here recounted and advised, and for which other reasons have to follow, a certain degree of motion amongst the constituent particles and atomic elements is necessary. In ordinary fermentations, a sufficient agitation is generally produced by the generation of an additional amount of caloric, and the universal commotion that it causes by the ascension of the heated particles, aided by the escape of gases; but in such fermentations as evolve little heat, it is requisite that the nitrogenised matter should be kept by artificial means, such as occasional agitation, in perpetual contact with the sweet parts of the compound; for otherwise the glutinous compound would prematurely assemble and fall inert to the bottom of the tun, leaving an inefficiency of its soluble matter in the must, to complete the decomposition of the saccharum.

Worts fermented at the proposed low temperature retain their own native air, that is, their carbonic acid gas, longer and in greater quantities, the process being of a nature so calm, from the absence of much heat and motion, that it does not expel the globules and force them away, except when in excess; having no opportunity for escape until it is poured into the goblet or cup, when it will produce a brilliant and sparkling appearance, equalled only by its delicious, light, aromatic, and spirituous properties.

It is well established in the minds of those who derive correct ideas of effects from the investigation of causes, that the shorter the column of the fermenting fluids, the less is the pressure on the lower constituent atoms of the mass, and with the greater ease do its elements move, act and react on each other, and change their constitution by partaking of the new arrangements and properties enforced by their decomposition. Upon this principle we may account for the motive of the Bavarians in adopting the wide fermenting vessel, besides the object of facilitating the absorption of oxygen from the atmosphere by the gluten. The shallowness of the fermenting tuns also prevents the accumulation of superfluous caloric, and brings the main body of the wort into contact with such of the precipitated yeast as may have coagulated and fallen, through the cooling influence of the attemperating media.

The system of little or no boiling has for one of its chief objects facility of fermentation at temperatures extremely low; and no good opportunity should be lost, nor should any scheme be omitted, in carrying out the principle to its greatest and most advantageous extent; but it should be nevertheless understood, that the same quantity of carbonic acid gas, and also of caloric, is generated in low fermentations as in worts attenuated at any higher degree of temperature, provided that the former and ultimate densities are equal, or, indeed, in all other instances of similarity, in the commencement and issue. In the former process the heat, &c., is absorbed and removed by artificial means; but in the latter it appears more evident from being allowed to accumulate, and to accelerate the process. Hence the difference of time occupied by each; but it is not impossible to cause the cool fermentations to be as expeditious as the others, if the end were desirable.

In summer brewings, the trade usually attenuate so as to insure just sufficient alcohol to check a further decline of the remaining saccharum; but this design is commonly frustrated by the danger of the whole gyle becoming yeast-bitten; and by avoiding this one calamity, they often incur another, or perhaps more than one, such as fretfulness, cloudiness, sweet clamminess, and ultimate acidity; so that in a warm atmosphere, or in a situation affected by a sudden transition or variation of caloric, or any heat above 55°, the attenuation of the saccharum never can be uniformly perfect, nor can the alcohol be secure from the attacks of the oxygen; for the ordinary heat of pitching the worts is seldom below 56°, and this of itself is sufficient to decompose the alcohol, which decomposition increases with the rising heat of the fermenting gyle, in some cases, as has been shewn, exceeding 80°; whereas by the plan now proposed, the fermentation will be closed and perfected, and the ales can be racked off, at a temperature many degrees lower than that at which they have ordinarily been pitched, and can never exceed that at which they leave the refrigerator, or from 45° to 52°. There is little danger of yeasty ales, or of extreme injury from either high or low heats, in the breweries of experienced and skilful managers, whose wisdom has adopted the artificial cooling means of attemperators, and other similar necessary implements.

As the fermentation has proceeded with little variation and no interruption, and as the alcohol is unmolested by the oxygen, even at this highest heat of 52° F., and as the very limited supply of heat throughout the process causes all matter which favours acetification to become insoluble, and consequently harmless, and of easy ejectment or precipitation, so are the liquors drawn off uncontaminated, either by yeast or by acidity. Such fermentations are also out of the influence of light, the circulation of varying currents of air, and their volatilization. The aromatic oil generated during the fermentation is also retained, which increases the pungency and spirituosity. The alcohol formerly lost being converted into acid or ether, the necessity for an enlarged quantity to be produced to shield the acrid taste, and to ward off acidity as long as possible, is all saved here, so that fewer materials also are wanted to make beer of the same strength. This stands fully exemplified already; in addition to which, the author can verify that this kind of fermentation has often been practised upon worts from 22 to 36 lbs. *per* barrel, which had been extracted and hopped according to the new theory as here established; that the heat of the fermenting gyle never exceeded 45°; that the attenuation was in every instance much lower than on the ordinary plan of fermentation, the time of the process having varied with the density of the wort, and occupied from two to three weeks in each case; and that the ale so produced is brilliant and highly spirituous, and very rich, though not in the manner called luscious. Indeed, experience proves that ales brewed upon these principles, are the most manageable during any part of the process, and are capable of the nicest modification either in flavour or spirituosity.

> "Nor wanting is the brown October, drawn
> Mature and perfect from the dark retreat
> Of thirty years; and now his honest fount
> Flames in the light refulgent, not afraid
> E'en with the vineyard's best produce to vie."

Thus, then, is perfected in greater security, a purely vinous fermentation; and the correctness of the foregoing will be further admitted when we consider that the lower we keep the heats of the fermenting tuns during the whole process (provided the ultimate transformation of the sugar is as perfect as we wish, and its transparency speedily secured), the finer and sounder will be the ales of such worts, and the longer they will retain their fresh and spirituous qualities. On the contrary, the higher the heat, the more rapid the fermentation, and the more are the most volatile parts of the beverage dissipated with the carbonic acid, whereby its flavour and strength are not only deteriorated, but may be totally lost; for the capacity of the air above and around the tun, is increased and rendered fitter for the attraction and absorption of the spirituous vapour and fine aroma, by the radiating heat of the tun itself. Even after such ales are bright, and they will not at all times readily become so, they will be far inferior in strength and flavour, and in every keeping quality, to those fermented in cooler situations, and at a lower heat. The higher the heat of the tun, the more numerous are the particles of yeast, &c., held in solution, and the more firmly are they incorporated with the liquor, and hence its turbidity and one cause of its early sourness.

TUN-ROOM ATTEMPERATORS.—In reviewing the various improvements brought into the brewery prior to 1841, the introduction of attemperators into the fermenting vessels, must be considered the greatest and most valuable. The first was introduced by Dr. Shannon in 1808, and is now called the "Portable Book Attemperator;" the idea, however, gave rise to a variety of shapes and contrivances, till after the lapse of a few years, fortunately for the public, competition in the brewing world increased, and their utility became better understood; but not till lately did they become generally known. Those now in most common use are coils of copper tubing coated with tin, fixed upon brackets or upright iron standards, 12 or 20 inches from the sides of the interior of the rounds or squares in which they are inserted; but they are all inadequate to the purposes for which they are intended, though capable of being enlarged in their dimensions, applications, and use;

this is owing to their limited length, their cooling medium, which is their surface, not being adapted to carry out the principle of extracting the caloric in sufficient quantities, and of overcoming the influence of the external atmosphere in a decisive and effectual manner. Of these attemperators, some notice has been taken in Chapter XI. of this work, p. 286, &c.; and some others now in use admit of the two following improvements. Instead of merely conveying the cold liquor into the body of the fermenting fluid, and thence directly away to *waste*, they should be made stronger, to enable them to withstand a greater pressure from the column of water that may press upon them, if carried up to a back placed above. The cold liquor should be let in near the bottom of the tun, and circulate its course upwards through the yeasty head, a few feet above which the tube ought to take a horizontal zigzag form, and ultimately continue a direct course upwards, into a second liquor-back; by which extension of the cooling means, the heated carbonic acid gas and atmospheric air, &c. &c., convened or hovering above, would be cooled, condensed, and rendered similar in effect to a natural favourable season, less attractive and absorbent of the spirituous and aromatic vapours brought over by the ascending caloric, which, under circumstances, escape from the gyle in warm weather in no small quantities, to the impoverishment of the article.

No little art and practice are essential to working attemperators of the simplest kind. But these schemes, taken as a whole, are invaluable under proper management, if only in their minor application of rectifying any misfortune arising from neglect, impatience, or accident, in the pitching heat, or extreme or sudden atmospheric changes; as water may be employed either hot or cold, as occasion requires. Although the metallic tubes are nearly allied in principle, the use of them by their respective managers is dissimilar; and moreover, *both* parties vary in their management, according to the circumstances of talent, custom, or necessity. Still a brief description of that which is conceived to be the most consistent and successful course of practice may be necessary.

The flavour of malt liquors depends as much upon the degree of heat experienced during the fermentation, as upon any other distinct cause, the quality of malt and hops not excepted; for the more boisterous and violent the heat becomes, the ranker and more acrid is the flavour, and *vice versâ,* mildness produces mildness. Those who depend upon nature, therefore, and work without any attemperator, can seldom make a full flavour, with a sufficient degree of spirit in their ales, during the warmer months of the year; but with a good apparatus, instead of submitting to the external influence of a hot atmosphere, the redundant heat accumulated by the vigour of the fermentation can be extracted, a gradual decomposition of the worts, at a comparatively moderate and secure temperature, can be effected, and an article tolerably uniform in flavour can be ensured at all seasons. Immediately after the vinous action has commenced, cold liquor may be passed in a gentle and regular stream through the attemperator, just fast enough to allow the generating heat constantly to have the ascendancy, and to increase at the rate of one degree for every three or four pounds of attenuation in ales of moderate strength; and for the stronger brewings it may be necessary, and probably more convenient, that the heat should increase yet a little faster; but the cleansing point will, of course, depend upon destination as well as strength: if for immediate consumption, it may be fixed at from

2 lbs. to 4 lbs. below one-half of the original density. When the proper period has arrived, and where the place affords plenty of square-room and water, the skimming process can be safely commenced, and with advantage, or the fermentation can be finished in the square by skimming off the yeast tolerably clean, occasionally repeating the operation during the following 18 or 24 hours; and the cold liquor must also be turned off until 2 or 3 lbs. more are attenuated, and then the processes of skimming and fermentation ought to cease. Recourse must again be had to the attemperator, and the heat of the gyle must be reduced as much as possible, so that the suspended yeast may now fall to the bottom; and in a day or two more the gyle will be fit to cleanse, or rather to rack, the skimmer and cold water having cleansed it already; therefore, it may at once be put into the casks to be sent out.

This is the principal object of cooling as low and as speedily as possible, though in winter care should be taken not to cool below 49° after the fermentation has closed; for although the temperature of the store may affect it, yet the excitable yeast is not present in quantities that can cause immediate mischief, or render the necessity of leaving the bungs or shives out as long as is usually done, to prevent fretfulness, and to secure early and permanent transparency.

A custom prevails with many who use the skimmer, as with others who cleanse into pontoons, of employing wheat-flour mixed with salt, to be wrought into the gyle after the first or second skimming; the professed object with some being to stimulate the fermentation, and create carbonic acid gas to float the barm upwardly, while others consider it to have just the opposite effect of retarding the further progress of the fermentation; and recently, a few have abandoned the flour to substitute bean-meal; each in his own view supposing the latter to have a better effect; though of these two materials, from their widely different constituents, as published at p. 26, and subsequently explained, they appear to know exceedingly little. Doubtlessly, as a reviver of decomposition, wheat has the advantage, because it contains a large quantity of the necessary constituent gluten, which acts as a ferment on the unattenuated mucilage, &c. of the must; but beans, on the contrary, as has been examined into at p. 52, appear to be destitute of this azotised ingredient; therefore, whatever be the value of the assistance given by this meal when decomposing, it must chiefly depend upon its meagre supply of albumen; and peas, composed of C. 35·74, H. 5·4, N. & O. 39·37, ashes 3·49, water 16 *per cent.*, are so much like beans in their composition, that their disqualification appears as pronounced at p. 51. Salt is a retarder of the process, therefore it cannot answer the designs of both parties alike; indeed, were they who use either to examine the constitution of the yeast that succeeds this corrective addition and rousing, they would perhaps discover for the first time, that, besides the glutinous composition of the extract, it consists of nearly the whole of the flour or meal so united. The gases disengaged from the must by the mechanical agitation, seize immediately upon the particles of the floating flour, and adhere to them, buoying them up so rapidly at the surface, that no time is afforded for their decay, or even for their saturation, neither at the same time does much yeast come up with them. In short, the utility of either, with whatever agitation it may be used, is altogether so questionable, that the author's experience convinces him that he is better without the trouble, risk, and expense of them. According to Booth, *sal prunella*, mixed with wheat-flour, is used at cleansing to promote the *discharge* of yeast, or previously to prevent languor.

Many London brewers of the first respectability annually waste loads of one or other of these alleged correctives, evidently to their own detriment, for they have been so long habituated to the practice, as to combat any opinion to the contrary: some, however, see the error and act accordingly.

CHAPTER XV.

FERMENTING PLACES.

DANGER OF NEW OPINIONS—NATURE SUPERIOR TO ART—PERENNIAL STANDARD—CONSTANT TEMPERATURE VAULT—PROOF OF ITS NECESSITY — EXPERIMENTS — RESULTS AND REASONINGS — APPROPRIATE APPARATUS—THE CALORIPHAGON.

NOVELTIES are not always palatable. Many of the great luminaries who shine in the firmament of science and literature, suffered martyrdom for their opinions, as abettors of treason or dealers in magic or demonology; and instances are on record wherein even sensible men have joined in the clamour; as to wit, Sir Walter Scott, so long "the great unknown," was one who laughed at the "*monomaniac*" that first proposed to light the streets of London with gas; and the philosophic Brougham had an equally unfavourable opinion of propulsive locomotion by steam: but both have outlived their prejudices; the one presided over a gas company, and the other sits in numerous steam committees;—as praisers of Murdoch, Watt, and Stevenson.

Reason and science have now so far triumphed as to humanise the mind, and to have caused men to become free enquirers and cool deliberators, and in a great measure to have laid aside their antipathies. Their mightily influential rays are now expanding to the embracement of their final object, the prosperity and ultimate happiness of all mankind; the projector of the new *locale* of operations, therefore, has no fear that he shall follow Socrates or Galileo in his fate; or that he shall have to encounter such difficulties as beset Bacon, Faust, or Petrarch; for he now knows that, like Jenner, he is "suspiciously believed," because the fact speaks openly.

Having endeavoured, with as much plainness as his ability will allow, to point out the influences of the changeable British climate, and of the variableness of locality, as two of the great impediments in the way of constitutional perfection in brewing; having, in the exposition of facts, and the development of a series of principles, erected a beacon, however rude and dim, to guard the brewer against error likely to be productive of injury towards himself and the consumer; having, in short, prepared him to enter upon the work of Fermentation, by which his character as a manufacturer of a staple article must either stand or fall; the author conceives that his duty now is to prove to his readers, and strongly to impress upon their minds, the important truth that to whatever degree of minuteness, in imitation of the operations of nature, the powers of art may be brought, still art is an insufficient substitute for nature, weak as an opponent to her, and oftentimes, as in the business before us, an unstable ally, if not a treacherous alien.

Apparently, fermentation is the general means which nature employs in the decomposition and reorganisation of her works; under its influence nothing is lost, but merely changed in form and constitution, situation and tendency; and according to the extent of the exciting and perpetuating powers, such as moisture, heat, motion, &c., the principles of which are beginning to be understood by maltsters, brewers, vintagers, distillers, vinegar makers, and bakers; or by those of them, at least, who have opened their ears and eyes to the voices and writings of experimental chemists and reasoning philosophers. To attempt, in a dissertation on practical brewing, a general critique on the various productions and theories of all the eminent authors well and practically acquainted with vegetable chemistry, would be presumptuous: a person, notwithstanding, who has attentively perused their several productions, and weighed them in the scale of comparison, may be pardoned, should he advance and maintain a centred conviction, not recognised or even seen by any of them. His reason for craving an indulgence in the latitude of his thoughts, may strengthen him with the impression that the system which he propounds is of as much national importance, both to the revenue and the public, as it is novel and practicable within itself, and unique in its disposal and its real consequences to all. This is

The Constant Temperature Vault.

Extraordinary measures are necessary for the production of corresponding results; and it is clear from what has been shewn, and from the internal construction of breweries, as now erected, that the fermenting process now discovered to be essential and peremptory, cannot be regularly conducted in any of them; as they are all subject to the extremes which lead rapidly to vicissitudes and disasters, such as neither fire nor water, nor both, with men to help them, can control, though only under such as are termed "moderate excesses of temperature," occurring at all seasons of the year, whatever may have been done by sinking the vats below the floor. Age after age, as long as the climate endures, those changes, and greater than any that have been noticed, will succeed one another; and hence the necessity of devising a place that shall be uniformly so much warmer than one extreme, and cooler than the other, that the influences of weather and season cannot affect it, but it shall be exempt from both, and from all approximations to them. The principle of selection is plain, and is at once this: the temperature, to be uniform as regards its component material and the circulation of its air and waters, must be a deep hole in the earth; for nothing *upon earth* that has been discovered or thought of, will answer the conditions of this grand problem; nor does it at present appear capable of solution in any other way; but if the place be already formed, so much the better.

Through the investigations of Humboldt, Laplace, Arago, Bischoff, &c., the doctrine is fully established, that the centre of the earth is very hot, and that the central heat is decreased in all directions towards the outside of the ground, a stationary temperature obtaining at a comparatively slight depth, which is determined by the course of an "*Invariable Stratum*," below which the internal increase amounts to 1° F. for each 15 English yards deep; but the contrary fact is observable, that the temperature of the ocean decreases proportionally; so that in various latitudes, where the surface heat, according to Sabine and Kotzebue, is 83°, it reduces to 77° at 250 fathoms, 75° at 300 fathoms, and $55\frac{1}{2}$° at 1000 fathoms deep; and, according to Captain Ross, at 60° 44′ of latitude, the temperature was 30° at 100 fathoms, 29° at 200, 28° at 400, and 25° at 600 fathoms; so that every where the bulk of water contributes to the coolness of the place: a fact which is pretty well exemplified in a foregoing chapter, and points out the necessity of having plenty of this useful fluid always at command.

In the work on Physical Geography, in vol. iii. of the Society's Natural Philosophy, is a note stating that M. Lacroix, in his treatise on the same subject, says, that "in the caves below the Observatory at Paris (lat. 49°), about 80 feet below the surface, Fahrenheit's thermometer stands between 52° and 54°, scarcely ever varying 2°; while above, the difference of temperature between summer and winter sometimes exceeds 90°. In the salt mines at Wielicza in Poland, lat. 50°, from the depth of 320 to that of 745 feet, the thermometer stands at about 50°. At Cairo in Egypt, at the bottom of Joseph's well, 210 feet deep, it is stationary at 70°; and in the mines of Mexico, lat. 20°, 1650 feet below the surface, at $74\frac{3}{4}$°." In these depths we see how the temperature increases on approaching the equator, and, as we have seen, approaching the earth's centre also; and they shew us, which is most important here, that an uniform heat may be found and maintained throughout the year, without dreading the uncertain atmosphere of July and August, or trusting to the equally uncertain variations experienced in October and November, or in the alternations of spring.

The mean temperature at the equator being $81\frac{1}{2}$°, the theorem for other places, as laid down by Phillips in his Geology, is $81{\cdot}5 \times$ *cos. lat.;* therefore, lest the observant reader should experience any difficulty in finding the Invariable Stratum, the following Table of the cosines of latitude for England, taken at distances of five minutes from each other, is compiled for his information from Dr. Hutton's Mathematics, the earth's radius being always considered as unity. The Table is here given, because the principles are not accessible without considerable expense.

Table of Cosines of Latitude for England.

50 Degrees.		51 Degrees.		52 Degrees.		53 Degrees.		54 Degrees.		55 Degrees.	
Min	Cosine.	Min	Cosine.	Min	Cosine.	Min	Cosine.	Min	Cosine.	Min	Cosine.
0	·642787	0	·629320	0	·615662	0	·601815	0	·587785	0	·573576
5	·641673	5	·628189	5	·614515	5	·600653	5	·586603	5	·572384
10	·640557	10	·627057	10	·613367	10	·599489	10	·585429	10	·571191
15	·639489	15	·625924	15	·612217	15	·598325	15	·584250	15	·569997
20	·638320	20	·624789	20	·611067	20	·597159	20	·583069	20	·568801
25	·637200	25	·623652	25	·609915	25	·595991	25	·581886	25	·567604
30	·636078	30	·622515	30	·608761	30	·594823	30	·580703	30	·566406
35	·634955	35	·621376	35	·607607	35	·593653	35	·579518	35	·565207
40	·633331	40	·620236	40	·606451	40	·592482	40	·578332	40	·564007
45	·632075	45	619094	45	·605294	45	·591310	45	·577145	45	·562805
50	·631578	50	·617951	50	·604136	50	·590136	50	·575957	50	·561602
55	·630450	55	·616807	55	·602976	55	·588961	55	·574767	55	·560398
60	·629320	60	·615662	60	·601815	60	·587785	60	·573576	60	·559193

Example 1.—To find the mean temperature at London, in latitude 51° 40′ N. cos. 51° 40′=·620236; and 81·5 × ·620236=50·549234, or rather more than $50\frac{1}{2}$°.

Example 2.—If the exact latitude does not occur, as at Devonport, lat. 50° $22\frac{1}{4}$′, we have cos. 50° 20′=·638320, and cos. 50° 25′=·637200; difference, 1120; then say, $1120 \times 2\frac{1}{4} \div 5 = 504$, and ·638320 − ·000504=·637816, which × 81·5, is 51·982004, mean heat there.

To prove the correctness of this theory as a general principle, we may refer to Professor Bischoff, who shews in his "Researches," that London lies 14 feet above the sea, and that the mean temperature of the soil is 51·01°, which is half a degree more than deduced from the Table. This is in some measure confirmed by Mr. Roebuck's experiments, who found that, according to three years' observations, the mean temperature of the London atmosphere was 52·16°, and that of Edinburgh 47·68°; and he adds that the mean temperature of the springs was 51,01° about London, and 46·985° round Edinburgh; so that the influence of water in each case affects the surrounding medium about 1° F. See Philos. Trans. 1775, p. 450.

Past experience has nevertheless shewn that the mean temperature of a place is often below that of a spring whose temperature is constant throughout the different seasons of the year; and Bischoff observes that the mean temperature of the soil cannot be deduced from the observations on wells *with exactness;* but that an approximate result may be found by trying many different wells and taking an average. With constant temperature wells, however, we may venture an analogy to connect a fact, and may safely deem it conclusive.

Taking the external decrement of variation at 1° F. for every 265 feet, the medium between Dalton's and Nixon's statements; and believing, with Phillips's authorities, that the internal increment below the invariable stratum is 1° F. in each 45 feet, we may infer that a stationary heat exists at a depth not materially affected by either of those graduations, but between them. The internal temperature of the earth does not, at all times and in all places, entirely depend upon the latitude, or upon the depth of the place any more than the temperature outside does upon the elevation; for the conducting powers of the soil are affected by the circumstances noticed in a preceding chapter, and by others of less moment. In our latitude, the annual mean temperature generally occurs about April and October, or after the equinoxes; and the *maximum* and *minimum* on each side are extremely irregular and uncertain, as already demonstrated, and yet still a medium *must* obtain.

The following corroborative testimony in favour of the present theory is from the "*Gallery of Nature and Art*," by John Hunter, M.D. F.R.S. "The great difference between the open air and that of deep caverns and mines, has long been taken notice of, both as matter of curiosity and surprise. After thermometers were brought to a tolerable degree of perfection, and meteorological registers were kept with accuracy, it became a problem to determine what was the cause of this difference between the heat of the air and that of the earth; for it was soon found that the temperature of mines and caverns did not depend on any thing peculiar to them, but that a certain depth under ground, whether in cave, or mine, or a well, was sufficient to produce a very sensible difference in the heat. In observations of this kind there was, perhaps, nothing more striking than that the heat in such caves was nearly the same in summer and winter, and this even in changeable climates, that admitted of great variation between the extremes of heat in summer and cold in winter."

The Parisian experiment is thus confirmed by the theorem: the cosine of 49° is ·656059, which being × 81·5, gives 53·46881° for the temperature at that place, which is within the limits noticed by Lacroix. The late Dr. Hutton, alluding to this subject, and particularly to the French test, says, in his *Mathematical and Philosophical Dictionary*, that it has been found by observation, that the same degree of heat occurs in all subterranean places at the same depth, varying a little at different depths, but is never less than 36° F.; and that at 80 or 90 feet, and sometimes much less, temperature deviates little, and is generally about the mean annual heat. With respect to the Observatory at Paris, he is more minute than Lacroix; for he says that the temperature there, at 90 feet deep, is $53\frac{1}{2}$°, varying only about half a degree *in very cold years.* He also informs us that Mr. Boyle kept a thermometer a whole year in a cave 80 feet deep, and found it stationary the whole time; and that Dr. Withering made a similar experiment on a well at Edgbaston, near

Birmingham, the temperature of which was 49° *in* (not *through*) every month of the year 1798. This is another convincing proof that Phillips's geological theorem is true; for the natural cosine of the latitude of Birmingham, 52° 30′, is ·608761 by the Table, $81\frac{1}{2}$ times which is 49·61402°; from which, if we deduct only half a degree for the proximity of water, we have Dr. W.'s standard to a nicety.

Dr. James Johnstone, of Birmingham, in an examination before a Committee of the House of Lords on the subject of the Brighton Railway tunnel, stated his opinion, that if a tunnel 600 yards long were 80 feet below the earth's surface, it would have a constant temperature of 52° or 53°; and consequently, that in the heat of summer, which is estimated at 76°, the vicissitudes would be 20° or more on immerging into and emerging from the tunnel; and that, on the contrary, when the wintry atmosphere was down at the freezing point, or 32°, the iniit and exit would also cause a difference of 20° in the contrary extreme; and that he did not think it possible to ventilate such a tunnel, so as to bring it to approximate to the existing state of the atmosphere, because the interior must necessarily take the temperature of the surrounding parts. The latitude of Brighton is 50° 50′, or thereabouts, and its cosine ·631578 gives 51·47361° for the mean temperature or invariable stratum, which by the theorem lies rather too near the earth's surface, but is full as high as can be required for a fermenting heat; and in general, in the south of England, the mean temperature would be found quite high enough without excavation, did not the external influences affect it to some depth.

Bischoff remarks that in mountains 7000 or 8000 feet high, the temperature of springs, with few exceptions, is from $38\frac{1}{2}°$ to $41°$, and that this shews how springs descending from great heights *bring down cold with them;* and, as he says, of course the more copious they are, the quicker their subterranean course, the steeper the mountains, or the nearer their channels approach the vertical position, and the less they are adulterated on their way with waters of a different temperature, the greater is their accompanying "degree of cold." Without speculating in such lofty altitudes, by taking the heights of some of our larger and smaller hills as examples, we have the Observatory at Greenwich at an elevation of 213 feet, in latitude 51° 29′, and the Wrekin in Shropshire, 1320 feet, in latitude 52° 40′, giving the result and temperature by the Table 50·75347° at Greenwich, and 49·42576° at the Wrekin; and as the increments have been taken at 265 feet for the first external degree, and at 90 feet for the first internally, measured from the point of mean temperature, and 45 feet afterwards, it follows that in a cave dug to 100 feet within the bowels of the Wrekin, the heat would correspond with that at the Observatory; and that at all subsequent depths after the first 90 feet, the internal heat at Greenwich would be $1\frac{1}{3}°$ more intense than in the Shropshire hill, though the altitude of the one position would still remain at 1100 feet higher than the other; and this depth of 90 feet for the first degree, may be estimated from theory as a correctly constant step, being a fair medium between the 265 feet of external atmospheric decrement arising from elevation on the one hand, and the afterwards constant increment of 45 feet *per* degree F. of subterraneous heat on the other.

The following Table, constructed on the same principles as the preceding, shews the depth to which theory would require an excavation to be made in England and the lowlands of Scotland, according to the parallels of latitude respectively crossing those places, in order to obtain the uniform high pitching temperature of 52°; from which it will be perceived, that in the extreme south of England, it would be almost impossible to obtain that standard without previous ascent, were it not for a cool constituency, or for maritime proximity rendering the situation cooler than the isothermal continental standard; for though the theorem gives a higher result at the lower latitudes, experiment confirms the fact that there, as in mid latitudes, the 80 or 90 feet of perforation will secure uniformity of temperature: a proof that the coasts of the "sea-girt isle" are considerably elevated above the continental level. The depths here apportioned to the different latitudes are calculated at 30 yards for the first degree of deficient latitudinal heat, and at 15 yards for each of the others; that is, multiplying any deficiency *less* 1 by 15, and adding 30 to the product, or multiplying 1 *more* than that deficiency by 15; a mode which will be found novel and conclusive in principle; but it does not by any means follow that those depths are to be rigidly insisted upon, but that the *maximum*, especially in the higher latitudes, should be avoided in practice. The only use of this Table is to shew that, philosophically considered, the northern parts of the kingdom admit of a lower standard temperature than the southern by some degrees, and that the worts ought to be pitched accordingly.

Table of theoretical Excavations to obtain an uniform Heat of 52°, according to the Latitude of each Place named.

Latitude. D. M.		Natural Cosine. Decim.	Mean temperature near level of the sea. Deg.Dec	Deficiency of temperature to complete 52°. Deg. Dec	Depth required to be dug. Yds. In.		Names of Places lying under or near the same parallels, and therefore giving like theoretical results, as intermediate Places must give intervening results.
50	0	·642787	52·38714	None.	None.		Ruan, Cornwall; St. Martin's, Scilly; Eau, France.
50	30	·636078	51·84035	0·15964	17	14	Bodmin, Callington, Ashburton, Portland Bill.
51	0	·629320	51·28958	0·71041	25	24	Hartland Quay, Taunton, Cranborne Chase, Downton.
51	30	·622515	50·73497	1·26502	33	35	London, Llandaff, Maidenhead, Mouth of Thames.
52	0	·615662	50·17645	1·82354	42	13	Tewkesbury, Fishguard, Buckingham, Neyland.
52	30	·608761	49·61402	2·38597	50	28	Birmingham, Plinlimmon, Market Harborough.
53	0	·601815	49·04792	2·95207	59	10	Newcastle-under-Lime, Malpas, Sleaford, N. of Norfolk.
53	30	·594823	48·47807	3·52192	67	30	Manchester, Leigh, Doncaster, Caistor, Kirton.
54	0	·587785	47·90448	4·09551	76	16	Bowland Forest, Mouth of Lune, Knaresborough.
54	30	·580703	47·32729	4·67270	85	3	St. Bees Head, Shap, Yarm, Guisboro', Whitby.
55	0	·573576	46·74644	5·25355	93	29	South Shields, Longtown, Annan, Glenavon Bay.
55	30	·566406	46·16209	5·83790	102	20	Cheviot Hills, Jedburgh, Ayr, Moss, Tweedsmuir.
56	0	·559193	45·57423	6·42576	111	14	Loch Tarbert, Inverneil, Falkirk, Dunbar.

It appears hence, as before observed, that 52° is too high a temperature for Scotland and the north of England; that the theorem does not produce less than 52° as a medium round the Lizard of Cornwall; and that there also its principle will amply apply, if 1½° be allowed for water and irregularity of surface, as the perennial standard in that most southern latitude is little above 52°.

Let the reader pay such attention to this Table, that its design be not misunderstood. It is correct, and agrees with the temperature of Paris, Limerick, the midland counties of England, and all other places not maritime, or affected by local causes: therefore, let not any one suppose, that, because theoretical examination and comparison give the above results at the extreme, in accordance with a fixed principle of 52° as an isothermal point, the invariable stratum lies 100 yards deep in Scotland, and is not to be found in Cornwall; for a philosophical theory thus laid down does not represent an absolute fact, but is merely an index to a system, confirmed by philosophical tests. If it were held true here, as in extensive territories it is, even then the brewers of the north would not have to dig deeper than some 100 yards or so, however elevated their sites; and the southerns would have only to select temperate situations, and there to carry on their cooling operations according to the Bavarian plan, arming themselves against excessive variations. The Bavarians stow large blocks of ice between their casks: well they may, to keep down their temperature at 50°, when their perennial stratum is full $3\frac{1}{2}$° higher.

To illustrate this doctrine by other proofs, let us refer to the Artesian well near Paris. During the progress of the works at Grenelle, where this well is sunk, opportunities of ascertaining the temperature of the earth at great depths were not neglected; for knowing that the thermometer always stood at 53° or $53\frac{1}{2}$°, at the depth of 30 yards, in the well of the Paris Observatory, they found it to do much the same at Grenelle, that at 440 yards it rose to 74°, and at 550 yards to 79°; and when they bored to 602 yards, the temperature of the water which rose to the surface was 81°, which corroborated their previous calculations to a nicety. The increase, therefore, in that district appears to be 8° F. to each 20 yards of internal descent; which is deeper than as before named, owing probably to the cool quality of the strata, being chiefly limestone, chalk, and clay; but shews at once that if the brewer digs beyond a certain depth, his worts will soon be in danger; he has therefore only to ascertain his position by means of his thermometer, and where it once takes its stand at the proper indication, there to take his also. The author sent down to Ironbridge, in Shropshire, to his agent there, correct thermometers, previously proved, requesting him to take some experiments in that romantic glen, for the purpose of publication in this work; and the result is nearly as he anticipated.

The spot selected for the first experiment was at an elevation of 150 feet above the Severn, in the middle of a defile, hollowed into caves by blasting away the upper stratum, which is of limestone. These caves lie open to the atmosphere, and are freely ventilated; so that an allowance of some 2° or 3° must be made for the influence of atmospheric air in producing rarefaction and condensation, according to external season. In this instance, the temperature without was 57° on going in at 6 A.M., and 58° on coming out at 8; but, on exploring the interior, the thermometer gradually fell to 52°, where it remained nearly stationary throughout, but rose half a degree near the foot of a shaft 64 yards deep, and 160 yards from the entrance; and at one place, where water dripped in from above, the temperature was somewhere about $51\frac{1}{2}°$ or $51\frac{3}{4}°$.

Several other trials were afterwards taken, all tending to confirm the belief that the temperature of these caves at any distance above 25 yards from the entrances, (aspect S.) ranges constantly between 50° and $53\frac{1}{2}°$ F. It is worthy of notice, that this temperature is dependent on the depth below the local surface, and not on any minute comparison with the level of the sea, above which, as appears by various surveys of the Severn to ascertain its fall, Ironbridge is about 130 feet.

Another experiment was taken on the Benthall or S.W. side of the river, within the entrance of two orifices, there termed "footrids," or tramways, directly overlooking the bridge in a northern aspect, and declining inwardly from elevations of 93 and 100 feet above the river. In the lower of these, at 40 yards within, which was as far as the light from without would allow the index to be distinctly read, it indicated as many as 56°; but in the upper, which was abandoned by traffic, the temperature at the same internal distance, and more on the decline, was no more than 54½°, where the atmosphere, which was at 64° without, had free and direct access.

Let not the brewer despair of finding a perennial and applicable temperature, reside where he may, even be it in the vicinity of coal mines; for the author having seen some valuable information in the "Chemist," respecting the mines and miners at Elland, near Halifax, by J. S. Hiley, Esq., M.B.; and having perceived, through him, that the mines there are shallower and more humid than those in Shropshire, instituted enquiry, and obtained from Mr. Hiley the important particulars, that the average temperature of mines of the depth specified, (30 yards,) amounts to about 51° Fahrenheit; that the temperature of the different springs in the parish of Halifax ranges between 47° and 52° F. at about 20 or 22 yards from the surface of the ground; that below this point the thermometer begins to ascend, standing at 26 yards down at 53°; at 30 yards down at 55°, at 40 yards down at 56°, at 50 yards down at 57°, and at 60 yards down at 60°. Another observation in a different shaft, gave the following results: at 80 yards from the surface the mercury rose to 58°, at 100 yards to 59·5°, and at 126 yards, which was the bottom, to 61° F. The temperature of this shaft, between 20 and 50 yards from the top, was pretty nearly the same as in the first-mentioned experiment.

The whole of these experiments distinctly prove that an "*invariable stratum*" of temperature, nearly identical with the medium of heat incidental to the latitude of locality, is every where to be found within a hundred feet of the earth's surface: hence, having clearly discovered the *locus* where Nature will not distinguish between January and the Dog-days, we can here safely establish our place of business, and carry on the process of fermentation without hindrance. The worts having cooled as described in the preceding chapters, and necessarily kept at an uniform temperature of from 45° to 52°, or lower, the tun-room being constantly supplied by a running stream, and its air being influenced by the solid earthy bodies and exuding waters that surround it, every thing in contact with it or with the water, is kept at an uniform heat; the running waters must also surround every part of the fermenting mass except at the surface, and the vault must be made sufficiently capacious *ab initio*, for that purpose: thus the natural propensity of the mass to advance in heat when fermenting, will be curbed; for these waters will be continually abstracting such extra heat as fast as it is generated, and will carry it away through a channel which must be made for that purpose; so that the fermenting liquor, from the commencement to the end, can never exceed, under proper care, that one permanent heat. For this, various potential reasons may be assigned: 1. Saccharine liquors readily undergo the vinous fermentation unaided, at between 40° and 50°. 2. Alcohol, whether mixed with honey, or whether emanating from malt, or mixed with malt liquor, of which it is not native, requires heating to about 50° before it absorbs oxygen; and hence it is that we conclude, 3. That by keeping our extracts *below* the heat necessary for the combination of oxygen with alcohol, from the time that such extracts leave the coolers or refrigerator, through the full period occupied in their fermentation and during their storage, we shall, by the aid of experimental knowledge in other respects, effectually succeed in manufacturing from malt, hops, and water, with a little yeast if we please, a spirituous, permanent, brilliant, and sparkling *wine*, deserving the name of British Champagne, which will be capable, by due admixture, of improving every foreign wine brought into this country, and of superseding, in fact, if taken solely, except as regards the eccentricities of taste and tasters, even the most notable of those wines, especially as it better suits the habitude and native powers of a constitution reared upon the same soil as the hardy elements from which such Champagne is to proceed. To such the Briton may comfortably say with Burns:

> "Thou clears the head o' doited lear,
> Thou cheers the heart o' droopin' care,
> Thou strings the nerves o' labour sair
> A's weary toil.
> Thou even brightens dark despair
> Wi' gloomy smile."

For as violence in the fermentation will produce acidity, so gentleness will prevent it, and will even cause the *must* (for it cannot now longer be properly called *wort*, when arrived at this stage of its purification) to withstand the shocks of agitation. This has been fully exemplified in the durability of Bavarian beer and the practice of the Champagnois. To prevent disastrous consequences, then, the great object evidently is, to keep the temperature within restrained bounds; and in that focus the energies of the brewer's mind must now centre, and his apparatus must be adapted accordingly.

In order to make the *Constant Temperature Vault* still more perfect as a house of business, the author, in addition to the foregoing, would introduce, as an auxiliary to his other arrangements in the tun-room, the provision of a plan to neutralise superfluous heat at all times, which he has entitled,

The Caloriphagon.

This instrument takes its name from *calor*, heat, and *φάγω*, to eat or devour, and would perhaps with more strict classical propriety be termed the *thermophagon*, or *caloredant;* but signifies, at all events, the *heat-consumer*. When any manual labour or other routine of business is to be performed in the subterranean square-room or stores, artificial light will of course be required; and since every precaution must be taken not to increase the temperature beyond the prescribed limits, that is, to prevent the smallest increase when the thermometer indicates 52°, a lamp of a peculiar construction, and, as far as the author's knowledge extends, perfectly novel, is provided for this purpose; by which it will be seen that every ray will be brought into useful play, without the usual heat accompanying the light. His plan is to envelope the whole light of the tun-room in water; for which purpose he provides, three, four, or five glass cylinders, of different dimensions, so that one may go inside another, and every where leave a space of an inch or two between the interior surface of any one of them, and the convex outside of the next to it, the innermost or smallest containing the light, and the intermediate spaces between these several tubes being filled with cold water, that within the outermost or largest, flowing round the next and over the edge of it, that of the second under the third, and so on successively, these waters gradually absorbing the heat in the order of their approximation to the centre, the innermost passing the water away through a metallic tube fixed in a dome above, which inner tube or pipe will convey off with the waters all the unconsumed carbon and effluvia of the lamp; for an unshielded light will transfer some of its caloric to the atmosphere through which it travels; that is, during the passage of its rays towards the reflectors, which should be a species of hemispheres, reflecting nearly the whole of the illuminating rays upon the objects requiring light. Each reflector should be made to work on an universal joint at its back, with a tightening screw to fasten it in the position it is intended to occupy, in order to direct the cool rays to particular distant objects.

In the next place, the inventor recommends that the drippings of the arch or roof be received on a light curved shield, for which purpose an excellent material will be found in Taylor's patent corrugated metallic roofing, which, to be preserved from oxidation, should be galvanized according to Porter's new process of coating iron with zinc. This contrivance conveys the waters to each side of the room, whence they run under a raised and grated iron flooring, by which means the attemperating and refrigerating property of the waters is rendered available, without occasioning the slightest annoyance from moisture or damp; and although the natural temperature of places thus systematically selected for the new and improved kind of fermentation will of itself in a great measure regulate the heat of the air within, the principle here devised contributes essentially to the comfort and convenience of the persons employed to conduct this department of the establishment. It also aids the general object, by giving great security, and by checking the first and slightest attempt of the fermentation to increase its caloric beyond the standard employed, be it the all-sufficient 52° or otherwise ; for as a current of air accompanies all running streams more or less, so will the motion caused by the numerous flowing waters in the vault, carry away all vapours that are emitted either by the fermenting vessels, or from the bodies of the workmen engaged in racking the "sovereign cordial," or cleaning the utensils.

CHAPTER XVI.

ALCOHOL.

NAME AND CHARACTER — ALDEHYDE — PECULIAR ETHERS — THEORY RESPECTING THEM — STABILITY OF ALCOHOLIC STRENGTH — NON-ACETOUS ANTIDOTE — THE POTENTIAL FERMENTING SQUARE — ITS GREAT ADVANTAGE — SLATES AND SLABS — THE PNEUMATIC LIFE-PROTECTOR — A NEW ETHER — THE MODERN AND PERFECTED SYSTEM OF CLEANSING — THE OCTUPLE FERMENTING, CLEANSING, ATTEMPERATING, AND PRESERVING APPARATUS.

The next subject in the order of progress, is alcohol, to determine which we now proceed, and to mark its properties. The external evidences of disorganisation, such is the hissing heard from within, and the motion to which it is excited, are in proportion to the liquidity, heat, and complex constitution of the decomposing body; but heat is the principal modifier of the whole process, whether it be supplied internally by chemical means, or externally by mechanical agency. As the fermentation of the must advances, its specific gravity becomes lighter, and it is now found to have acquired properties which it never before possessed, the most remarkable and most valuable of which is the *ethereal* part, which the ferment has formed from the hydrogen with some carbon and oxygen. The former rich body is now attenuated; the heat, if left uncurbed, has considerably increased; and the degree of attenuation has been provoked in accordance with such heat; and if the temperature be not checked by removing the ferment, by dividing and cooling, or by stopping the process through such other convenient means, the alcohol will begin to decay, because the second stage of fermentation will now set in, and convert the alcohol, by too great a diminution of its hydrogen, into aldehyde; a general and final dissolution will ensue; and the remnant will be no longer fit for animal consumption, as beer.

What, then, is alcohol?—and what is aldehyde?—and why is the one to be coveted, and the other renounced? According to Liebig, alcohol is a hydrate of ether; the latter being composed of $C.^4\ H.^5\ O.$, and the former of $C.^4\ H.^5\ O. + H.$: that is, ether contains

Carbon	4 atoms	=3·000, or *per cent.*	64·865
Hydrogen	5	=0·625	13·513
Oxygen	1	=1·000	21·622
		4·625	100·

But alcohol consists of

Carbon	4 atoms	=3·000, or *per cent.*	52·174
Hydrogen	5	=0·625	10·870
Oxygen	1	=1·000	17·391
Water	1	=1·125	19·565
		5·75	100·

Or, as the atom of water is compounded of an atom of oxygen with one of hydrogen, the real composition of alcohol is $C.^4\ H.^6\ O.^2$; that is, carbon, *per cent.* as before, 52·174; hydrogen, 13·044; and oxygen, 34·782.

The signification of the word *alcohol* has been a matter in dispute. Some say that *al* is Arabic, and synonymous with *all*; as *alkoran*, the *whole code*; but we go no farther than the Greek, which gives ἀλκή or ἀλκά, *help* or *strength*, and ὅλος, the *whole*; wherefore alcohol contains the *whole virtue* of the wort or must. Here be it noted, as a contrast, that the advocates of total abstinence principles have recourse to bastard roots and an offshot idiom, in order to carry out their measure by terrifying persons of a contrary persuasion, deriving the word literally from ἄλκω, *to burn*, and ὅλως, in the *highest;* and telling us that, like eremacausis, it takes its name from its destructive qualities, as it might with some degree of truth be said to do, were the premises correct, or were it obtained, like spirituous liquors, by distillation only. In such a sense, alcohol might be mistaken for aldehyde, which is constituted of $C.^3$ $H.^4$ $O.+H.$ $O.$; that is, alcohol coerced out of two atoms of its hydrogen, by which means it is reduced to carbon *per cent.* 54·545, hydrogen, 9·091, oxygen 36·364; and it is this subtraction of hydrogen which induces its tendency to become acid, and to perish in that state. This substance, according to Thomson, has a peculiar ethereal and penetrating odour. "When we draw this vapour into the lungs, we lose the power of breathing air. It produces a kind of cramp in the stomach." Moreover, "when kept in a vessel full of air, it absorbs oxygen, and is gradually converted into very concentrated acetic acid." (Org. Chem. p. 302.) It therefore exchanges its water for two atoms of oxygen, because acetic acid is $C.^4$ $H.^3$ $O.^3$, or C. and O. each 47·059, H. 5·882 *per cent.*

The etymology of *aldehyde*, as derived by Thomson, is a contraction of *alcohol dehydratus*, and such, as shewn above, is its character; and Liebig also says that aldehyde is alcohol *minus* hydrogen, acetic acid being formed by the direct union of aldehyde with oxygen. Alcohol, therefore, is the product of *vinous* fermentation, and *aldehyde* of a tendency to the *acetous*. Let the brewer, then, discriminate within himself upon the course which he must pursue to obtain the one, and eschew the other. All things combine in one general warning voice to him, not to permit his fermentations to rise above 50° or 52°; because any excess above this heat attacks the alcohol and weakens its powers, if its existence is not altogether destroyed: indeed, the fact is plain and simple, that the higher the temperature, the greater is the absorption of oxygen and the loss of hydrogen. It is true from experience that malt liquors fermented by artificial means at 45°, in an ordinary summer atmosphere of 70°, will become acid sooner than if fermented at 65° or 70°; which once again testifies that high temperature is not the *sole* cause of destruction to the alcohol; and though the Cambridgeshire ales, which are wrought at 80° to 100°, will keep fresh and sound in a temperature of 40°, nearly as long as those fermented at lower heats, they exemplify a striking difference in flavour and strength. Forlow's heady college ale was thus prepared. Probably in such cases the alcohol has assumed the property of aldehyde, and a change only is wanted to bring on the acetous fermentation. Labouring men who are accustomed to beers fermented at these high heats, may perhaps prefer them to lighter and better; for that some of them are bright enough, must be allowed, and they are inured to their fare by habit; but wo to the stranger who partakes of them! Their effects upon his frame is a prostration of his mental and physical powers, and an attack of stupor, sleepiness, dulness, depression of spirits, and not unlikely headache; all caused by an inclination to aldehyde in the body of the beer.

The circumstance of a hot atmosphere in contiguity with must at a low heat, as 45°, for instance, precludes the possibility of bestowing that time upon it which gentle fermentation necessarily requires; but in this case, though the absorption of oxygen by the must may not create apparent injury, yet the rapidity with which the rarefied air absorbs the alcohol, at once interposes an obstacle not easily to be overcome. It is not necessary that the spirit should be rarefied in the cool must, except at its very surface, to enable it to ascend; but there is an affinity between such hot atmosphere and the spirit and gases, which causes them to unite by evaporation; and this volatility is urged onward by the escape of gases newly formed; but the propulsion and evaporation in a colder atmosphere, do not affect the alcoholic principles to any serious extent, which again exhibits the necessity of a cool situation where to conduct the low species of fermentation. In the next place, though ales fermented under 50° in a corresponding temperature, may be in part subject to the ill effects of heat on being removed into a hot atmosphere, yet the heat will not be so decidedly felt as to cause acetification, because the absorber of the decaying element is not present to so large an extent, it having been purged downwards during a lower, and therefore a more congenial, perfect, and conclusive attenuation; and if the mode here advocated be conducted wisely, or to its fullest extent, so that the liquor may not exceed the specific gravity of foreign wines, it will keep in a pure, fresh, and wholesome condition in any atmosphere, equally with any of those wines if not alcoholised. The low specific gravity of such wines as are brought to this country is generally in a great measure owing to the fictitious alcohol added before shipment, and often amounting to 25 *per cent.*; so that we cannot expect to attenuate down to them in any convenient duration of time; neither would the beer be improved in the estimation of Englishmen by being attenuated so low. Spanish and Portuguese wines do not contain less than from 20 to 30 *per cent.* of alcohol; but the strongest

English ale, if genuine, does not exceed 10 *per cent.* of that stimulant.

If malt liquor be fermented uniformly at 45° by the intervention of the attemperating quality of cold water, in an atmosphere as high as 70°, it will not be so gaseous as that fermented and kept at 45°, because the thirsty hot air, hovering so long over the must, has decomposed or carried off the spirit nearest the surface; and as fast as one stratum is destroyed or evaporated, another takes its place and meets with the same fate. These arguments shew that low heats are safe, whereas a high or fluctuating temperature is uncertain, and generally dangerous; for aldehyde itself, the principle to be avoided, would boil at $71\frac{1}{4}°$, if separated from the nutrimental and more voluminous fluid composing the beer, and is so readily reducible, that if but a *minum* of it be dropped into a vessel filled with moist air, the smell of acetic acid is directly perceptible. (Org. Chem. p. 302.) The author has for a considerable period entertained the idea that malt liquors do not depend for their exciting powers upon the liquid alcohol alone, but that some other property yet unaccounted for exists within them, and this he ventures to call an ether; because,

Firstly.—Although as much rectified spirit as a pint of beer will yield be added to as much water, with a portion of sugar and carbonic acid gas, as will together refill the measure, and this mixture be close stopped and kept some days, so that the contraction and combination of the ingredients may be complete; the compound will not affect the animal system in the same degree as a pint of original beer containing the same quantity of each.

Secondly.—Old bottled ale, or such as in good condition in the wood, or is copiously charged with carbonic and other native gases, excites the circulation and the nervous system, and causes the flow of the animal spirits to become freer and more spontaneous than can be done by new beer.

Thirdly.—That this secondary stimulant is composed of an ethereal fluid, is an argument that is strongly supported by a phenomenon with which grain distillers are well acquainted, called "blowing off," and which occurs thus:—Immediately before the weak foul liquid called "singlings" comes over by issuing from the lower end of the condensing worm, some incondensable gases of a very strong and intoxicating nature, rush out of the worm. These are clearly distinguishable from carbonic acid gas by their extreme lightness and spirituosity; and as the gases, as well as the liquids that pass through the condenser, are equally temperate, we may infer from the specific gravity of carbonic acid gas, that a great part of it would flow down the worm as soon as it left the boiling wash, and parted with its caloric; but not so the ether; for though it left the hot wash even before the carbonic acid gas, its specific gravity would prevent its sinking through the air contained in the worm, till forced out by the accumulation of alcoholic vapour: hence arrives the period of this said "blowing off."

Fourthly.—During the ordinary fermentation of brewers' worts, a portion of each of the elements that contribute to the formation of sugar, gluten, and even water, is emitted from the tun in a gaseous state, the largest portion being of a carbonaceous and acid nature, and the smallest and lightest hydrogenous, but inflammable. On the other hand, if the decomposition is effected at high temperatures, carburetted hydrogen is evolved in quantities so large as to be inflammable on coming in contact with a burning light, and is extinguished only by excluding the atmospheric air; and it is notorious, as before seen from other premises, that the higher the heats of fermenting bodies, the more hydrogen they emit; but whether it emanates directly from the decomposed sugar, or from a secondary condition from decomposed alcohol, has not been positively defined; but in either case the waste of strength is an evident evil.

Fifthly.—It appears hence that an ether is formed at the expense of the alcohol, as indeed all manipulated ethereals are. Common ether boils at 98°; its specific gravity, as compared with atmospheric air, is as 258 to 100; so that it is, like aldehyde, readily formed, and as easily lost in warm situations. The temperature at which malt liquors are usually fermented and stored, is not so low as to prevent such a metamorphosis of the alcohol as this; and hence the natural consequence of the existence of this ether.

Sixthly.—A dewlike and tasteless moisture is often observed in the interior of the upper parts of fermenting vessels, and sometimes runs copiously over the edges of the barm boards, and down the outsides. There are two ways of accounting for this watery appearance. 1. According to modern science, alcohol being considered a hydrate of ether, this moisture may consist of some of the surplus water which is set free on the conversion of some of the alcohol or ether, and which water, from its extreme purity, comes in contact with the escaping ether, and by the velocity of its exit is brought over by that mere mechanical contact, rather than by chemical affinity, and condenses on meeting with a colder medium. 2. If not more truly, certainly more plausibly, the water may escape from the fermenting gyle with the carbonic acid gas, by ordinary evaporation; the carbonic acid gas, hydrogen, and ethers, in each case, being incondensable by cold, making their escape invisibly, except as to the sense of taste.

The action of this ether upon the senses, may well lead us to presume that it slightly partakes of an oily as well as an acid character; but these properties are more odoriferous than spirituous or inebriating. Old vatted ales, strong with age, such as were not attenuated beyond one-half of their original gravity previously to vatting, and have consequently undergone a long spontaneous decomposition while in a store of moderate temperature, ranging from 50° to 60°, possess this peculiar and agreeable, but insinuating strength, in high and rather permanent perfection; and if either carbonic or acetic acid is necessary, by combining with the alcohol, which is more than probable, such an article will always afford an ample supply to produce ether in abundance; for chemists can obtain either by distilling a mixture of alcohol and acid. Indeed the older good sound malt liquors are, the more of this ethereal strength they contain; and so valuable is its presence, that it compensates for the time and capital absorbed during its storage, either by yielding a better price in the market than new ales of the same original density, or by being brewed some pounds *per* barrel lighter, and sold at the same price as the heavier bodied. Again, if the first attenuation of such keeping ales were conducted to a somewhat low degree; as for example, if a 34 or 36 lbs. wort were reduced to 5 or 7 lbs. before vatting, and subjected, with regard to situation and time, to the like treatment with that which at first is less attenuated; it will in reality be stronger after a lapse of time, and its effects on the system will be more durable; though since its spirituosity is less volatile, its features will not be so striking, or so instantaneously evident to the senses. In each case the decomposition continues almost imperceptibly, but the strength and wholesomeness of the deeply attenuated ale increases much more abundantly than the other; yet it is exceedingly questionable whether the real alcohol increases much, and whether it fully retains its original character: indeed, Bouillon-la-Grange has asserted, (Jour. de Phys. XXIX. 6,) that *when wine is distilled new, it yields more alcohol than if allowed to become old;* which change of condition, independently of the hypothetical evidence adduced, establishes the ethereal principle.

But the question for present consideration is this:—Will ales fermented at between 40° and 50°, and continually kept in a store of equivalent temperature, possess the new ether under contemplation? For if they do not, we gain less by the storage under this circumstance than others, because the alcohol does not decompose; but if they may contain less ether, they then possess much more alcohol.

Now, notwithstanding the great varieties of ethers and ethereals already discovered and defined by chemists, and Dr. Turner's observation, that "no department of organic chemistry has been so thoroughly investigated as that of the ethereal compounds," here is at least one that has been nameless, but which may be entitled the *demeteric*, from Δημήτηρ, a title given by lexicographers to Ceres, the goddess of corn, derived from γῆ, the earth, and μήτηρ, mother; and it does not appear that the subject claimed the attention of either chemist or brewer till noticed by the present author.

The increase in value of old ales during their storage, is probably derived from an evolution of alcohol and acetic acid while the ale remains in comparative quiescence; and they undergo an undisturbed affinity, by means of which they etherise. The existence of an ether in all ordinary fermented and stored liquors is inevitable, because the heat at which they are fermented is favourable to the formation of acid and the disengagement of a volatile spirit therewith connected. First-rate summer brewed ales, prepared for immediate consumption, with the advantages derivable from refrigerators, attemperated, and hard water, such as easily brighten, evince their decay ambiguously, though in warm situations; and ultimately in a peculiarly mild species of acidity, partaking more of hardness than of tartness, and for a considerable time preceding that of a more positive character; and while kept stationary in this condition, the ale retains its brilliancy several months, though otherwise under many local disadvantages; yet it decays gradually, and in some instances with such obliquity as to produce innoxious effects, with little deterioration of the genial strength; the principle cause of which is, that the remaining yeast being precipitated and kept dormant in the mass by the intervention of natural and adventitious means, it does not acquire an atmospheric supply sufficient to produce an immediate and radical change in the constitution of the liquor. These circumstances have led the author to conclude that little besides the lightest and most susceptible of the spirituous parts of the liquor are subject to the decomposing influence of the absorbed oxygen, and the evaporative power of a hot atmosphere; for the ordinary fermented ales, however new, are never devoid of some little acid; and imagining inferentially that some acid is necessary to the formation of this singular ether; yet we may presume that an additional supply of oxygen is required, so that even this mild acid may be evident to the palate. When the appearance of the liquid is otherwise than brilliant, and its turbidity is occasioned by the suspension of decomposing matter, the avidity with which large quantities of oxygen are imbibed or imparted during decomposition, actually and immediately diminishes the amount of alcohol; and being aided by a favouring heat, it ultimately transposes the whole, by creating a sharp sour acid of intolerable strength, be it aldehyde, be it acetic acid, or be it whatever it otherwise can.

All fermented liquors necessarily contain alcohol; and this product, as its definition imports, gives the liquor strength, and preserves the sweet and flavour; but as soon as this alcohol combines with oxygen, the transmutation weakens the beverage, and it becomes sour by the formation of aldehyde, and subsequently of acetic acid, at the expense of the alcohol; but by the more gentle process of fermentation, such a ruinous result is entirely avoided. Liebig attaches much weight to the free admission of mild air, arguing that when the power of attraction in gluten over oxygen is increased by contact with precipitated yeast, in a decaying state, nothing more is necessary to its own conversion or oxidation into the same state, than the unrestrained access of air. Upon this indubitable circumstance, as upon an indestructible basis, he founds his demonstration of the most splendid problem in the theory of fermentation; namely, that at a low temperature of less than 50°, the efforts of gluten and free oxygen cannot affect the newly-formed alcohol, so as to produce eremacausis; that this low temperature therefore retards or resists the *combustion* of the alcohol, which would necessarily ensue if greater heat were applied. The great analyst last named advances the doctrine that alcohol undergoes no change at low temperatures, but is in the same state from its contact with oxidating gluten, in which the gluten of wine is placed by the addition of sulphurous acid; the oxygen of the air uniting with acid in one case and with the gluten in the other, without touching the gluten in the wine or the alcohol in the beer, though it would unite with the gluten and alcohol of the wine if the acid were absent, and would combine with the alcohol of the ale at higher temperatures, and turn it into acetic acid; for while kept low, as in the Bavarian process, the free access of air separates from the beer every substance capable of decay; and the removal of this matter lessens the tendency of the beer to become acescent.

These principles, the author can aver, were seen and appreciated by him, though without a clear conception of the causes, at least seven years before he heard of Liebig's name; and although the theory may be for a while opposed by such as choose to maintain that no atmospheric air can pass through the very dense layer of carbonic acid gas always resting on the face of the fermenting fluid, and continually making egress from all its parts, they should know that Dr. Hales found in the course of his experimental enquiries, that the extract of grapes absorbed one-third of its bulk of that compound element during fermentation, and that malt liquors imbibed one-fifth while under the like process. With what consistency, then, can men who deny this absorption of oxygen, rouse in the yeasty head in order to stimulate languid fermentation, or to re-excite its energies at the cleansing point? They know by experience that such a practice generally succeeds; for if the floating yeast had not actually absorbed a large quantity of atmospheric air, or of its oxygen, it would not have been in a condition sufficiently advanced in decomposition, to perform the functions of a ferment so promptly. The fact of itself negatives the error, that a fermenting wort is rendered impervious to the oxygen of the air by the interposition of a denser gas.

A word more on the low fermentation termed sluggish, which is commonly the effect of stale yeast and long boiling, and is neither natural nor wholesome, but a condition to which mashing at an improper heat likewise contributes not a little. The fermentation of liquor thus mismanaged is never complete, but leaves it in that drowsy state so accurately described by Pope, where he says,

> "Flow, Welsted, flow, like thine inspirer, beer;
> Though stale, not ripe; though thin, yet never clear;
> So sweetly mawkish, and so smoothly dull,
> Heady, not strong; and foaming, though not full."

Having now pointed out the advantages of a well-conducted and vigorous but low fermentation, and some of the disadvantages of deviation into an extreme path on either hand, let us treat of fermenting vessels, as a subject of greater commercial importance in point of economy as well as appropriateness, than some have been disposed to imagine.

In economising space, and in facility of construction, squares are superior to rounds, at all times and places where minerals can be employed without being dearly bought; but when made of wood, rounds have the advantage in cleanliness and strength, by having fewer angles to interrupt the cleaning, and by being bound with iron hoops, which are preferable to the nails and bolts that fasten the corners of squares. Minerals, however, are better than wood in the abstract; hence, in all localities that will admit of the introduction, the author recommends, as a safe and economical utensil,

The Potential Fermenting Square.

The Constant Temperature Vault, or fermenting-room, should be so planted, that the fermenting vessels resemble so many islands placed in the middle of a lake or reservoir of the running water supplied from the crevices of the roof or ceiling, or from the sides and natural floor, in the form of springs, or by artificial conveyances; and the lake should be bounded by a low partition erected in front of the squares, separating them from the stores, and so properly elevated that they would be constantly immersed in water to within a few inches of their brims, and that when the lake is brought to that altitude, the superfluous water would flow over the edge of the partition.

In tun-rooms situated on level plains, where no fall or flow can be obtained for the accumulated waters, and also where the expense of removing present establishments is an obstacle in the way of business, in order that their occupiers may, like the inhabitants of Scotland, Wales, Derbyshire, &c., "call spirits from the vasty deep," recourse must be had to the usual means adopted in mines for effecting this object, as air or water pumps, blowers, or other available engines; and the lower extremities of the conducting tubes of these contrivances must be inserted into large reservoirs or wells, situated in the lowest part of the subterraneous receptacle, and made expressly capacious for the purpose of accumulating such waters, and the carbonic acid gas, as the latter issues from the fermenting vessels. The prime mover of the brewing apparatus above ground should be applicable to this work.

It is the want of substantiality and of regularity in the local plant of the fermenting vessels, as well as of management, that causes the encouragement given to the importation of paltry foreign wines, and the home consumption of wines that are falsely *called* foreign, such fictitious and low-priced rubbish, though far from *cheap*, having fine delusive foreign names given to it;

all of which kinds of trash, whether British or foreign, are as inferior to our own genuine and scientifically brewed "national beverage," in their nourishing, cheering, and invigorating qualities, as they are superior to common pop or lemonade; and the antidotal salvator, to produce and sustain the "*quant. suf.*" of alcoholic and durable life, is the "POTENTIAL FERMENTING SQUARE," a vessel made of slate or flag, and for the following reasons:—

I. ITS PECULIAR FORMATION. One of the most remarkable properties of this mineral is its cleavage; a quality which preserves to it two parallel smooth surfaces, the porosity of which decreases in proportion to its density; for it is a property of all bodies of a similar kind, that the denser the species, the less permeable is it to foreign intrusion. The heavier kinds must be the best, as drawing slate, for instance, is too brittle, too unctuous, too porous, and, of course, too light, when a more durable kind can be procured; and common mica slate, though exceedingly useful on light roofs, where it will lie for centuries and be little impaired, is yet too delicate in texture for the purpose in view. The specific gravity of the best drawing slate is not more than about 2,110, whereas that of mica ranges from 2,650 to 2,930.

Gwanas, near Dolgelly, produces a beautiful, clear, and cheap slate, but has not at present displayed masses sufficiently large for this purpose. A very useful specimen will be found in the "Bangor Quarry Slab;" the vein in the island of Valencia, on the coast of Ireland, is by some preferred to any other for its polish, density, and cheapness, but is liable to scale; and that obtained from Delabole, in Cornwall, is a tolerable rock, though not so fine as the Bangor; but perhaps each will be preferred to the others by persons living in their respective vicinities, through the saving in carriage, which, if they be sent to any great distance, raises the price so considerably as to become an object with the purchaser.

II. The simplicity of form in its construction. The ease with which slate cuts into longitudinal and latitudinal sections, naturally straight and not liable to warp, is a great merit; and they may be made to fit the room in which they are placed, without any waste of space, and fixed together by any of the cements known to practical mechanics, aided by bolts and nuts.

Let us next consider that of transplanting, by one operation, into one vessel, all the hitherto various processes of fermenting, cleansing, purifying, racking, and occasional minor trouble; for as soon as the subject brightens, which it will do in a few days by the new process, in the same square into which it was pitched, it is racked directly into the store or other casks, and is at once fit for sale or consumption. By almost every other plan of fermentation, a large quantity of the liquor is wasted by being absorbed by the many vessels used, or through adhering to them, and the consequent increase of evaporation of the volatile principles, upon which the strength and good quality of the liquor mainly depend; moreover, those multiplied processes convert the remnant, more or less, into a flat, foul-flavoured, and acetified drink; and again, the liquor thrown off with the yeast in the ordinary processes, trickles down the spouts and sides of the cleansing casks in thin streams or films, being the most approved plan of acetification now adopted by vinegar makers. The quantity so unwisely exposed to oxygen, yeast, and corrupt matter, and so often returned into the fermenting vessel, to work over again only to be replaced, usually amounts, during such wasteful and protracted processes, to about 50 *per cent.* of the whole gyle! These, with many other thoughtless proceedings already named, fully account for the immense quantities of sour and undrinkable ale daily seen or heard of, with pain to the brewer and grief to his customers.

III. *A few of the minor benefits* accruing from the subterraneous process, are the immediately intimate and certain incorporation of the hop, and the assurance that the whole of the essential oil (if not already boiled away), with the resinous and other antiseptic qualities, are permanently fixed in the liquor after it becomes bright, thus considerably economising this costly flower. The extreme bitterness of common yeast is evidence of a waste of hop, which cannot escape the notice of the most casual observer. The most skilful and circumspect of good housekeepers prefer the barm of weak ales to use as a leaven, for the sole reason that it is less bitter, provided that it be fresh; but this bitterness betrays an evident waste of the hop; the yeast, therefore, which they most dislike, is that which the carbonic acid gas has succeeded in floating out of the fermenting vessel from the stronger and better musts, which, as is well known, contain the most essential oil and resin; these valuable constituents are therefore thrown away; but in the fermentation which precipitates the yeast, they form a portion of the beer.

Each fermenting square may be provided with a loose metallic cover, having a rim sufficiently deep to enter the water at least half an inch; so that, when put on, and in its proper place, the fermenting fluid will be kept sufficiently air-tight by such hydraulic valve cover, to prevent an excess of air; whence, if any external air is required by the decomposing fluid, it will be equivalent to the task of drawing it through the water, and under this cover rim; but such an absorption of air cannot occur, except on the formation of a vacuum, and at such times as when the expansive force of the increasing and compressed carbonic acid gas is greater than the weight of this short column of water, since as much gas will ooze out through the water as will restore the equilibrium. But this seldom occurs where the surrounding stream descends with any rapidity; because the water is ever absorbing the gas as it falls upon the surface, and is conveying it away down the channel in small globules, giving to the stream an assumptive property, not altogether unlike an economic soda water. These lids may be made of tinned copper, and where the vats are large, may be suspended over them from the roof or ceiling, so as to be drawn up and down.

Wherever local circumstances effectually prevent the increase of temperature after pitching at between 40° and 50°, the cover will not be absolutely necessary, because air cannot be engaged in injurious excess. The principal and perhaps only definite use of it, is simply to drop it on when it is found necessary to curb or stop the fermentation, which the exclusion of the air would sufficiently do. In this case, the rim should dip five or six inches into the water, the more effectually to cut off the supply of oxygen, and to increase the pressure of the gases on the must; and means can easily be adopted to maintain the pressure, if found advisable, during the attraction and precipitation of the yeast, and even under racking.

As alcohol does not combine with oxygen from the air at temperatures which in fermentation are accounted low, or beneath the medium, and as experience shews that the exclusion of the air greatly checks the fermentation, these circumstances constitute the reason why, when the heat is much reduced, the cover will not be needed; because the alcohol will prevent all the saccharum from being decomposed, the ferment can be sent downwards by precipitation, and the ale can at once be racked off bright, if required. When the cover is left on, the heat cannot rise into the atmosphere; and if it be not transferred through the sides, and carried off by the attemperating water as fast as it is generated, it must accumulate in the must, and keep it a few degrees higher than the abstracting water; yet the use or absence of the cover will be optional, according to the state of the external atmosphere.

Timid people may object to fermentation under ground, through apprehending some accumulation of carbonic acid gas in the vault, which may have a tendency to endanger life; but the risk is not greater here than in any other confined room, as the gas, by subsiding upon the running waters, is carried off in the draught and current. In breweries of the usual construction, are on record several awful instances of its deadly effects upon certain brewers' labourers and others, who have imprudently ventured into vats without ascertaining whether they were quite clear of that noxious gas prior to their descent. The usual and most certain proof of its presence is the introduction of a light, as carbonic acid gas will not support combustion; and as a test of this, if a lighted candle be lowered into a vat which has lately contained malt liquor, the light will instantly be extinguished by the power of the gas, in the absence of atmospheric oxygen, below which the former sinks by its own gravity.

To countervail the dangers and consequences hence arising, the assignment of the province of examining these vaults to a careful workman of sufficient ability must be evident; he having intelligence, attention, and thought, superior to the persons usually selected in breweries because of the bone and muscle which they display beyond men of ordinary strength. This person will have the especial duty of clearing the water and gas from the tun-room; and to facilitate his duties herein, the author has invented

The Pneumatic Life-Protector.

As the subterraneous fermenting-room, when not situated on a declivity, or where a natural sloping gallery or drainage cannot be obtained, will be liable to the objection of insecurity to the lives of the men there engaged, notwithstanding the provision of pumps and other remedies and preventives, inasmuch as they may not always be duly worked, therefore to render the place both healthy and safe, by superseding the possibility of any such evil effects, unless from the men's own gross neglect, let a lamp be fixed near the doorway of the staircase or geometrical shaft leading to such subterraneous room, and let a small metallic or gutta-percha tube be attached to the bottom of it, long enough to reach to about six or ten inches from the floor, and by this contrivance all the air consumed by the lamp will be supplied from below; then the air suitable for combustion, and consequently the light so circumstanced, will cease to burn as soon as the gas touches the orifice; for as carbonic acid gas is heavier than atmospheric air in the proportion of 1527 to 1000, as soon as it is thrown off by the worts, it will accumulate upon the floor and increase in depth until it reaches the lower end of the air-pipe, on which the dense gas will act as a valve, and prevent the admission of air suitable for combustion.

Having taken this precaution, all persons entitled to enter the tun-room will possess a foreknowledge of the state of the air; therefore if any one descends into the cave when the lamp refuses to burn, he does so at his own peril, as a madman. A lamp on the same principle as the former, having a tube that supplies it with air from the tun-room, should also be fixed in the engine-house, or within the stoker's room, or indeed in any convenient place which is often used, or is constantly passed by the stoker, or by the manager of this department, who will have the duty to perform of refusing admittance at improper times; and a beacon of the same kind will be found in the Caloriphagon; for that being supplied with air upon the same principle, in case the pumps should be neglected at the time when the men are engaged below, notice of such neglect will first be indicated by a lowering and discoloration of its light, until ultimately, when the gas has increased in depth till it has reached the bottom of the pipe, the extinction of all its light will envelope the workmen in darkness, and they will be obliged to leave off working to walk out of the reach of danger. Thus all hazard arising in subterraneous vaults, *constructed without a gravitating drainage*, is successfully averted, and the men can perform their few occasional duties within it in quite as much security as in the old establishments, and in greater safety, because of the warning; and when a descent below the bed of the room can be had, which will always be a point in contemplating a new erection, no such danger can arise or be anticipated, and consequently none of these precautions can be at all necessary; and besides all this, the alcohol, unaffected by the vicissitudes to which houses of the ordinary kind are subject, is preserved and fixed in all the vigour which appertains to its character and constitution.

Admirable as the foregoing scheme is in comparison with the old worn-out chance work of fermentation, yet we must admit that, after all, the unerring laws of placid nature may be purchased too dearly, and in a great majority of establishments the construction of subterranean fermenting vaults is totally impracticable, however desirable they may be.

The foregoing reasonings have necessitated the invention of a new fermenting apparatus, by which malt beverage is produced of the finest and most exhilarating quality, without either risk, mechanical or other stimulants, or trouble, dispensing with no small share of that tormenting, painful, and wasting anxiety which falls to the lot of every practical brewer.

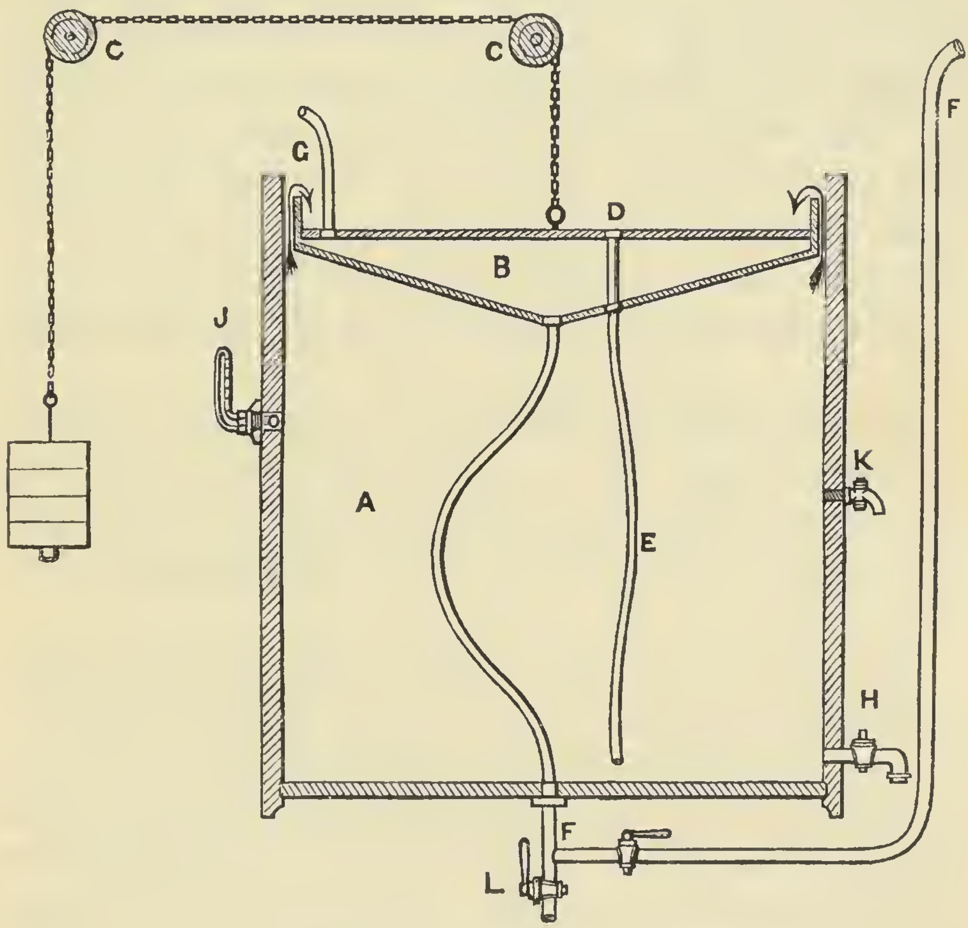
To theorise on the merits of such an invention would be superfluous, since a mere glance at the following sketch, which briefly displays its leading feature only, convinces all practical men of its entire perfection. Its title is

The Octuple.

Its uses are to enable the operator to place a running sheet of cold water between the whole surface of his fermenting worts and the yeast rising therefrom, and so conduct the vinous fermentation in a closed, or nearly closed, vessel; to keep his fermenting worts in a state of circulation by natural means only; to secure the yeast more free from beer than heretofore; to prevent excessive evaporation of the aroma and spirit; to save at least five *per cent.* in malt alone; and to control the temperature of the fermenting wort without hot water.

Hence the Octuple performs the several functions of Cover, Barm-back, and Attemperator, either together or separately, excepting that it cannot be either unless it is a cover.

The Octuple consists of a double metallic vessel, which nearly fits the interior of the fermenting square or round, somewhat conical or convex on its bottom, and flat, or slightly concave, on its top, its outer edge rising a few inches above its surface, as shewn in the following sketch.



A, square; B, the Octuple or double cover; C, C, pulleys and chain, by which it is lowered or raised; D, one of four tubes through which the beer drains and passes to the bottom of the tun through hose E; F, ingress water-pipe to take a flexible tube; G, egress water-pipe; the bent arrows shew the direction the yeast takes; H, racking cock; J, thermometer; K, sample cock; L, cock by which the Octuple is emptied of water.

Its *modus operandi* is briefly thus:—

The Octuple, B, is lowered to within a foot or two of the bottom of the square, and cold water passed through it by means of the pipe, F. The pitching yeast is put on the cover, B. The worts from the cooler or refrigerator flow over the surface of the attemperator, B, and pass down one or more of the tubes, D. The floating cover, B, now rests on the surface of the wort and receives the yeast as it rises up round its sides and falls on its surface. The yeast does not present its usual light and bulky appearance, in consequence of a large portion of its attendant gases and beer being squeezed out during its passage up the narrow channel.

The beer that accompanies the yeast flows away and re-enters the gyle tun, A, through the tubes, D. When the beer is sufficiently attenuated, plugs are placed into D to prevent any more yeasty beer passing into the gyle tun.

The yeast now rises sparingly and in a more solid state, and continues to be retained on the barm-back, B. Just before the close of fermentation the plugs are partially withdrawn a few minutes to allow the clean beer which may have subsided on the precipitated yeast to run down into the square. The yeast soon becomes comparatively solid, and may remain on its cool plate, B, always fresh and ready to be taken off as required either for sale or use.

The heat of the gyle never need be raised 5° F., even when pitched at 56°.

Cold liquor may always be flowing through the Octuple in a small stream (beer will deposit its yeast, or fine, best from 56° to 58°), and the beer racked sufficiently clean from the square, either the whole or part of a gyle at once, the remainder being kept cool, and covered from the air until wanted, or the carriage casks are ready to receive it.

Extreme temperatures cannot affect a gyle protected by a sheet of cold water.

The Octuple is allowed to descend during the process of racking. The square being drained, a man gets in on the Octuple and washes all within his reach. The apparatus is now raised high enough above the edge of the fermenting vessel to enable the man to wash the bottoms of both.

The peculiarities of this apparatus, and the very superior advantages attending the foregoing operations, and their immediate results, are as follows :—

1. The absence of attemperating tubes and other obstructions in the gyle tun.

2. Performing in *one vessel* the processes of fermenting, cleansing, and purifying.

3. Begetting cleanliness, a lively and expeditious process, and early brilliancy.

4. Enabling any brewer to achieve that peculiar fermentation so essentially productive of bitter ales, either for exportation or home consumption.

5. Escaping the annoyance and often fatal consequences of excessive heat and cold, peculiar liquors, errors in pitching heats, and other circumstances which usually impede the process.

6. Avoiding the waste attending every other plan of fermentation, particularly with cleansing casks, stillions, pontoons, yeast-troughs, settling-backs, skimmers, &c., to say nothing of the splashings, slops, and loss, by filling up and oxidation, and the residue in every kettle, tub, and vessel, besides accidents, and the inevitable injury of the article subjected to so many transportations, divisions, vicissitudes, and atmospheric influences.

7. Great economy of room and labour in the brewery.

8. Giving the operator full control over the most delicate, precarious, and important processes in the art of brewing, enabling him to produce, at all seasons of the year, an article of uniform quality and character.

9. Facility of collecting all the yeast in one solid bulk without the usual accompaniment of waste beer, which often amounts to three *per cent.* on a gyle.

10. The general applicability of the apparatus, and facility of its adaptation to old fermenting squares, rounds, or ovals.

11. The Octuple is the only cleansing apparatus that adjusts itself to long and short lengths alike, and prevents the radiation of caloric, and evaporation of aroma and spirit during fermentation.

12. Increasing the generation and preservation of aromatic oil, alcohol, and ether, which adds to the pungency, flavour, and strength of the article without additional malt.

13. In short, the Octuple is managed and cleaned with ease and facility ; is less costly than, embraces all that is valuable in, and avoids the imperfections of, every other apparatus and system. It fills the long existing void, supplies the great want in the brewer's laboratory, and affords mental and physical relief to the operator.

Finally, the Octuple condensing and confining the alcohol and the aroma in the beer, it follows that a very superior beverage results from its employment, which the public will be sure to appreciate.

CHAPTER XVII.

PORTER.

ORIGIN, NAME, AND HISTORY—OLD ENTIRE—UNSUITABLE WATER——DUTIES AND ALTERED CIRCUMSTANCES—BROWN STOUT—LONDON BREWERS—ADULTERATIONS AND DECEPTIONS—SCOTCH FRAUDS—ENGLISH LAWS—BOOKS—EVILS OF BLACK MALT—CAROMEL—LONDON AND DUBLIN—TABLE OF GRISTS—VATTING—HYGROMETER—LEGITIMATE FLAVOUR—URE'S DELUSIONS—PALE BEER—CONSTITUTIONAL PROPERTIES—AFRICAN GUMMY DIET—THE FACULTY EMBARRASSED.

Porter, though held in great request in most places, and especially as a cooling draught in summer, is not of ancient origin, but owes its name and character to accident, and its history to adventitious circumstances which have occurred in variable succession. To persons who have lived in London, it is quite unnecessary to mention that the metropolis is the grand mart for its consumption, the natives still denominating it *beer;* whereas, in the country it is scarcely any where seen except in summer, when warm; and though gradually becoming more common, till in some parts its price has fallen from exorbitance till it is lower than ale, yet such is the force of habit, that the rustic palate still regards it as a luxury adapted to entertainment, or perhaps to medicine, rather than to ordinary use.

According to the Society for the Diffusion of Useful Knowledge, or the authority whom their editor has quoted, the Londoners, as well as the Scotch people, had three qualities of malt liquor, distinguished as ale, beer, and *twopenny;* which last was in Scotland a *pint*, containing nearly *two English quarts*, till the establishment of a court of exchequer, under an article of the union with England in 1707, subjected the Scotch loomer to a licence or a penalty; besides which, a heavy tax was put upon malt, so that the Scotch guidwives were obliged to bree sae thin, that their customers deserted their bens, and the fairies "ran e'en awa' with the twapenny." In London a very different fate befel it; for the people there, having accustomed themselves to indulge in "half and half" and in "three threads," till they found that these admixtures could not be relied on as halves of each of the better, or exact halves of any kind, or as equal quantities of the three, an ingenious brewer, named Harwood, contrived, about 1730, how to brew a liquor *all one way*, which should have the conjoint flavour of the whole three *threads*, and be but one trouble to the tapster, which production he termed "*entire butt.*" His scheme succeeded admirably, his business expanded, and, say they, as his was "a very hearty and nourishing liquor, it was very suitable for *porters* and other working men; whence it obtained the name of PORTER." This tale is otherwise told by some, and the subjoined version appears the more rational and credible of the two. A rumour has been handed down to posterity that Harwood, being an obliging man, had his beer *ported* or *carried* round in pots and pints of pewter, upon *racks* or cratches, and left at the houses of his customers, as is still the metropolitan practice; and that his potboys cried "Porter," as they knocked at the doors; meaning not the beer, but themselves *as its porters,* till one became identified with the other.

Scarcely does this our beer-sipping country contain any two brewers, particularly neighbours, whose productions are alike in flavour and quality, and especially in the article porter; for even in London, a practised connoisseur can truly discover, without hesitation and by mere taste, the characteristic flavour that distinguishes the management of each of the principal or neighbouring breweries; and a more striking difference still is discernible among some of the Dublin houses, none of which yield a flavour like country-brewed porters, many of the latter being shockingly bad, sometimes blinked, often tasting of empyreum, some black, some musty, some muddy, some barmy, and some having the predominant taste of Spanish juice, which is not an uncommon ingredient, and generally speaks for itself when taken upon a delicate stomach. This diversity is caused by a variety of circumstances, known and unknown, as some of them are profoundly veiled in secrecy; but at present as much from the colours and proportions of the grists brewed, as from any other general cause, excepting unsuitable, or saline water.

Besides its peculiarly agreeable flavour, Mr. Harwood's production had an inviting brunette complexion and a mantling effervescence, giving it a spumous "cauliflower" head, when poured from one vessel to another, or otherwise agitated, which distinguished it so far from all other beers then brewed, that though no other competitor of that age could produce any thing at all to vie with it, all were alert to imitate it, and were aware that it had the advantage of age. One brewer of eminence, perceiving that it had the smell of oak, and knowing that newly manufactured oak timber imparted a brown tinge from the tannin which it contained, had his store vats made of this material, which, it is said, answered exceedingly well; and this, together with experiments in browning malt, to which process the Hertfordshire and Berkshire maltsters were speedily alive for their own benefit, led to the establishment of the porter trade as a lucrative city and suburban monopoly. Drying the malt with *fagots*, or *pieces* of *beech* (from *fagus*), and bavins, or *billets* of *birch* (from *betula*), had long been known to deepen the colour of malt, which to the admirers of straw-pale ale had been an eyesore, but which now converted expediency into virtue, and by those whose convenience it suited, or to whom a little expense was not a considerable object, recourse was had to oak, the smoke of which fixed a still deeper brown and stronger flavour. In the mean time, the more fraudulent of the malting fraternity found that the process of browning their ill-harvested and imperfect barleys, hid the stains and other blemishes, and the blowing system also became prevalent.

Blown malt was for a while greatly in demand, from its giving a "flush" to the porter brewed from mixtures of this and others; but the brewers found that the deficient yield of these fictitious malts would not maintain their prices, unless the extracts were made *thinner* by spinning out the lengths; therefore, some of the London capitalists determined upon manipulating none but the soundest barley, browning it in the most improved manner, mashing with it a quantity of the best pale or amber, according to relative taste; selecting the best matured brown hops for the maintenance of the beer, and each adding likewise his little secret chemical preparation to modulate flavour and excite effervescence. As the very best brown malt was found to be defective in its produce, when compared with pale of the same growth and steep, the more affluent made up the deficit by stronger mashes, less attenuation, and longer vatting, by which means they prepared a stronger body, which they sold at a price greatly advanced above common porter, and gave it the appropriate name of Brown Stout.

Brewers were not aware of the full extent of default to which their malts had been reduced by browning and blowing for porter, through the heat at which they had been dried, till the introduction of the saccharometer (*vide* p. 181) detected the absolute amount of their loss, and declared it to be from 20 to 25 *per cent.* in blown malt, and from 16 to 20 *per cent.* in the best brown, in comparison with pale; and, in proof that these indications were true, they discovered, through the agency of the chemist, that their good ales would analyse 8 *per cent.* of alcohol, but that their best porter would not produce more than 6½; and then it was that the immense profits realised by the maltsters made the brewers of "common" bestir themselves in devising better means of self-protection than could be afforded by the loss of their trade, through the lightness of their extracts. Wits went to work, foreign ingredients were slily recommended and snugly embraced, the herbals were consulted, the mariners rewarded, the druggists enriched, the trade lost its reputation; and Government, taking advantage of the overstrained ingenuity and contraband intrigues of the traders, not now confined to London, or yet to the porter department, levied an enormous additional duty on malt.

The year 1798 gave birth to Richardson's "Philosophical Principles of the Science of Brewing," in which he recommended socotrine aloes (*aloë succotrina*) for flavour, salt of steel for a "retentive head," and afterwards quassia instead of the former, and copperas or sulphate of iron as superior to the latter, the *green* mineral being greedy of oxygen, which converts it into *brown*. For malts, he informs us that his usual blend was in equal quantities of brown, amber, and pale; or when the porter was to be sent to "a country where its production is novel," he preferred mixing two parts of brown to one of pale, omitting the amber. Whether the above or similar innovations led to the interference of the legislature, little doubt can exist, as the tax was imposed in 1802; after which we read of numerous additional expedients to evade it, which the brewers chose as indemnification against increased risk and exigency. Liquorice-root (*Glycyrrhiza glabra*) was one of the most prominent adulterations, both in powder and as manufactured into black Spanish juice; and molasses, sugar, and raw grain took the place of malt; black resin (*resina nigra*) was picked out as a flavourer, and when mixed with finings that would float, as a shield against the admittance of atmospheric air; and marsh trefoil, bitter or shrub quassia sticks (*quassia amara*), and more largely the chips and rasped bark of the tree quassia (*quassia eccelsa*), with alum (*alumen liquidum*) to clear and heat it; and gentian, or bitterwort root (*gentiana officinalis*), all became substitutes for hops; and as narcotics, to end the catalogue, tobacco (*nicotiana*), bitter bean of St. Ignatius (*fabamara Ignatii*), is recommended in several brewing treatises; and though perhaps at first in mistake for buck or *bog* bean, seems to have led, through ignorance, to the importation of the bitter *nut* (*nux vomica* or *strychnos*), which last are poisons in a rank degree, admitting no pardon or excuse whatever, more especially as all drugs were interdicted by the statutes.

We must not attribute these vicious preparations to the porter trade alone, though the immoderate length to which the impositions were carried out, led, after their discovery, to a relinquishment of porter-drinking by many, and to a consequent stagnation in the trade, though the ale brewers were not less guilty, entertaining raw grain, sugar, gentian, quassia, and alum, with equal temerity; besides which they mingled salt, to chase the fox; honey (*mel alveari*) as a saccharine sweet and preservative; jalap (*yalapæ pulvis*) to effervesce and correct acidity, and to counteract the effects produced by the heating India berry (*cocculus Indiacus*), or by decoctions of the sliced root of sweet flag (*calamus aromaticus*), with caraway seeds (*carum carui*), and those of coriander (*coriandrum sativum*), which were infused ground, to act as a cordial; and another consisted of the powders of the following, or some of them, boiled with the wort; orange peel (*citrus aurantium*), long pepper (*piper longum*), Guinea pepper (*capsicum annuum*), grains of Paradise (*amomum grana Paradisu*), and ginger (*amomum zingiber*). Hartshorn shavings were boiled in "the best London ale," to fine it; and in some breweries marble dust, crabs' claws, oyster-shells, and egg-shells, were pounded as carbonates of lime, when that mineral was not native in the water, were put into the ale as anti-acids, after it was brewed; and the subcarbonates of potassium, magnesia, and soda, were added, as they still are by some, to soften down a sharp acid before drinking. Sulphate of lime was to prevent fretting; and lastly, opium, and a compound nostrum called *multum*, containing opium and other matter, was sold by the druggists to create strength and a drunken sleep. All these had their run, with greater or less comparative success, according as the taps satisfied, and the deception continued; and the sale of all these, or the most of them, constituted the staple of the brewers' druggist, who travelled from town to town to dispense his boons for the "benefit!" of the community. Nor did e'en the cannie Scotchman, whatever his defence, escape the contamination; for though "the Edinburgh brewers have been less the prey of travelling druggists than their brethren of the south," yet "*a little* honey to add to the sweet, and *a few* coriander seeds or *other aromatics* to assist the flavour, are, as far as we (the Useful Knowledge men) have learnt, the amount of the sins of which they have been accused;" they have not been altogether guiltless, nor, perhaps, were their malefactions so narrowly watched. We may agree with them upon the hardship, that "while the excise officer shall be threatening or prosecuting a brewer for putting a quarter of an ounce of sulphate of iron into a barrel of his *porter*, another brewer, under the survey of the same officer, shall have ten times that quantity dissolved, naturally, in the water which supplies his brewhouse!" (Treatise, p. 20.) And then it was *very* hard upon a poor Scotchman, that "*if* the substitutes were not more noxious than the principal, and some of them were less so, the conscience of the brewer was easily satisfied; especially seeing that he could procure as much bitter for sixpence as would otherwise have cost him a pound." (p. 27.)

Now this may be the identical reason, or one of them at least, in prominent conjunction with the train above, why the legislature interfered; for the practice of adulteration had been carried so far in 1810, especially in brewing from raw grain and from sugar, that, notwithstanding the tremendous charge put upon malt by the Excise, the malt revenue for the ten years then expiring amounted to an average of more than 28 millions of bushels less than in any of the three preceding equal periods, being a diminution of $9\frac{1}{2}$ *per cent.;* Scotland alone having yielded less by 6 millions and odd out of 17 and odd, being rather more than $34\frac{3}{4}$ *per cent.* Well, therefore, may Scotch writing brewers boast of their countrymen's honesty under temptation, and insinuate thus! "The immense capitals and influence of the ten or twelve principal (London) houses defy all competition, and whatever malt liquor they agree to designate by the name of porter must eventually pass current with the multitude. This is no random assertion; for it is well known that the liquor now retailed under that denomination has little or no resemblance (1827) to what was so called thirty years ago." In the eye of this scribe, therefore, the principal Londoners were as roguish as the Burton men (*vide* p. 113), and no doubt were *equally* culpable; but, without presuming to determine upon this point, Government being aware of the nefarious practices existing at the period in question, passed an act of parliament in 1811, containing certain prohibitory clauses against the practice of mashing with raw grain or sugar, allowing the latter only in its concentrated state of *essentia bina* (*vide* p. 87) as a colouring material for porter; which act had the effect of increasing the English revenue, but not the Scotch, or yet the national aggregate, for "the *more scientific* brewers were enabled to save two-thirds of the malt duty, and consequently gained an advantage over their less knowing brethren." In 1812 sugar was again permitted to be used.

In the season of 1812-13, hops rose from £5 to £15 *per* cwt. and remained at £8 or £9 till 1816, when they ran up to £14, and in 1818 as high as £31; though meteorology does not shew that any thing remarkable happened to the harvests of all those years; but in 1816, as the duties did not increase, parliament again interposed, and put down all ingredients in the brewery except malt and hops, and the following year brought out Mr. Wheeler, as noticed in a former chapter (*v.* p. 87). Yet with all these enactments to suppress fraud and protect the people's lives, there has been, through the publication of books or otherwise, "a general complaint of the declension of the quality of London porter," or at least of its character. Who can be surprised at this, when, eight years after the last-mentioned act became law, we can find "a brewer of thirty years' practical experience," recommending that to each hogshead, "generally speaking," there be added "capsicum ½ oz., ground and used in the copper; cocculus Indicus 1 oz., must be bruised, ditto; liquorice 4 to 8 oz., either dissolved or dropped by single pieces into the copper in full boil; salt of steel rather less than ½ oz., dissolved, and added on sending the porter out; colouring 1½ pint." If porter is put into vats, then will be the "proper place to use the colouring, if not, then in the tun;" and in a specimen of "the process" likewise naming an indefinite quantity of "galls" for colouring! We had heard of galls being used in France, but not here.

The motives assigned by that writer for the continuance of these forbidden commodities are unsatisfactory, and in some respects unwarrantable:—"Spanish juice imparts *colour* as well as flavour and considerable richness, fictitious strength from the use of the cocculus Indicus berry, sensation of warmth by capsicum, and a fermentation is produced by salt of steel, which brings a fine head, giving a peculiar colour by striking a dead brown with the astringent matter of the hop:"—but why colour with *both* this and liquorice? or why use either, when a better might have been found in *essentia bina*, which was obtainable at the same risk, and was "merely the sugar of which the *colour* is composed, more highly calcined, so as to become a *very* dark brown, and exceeding bitter?" And why brew with cocculus, which, "if taken in too large a dose, will occasion severe pains in the head, vertigo, and distressing sickness," and when if that which is "contained in a pint should occasion any degree of inebriety, the individual who sits by his side, and drinks a gallon, may pay the forfeit of his existence?" And all this in 1824, when the extract of cocculus sold at a guinea and a half *per* lb., though about the time of passing the act, "the numerous body of quacks, who called themselves brewers' druggists, were almost annihilated by exchequer prosecutions:" and though so lately as 1827, "seizures and convictions had continued to be made, and were still making by the excise," yet we find the very Scotch writer who then complained of the conduct of the "reckless beings who used deleterious ingredients," urging breaches of the law, by prescribing in one place loaf sugar, in another salt, salt of steel and sulphate of iron, and black resin with half-spent hops; in another *essentia bina*, aloes, and quassia; in another horse-beans and egg-shells; and in another honey, over the prohibition of which, especially, he laments most pathetically, because, though illegal, it is not deleterious. "It is melancholy to see its expiring efforts in the excise accounts for 1808; the gross actual receipt in money for duties on *metheglin* or *mead* is there stated to have been *one pound, eleven shillings, and sixpence.*" Yes, just the price of a pound of expressed cocculus, which this writer describes as "a strong narcotic it is doubtless; for it is on that account alone that it has preserved its place in the brewery;" but he gives a similar account of hops, which he pronounces "astringent and narcotic," decrying by word, measures which he was encouraging by deed. So much for consistency and the interference of the law! The Scotch malt duties, which then barely covered a million of bushels annually, have of late years, since the suppression of illegal traffic, averaged more than four millions. Down with the idea of a man covertly condemning that which he overtly commends.

Disregarding, then, all absurd notions of any gain in purse or character, from the adoption of spurious policy or illegitimate infringement, the best mode of brewing *genuine* porter is the matter now for consideration, since the very same brewers, whose principles lead the whole fraternity into jeopardy, admit that "exceedingly good porter may be brewed from two sorts of malt only." It is ridiculous to say, as some have done, that vinosity is not requisite in porter so much as potency, or yet to argue in favour of fulness without spirituousness; and it is more ridiculous still to assert that "flavour is little studied" in the porter brewery, or that "the hops usually employed in brewing that beverage are either coarse or old, and would not be admissible in fine ales," as though the porter brewer were some despicable creature, who would put up with any thing which his superiors spurned. The criterion is, the malt should be sound and very well dried; and the hops strong and sufficiently matured in their growth; but not *coarse*, as some express it, nor yet very *old*, as it is well known that long keeping entirely deprives them of their virtue; and let this suffice for qualification.

The temperature of the mashing liquor for porter grist has by some been a subject of grave consideration, while with others it is taken as mere custom and example. The old and erroneous idea that the brown and amber malts are in greater danger of setting, and consequently that they require colder mashing than the paler kinds, is now being abandoned, and the reverse belief having begun to prevail, a more correct practice has been introduced, and is becoming general. The effect of much fire under the kiln not only gives colour to the farina of the grain, but in some cases so far destroys the diastatic gluten by charring, as to render it inoperative in the mash-tun; while in other cases, the previously formed sugar is deprived of its sweetness by excessive heat: this satisfactorily accounts for the apparent deficiency in the extract of malt, in proportion as its colour is deepened by the maker.

When the whole of the grist or malt is subjected to the operation of mashing, the ordinary mode of extraction is often necessarily different from the treatment of pale malts alone, where sparging and as few mashes as possible are practised in the latter case; whereas the pasty consistence and insoluble parts of the high-dried corn require additional mashings to reduce them, and particularly where black malt is employed, by its accumulating on the false bottom of the tun, or amongst the lower strata of the goods, by which the vertical descent and regular process of the worts are impeded soon after each mash, so that the goods as often require breaking anew and remixing, in order to admit of their equal dispersion and dilution. The chief evil in these repeated mashings, is the saturation of the top and bottom parts of the goods with wort of equal gravity, without the usual advantage of totally exhausting even one-half of the grains by the downward washing and filtration afforded by the sparging system; so that a diminution of extract is the consequence, in proportion to the quantity of the black substitute, and its hordeous or imperfectly malted state. These objections, however, do not exist where the vertical masher is used.

Allusion has been made in former pages to the improvement which has of late years been made in the metropolitan ales, while on the other hand their beers have, in too many instances, gradually declined in virtue and beauty; which circumstance is not wholly, as we have seen, though in part attributable to the introduction of Wheeler's patent malt, or such as is roasted in imitation of it; the "nappy brown stout" produced from amber malt, having fallen off, and in many houses a black sulky beverage being substituted in its stead, on the taste of which the stranger experiences a shake, as sudden and electrical as that which seizes a spaniel when quitting the water.

This obdurate ingredient, though now considered by many to be almost or wholly indispensable, is often in the porter brewer's way, from the obstacle which it presents, whether mixed among the grist in the mash-tun, or with the hops in the copper. In the latter place it inflicts its penalties by the descent of its insoluble particles, and their adhesion to the bottom of the copper, and particularly if it is of an inferior quality from not having gone through the proper stage of vegetation. In this situation it forms a lining, sometimes of considerable thickness, and obstructs the passage of the heat from the furnace beneath; and the consequence is, that the bottom of the copper imbibes and retains much caloric; and if the heat reaches to redness, oxygen is absorbed by the metal. In this case, a fracture is commonly first evinced above the *lag* or channel in front of the fire, or wherever the greatest and most rapid contraction of the metal occurs after drawing the fire and introducing cold air: thus are many copper bottoms burnt out through the practice of boiling malt. In some establishments this destructive operation is obviated by the use of steam, and even by rousing machines, which prevent the subsidence of the ponderable matter; but this precautionary measure is not very common. Many brewers consider it more economical to boil the black malt with the worts ; but the facility with which both gum and sugar, whatever their colour, dissolve in water of any temperature, shews that the idea is incorrect, as far as the extraction of colouring matter is alone considered.

Of this black or porter malt as great a variety obtains, both in quality and colour, as in any article of commerce, for reasons already given. The inferior and low-priced, which by some is thence foolishly accounted *cheap*, is mixed with grain that has never properly germinated ; and in too many instances very light barley, and even that of a better quality, is dried as soon as the excise officer has taken his floor gauge, and consequently before vegetation has proceeded through one-tenth of its proper course, in order to preserve the form and substance of the corn as much as possible. Thus the malt duty is paid, and the grain is without the advantage of being malted, merely because such mean barleys would become exhausted by the process : this is not rational, nor is the maltster honest to himself or his customers, through its being unsaleable while undisguised. The colour is often so black that it resembles mere cinders, and the whole corn is puffed up to an enormous size, its shape is destroyed unless secured by fraud, and it adheres together in bunches, through the bursting of the shells and the exudation and fixation of the gummy matter when in the roasting cylinders. This article is never bought by any but the ignorant ; for the colour and flavour which it imparts in such a state are deficient and poor, because charred vegetable matter is insoluble in water ; and it is also sometimes so very unpleasant to the sight and scent, that no spirited or fair trader will touch it, or have it in his possession : its extract, too, is so unstable, that a vat of porter impregnated with its rubbishy particles, will soon lose a large share of its colour by precipitation, particularly if brewed with hard water.

Black malt, properly so called, is certainly a convenient and profitable acquisition in the brewery; yet none but that which has been made from good barley, thoroughly malted, and possessing a sound interior, of an uniform dark chocolate colour, can properly be deemed a good sample deserving public patronage. Besides these characteristics of a genuine specimen, each corn is separate, and as free from excrescences as when it was in the state of raw grain, and as near its original size and shape as the process of its manufacture will permit; and as the greater part of its interior is rendered soluble and perfect by the saccharising power of germination, it contains a much larger quantity of colouring matter of a superior and very desirable kind, consisting chiefly of a species of *caromel,* similar to the colouring matter of former times; being burnt saccharum and mucilage, which impart an agreeable odour to the beer, and maintain its colour with tenacity. The author, desirous to do justice to those gentlemen in the trade who use this new species of carbonised sugar (caro mellis, *flesh of honey*) as their colouring substance, in moderate quantities, and of the best description, must say, that they consist of all the larger London and Dublin houses and some others, where first-rate talent and liberality continue to exist, and where, as a consequence, none but the best materials are used; and they have their reward, in extensive sales, fair profits, and the satisfaction evinced by the public.

The impediments offered to an economical application of this kind of malt in the ordinary way, induces the author to suggest that it would be advisable to mash it alone, in a vessel made expressly for the purpose, and to add the product to the ordinary wort in the under-back, the copper, or the hop-back, in such proportions as the colour of each extract may indicate after experimental mixing for a few moments. On account of the extreme brittleness of the patent malt, it can seldom be cut or crushed without reducing it to powder; and since, unlike other malts, nothing but a simple solution of its caromel and gum occurs when mixed with either hot or cold water, and the whole of the husk and other insoluble particles fall in a compact mass upon the nether parts of the vessel; hence as it would be impossible to run the extract through the sediment, as in other cases, the wort which it produces must needs be drawn off from above, by means of taps placed one above another in the side of such adjutant tun: in this way repeated mashings may be had, with the addition of a few hops, and the process may be continued as long as any colour can be obtained.

This kind of extract may be cooled, and instantly vatted in its dilute state; but perhaps it would be more advisable previously to boil it for the sake of concentration. In this way several weeks' stock may be kept on hand in good condition, there being no danger of its decomposition, if kept tolerably cool and free from yeast or other eremacautical matter. It would be difficult to define by words the exact flavour, colour, and constitution, produced by the various combinations of black, brown, amber, and pale, or perhaps to confine the shades of separate malts within these four terms; for the scales of admixture are nearly equal in number with the practitioners themselves. The shades of amber malt, in particular, are so many, and so much difference of colour is imparted by black, that frequent trifling variations are made in the proportions of each, by persons who draw out a standard scale for their individual guidance, in endeavouring to arrive at uniformity in colour and flavour, be they such as they may; but by an experienced brewer, this is done with admirable accuracy. The following six, which are varieties in rather extensive use, are here selected as being suitable to the taste and judgment of the author, according to attendant circumstances.

Table of Porter Grists.

No.	Black.	Brown.	Amber.	Pale.	Total.
1	9	0	0	91	100
2	6	34	0	60	100
3	2	30	10	58	100
4	3	25	15	57	100
5	4	24	24	48	100
6	5	0	95	0	100

With those who brew the low-priced shabby article above alluded to, a grist something like No. 1 is used, producing a flavour which would lead a stranger to conclude that liquorice had been engaged in its production, so much like it is the flavour of porter brewed of pale and black malt only, whatever be their relative proportions. Any fulness which this porter may have, principally depends upon the gum-like portions and properties of the black malt, which, unlike the mucilage of the paler malts, does not submit to the process of saccharisation, either in the mash-tun or in the fermenting-tun, and consequently does not contribute to the formation of alcohol; if, however, such an article be strong, and not attenuated too low, but vatted six or ten months, its objectionable flavour is in a great measure dissipated, and a new one is acquired, which renders the potation tolerable, and sometimes really good. Thus porter made by an excessive use of black malt, is much more mucilaginous than that which is brewed from lower-dried materials.

The destruction of the constitutional principles of corn by a heat nearly triple the *maximum* which it can withstand, also helps to account for the deficiency of extract from porter malt; for this high heat, which the porter malt has to endure in drying, destroys its diastase, and consequently its generative or converting power, when in the mash-tun. This, and not the double cylinder, has of late started an objection to Poole's patent (p. 86): indeed, the old-fashioned blown, and even some of the ambers, do nothing more than passively *dissolve* in the mash, through having been deprived of their activity by heat.

No. 2 in the above table produces porter of an ordinary kind only, and with a lower flavour than the first, though much superior to it; but its quality greatly depends on attendant circumstances. No. 3 is much improved in consequence of the introduction of one-tenth of amber and a small quantity of brown, or of the deceptive blown malt. No. 4, which perhaps is much more general in the provinces, is preferable to No. 3; and, if used without any counterfeit matter, gives general satisfaction where the brewer is provided with the necessary plant, proper vats, and a sufficiency of knowledge; but the great misfortune with many of the less experienced country brewers is, they imagine that porter cannot be brewed from malt, hops, and water, without some other ingredient; hence they often spoil the flavour of a really good beverage by contamination with liquorice or other alien matter: a fact which, as it demands condemnation, must be admitted with regret. Besides this, country porter is often prepared of a greater gravity than the common London tipple, and is consequently of a higher and ranker flavour, arising from the concentration of its carbonised matter. Country brewers would find their pecuniary advantage secured, and their beer at the same time improved, were they to use newer and better hops than they usually do; and were they to adopt the grist now in use by those whose produce is so much admired by the public, namely, No. 5, and still more so by the exclusive employment of No. 6.

One cause of the decline of London porter during the last twenty years, arose from those who, till then, were porter brewers only, embarking in the ale trade, and inundating the porter department with the gummy refuse of the ale brewery, as animadverted upon at p. 177, in the form of return worts; which carry with them much of the mucilaginous portion of the pale malt, adding weight to the porter without strength, and fulness without flavour. Undoubtedly their ales ought to be better than such as are brewed entire, as much so as new-milk cheese exceeds that of skimmed milk; but frequently it is worse than entire, besides which their porter is greatly inferior to the production of the few houses who continue to brew porter only.

Irish Porter.—The most respectable of the Irish brewers are deservedly noted for the genuine qualities and remarkably pleasant flavour of their porter; and although some of the peculiarity may be attributed to the fumes imbibed from the drying kiln, and from the choice hops, of which they are not sparing, yet it mainly depends upon the character of their grist. In this respect their practice is similar to that of the best modern London houses, which is the admixture numbered 6 in the above table, or a close approximation to it; and the chief material with the first establishments in both countries, is a perfectly malted corn of the finest description, dried to a shade lower than that which is generally recognised as amber malt, the necessary colour being imparted by about one-third or one-half of the black material required when pale malt is used in lieu of the browner kind. This modern porter malt just described, is dried in such a manner as to cause only very little diminution in the extract, when compared with the paler article, and yields a sufficiency of colour with a desirable flavour, to render no more than a moderate and profitable application of the black malt necessary; and thus is produced a mild, soft, and agreeable potation, of established soundness and permanently good quality.

Some portion of the Irish brewers, and those who rank among the most celebrated, form their grist of pale and best black malt only, first taking the precaution to redry the pale on a kiln kept for the purpose in the brewery, perfect and sound dryness being wisely considered indispensable in malt, and of particularly high importance. In short, much of the Irish malt is so indifferently manufactured, that the acquisition of a kiln is quite indispensable to a brewery. To ascertain the condition of any specimen, in store or elsewhere, a hygrometer would be very useful: it is a cheap and simple little instrument, capable of indicating the degree of dampness or dryness of whatever is in contact with it, with promptitude and decision.

London porter, though justly extolled in every part of the civilised world, is not, nor ever has it been, indebted for its superiority, as thousands have imagined, to any particular virtues possessed by the water of the Thames; indeed, it would be very strange if it were so, not only from the disgusting filthiness imparted by its tributary sewers, but from the fact that the "silvery Thames," as the poet calls it, does not supply any of the London houses with brewing liquor, except they are situated at some considerable distance up the river; and even there the water is pumped up and filtered by the works of the South London and Vauxhall Water Company, at the ebb of the tide, or at low water, so that those who then employ it may be able to vend it to their customers in the purest state that is possible; for there is not any appearance of "silver" any where below Battersea Bridge, except what a poet's eye can see; and even those who employ this water in the purified manner here described, reject it during the summer months, especially if they have spring wells within their premises, and know how to appreciate them: an acquisition which few are willing to be without, for the above and other good reasons.

The process of extracting the porter wort is much the same as that which has been recommended in brewing ale, with the exception already pointed out, in consequence of a choked mash. Some brewers recommend that porter be boiled 8 or 9 hours to increase the colour, and if of different mashes, to apportion that length of time among them, according to relative strength; forgetting at the same time that "long boiling prevents free fermentation."

Common London porter ranges from 20 to 22 lbs. *per* barrel, and the ordinary stout for town consumption about 26 lbs.; and stronger than this is mostly sent into the provinces, or consigned to exportation. The different qualities of beers, whether porter or not, are generally marked upon the casks in which they are sent out; and it is now common to stamp X, XX, or XXX, to designate such gravities as at the option of the proprietary may be determined upon, as a guide to the servants, and as a scale of charges. X was at first stamped by the Excise, or with their authority, on all casks and stores containing beer, which was deemed to be worth ten shillings *per* barrel, to denote that it was strong, and chargeable with duty accordingly; but as this was determined by the consciences of the trader and his surveying officer, the latter of which was sure to predominate, the course gave rise to an infinity of disputes. Ten shillings afterwards became the duty *per* barrel on malt liquors not accounted small, and the letters X and T were introduced into the officers' books to represent EX*cisable* and T*able* beer respectively, till the total repeal of the beer duties in 1830 rendered all further notice unnecessary.

The general method of procedure in the fermenting department, is to finish the cooling of the worts by efficient refrigerators, and to pitch at 60°, or between that and 63°, in squares or rounds fitted up with attemperators. The attenuation is seldom carried below 11 or 12 lbs., and the heat is curbed within 70° or 75°, when it is started into pontoons containing from 10 to 20 barrels each, where it ejects its yeast into stillions. These smaller fermenting vessels are kept filled up by a self-acting apparatus provided for the purpose, consisting of parachute, tank, ball-cock, pipes, &c., by the agency of which a considerable burden of manual labour is avoided, considering the quantity of work required to be performed. The ultimate attenuation is from 5 to 7 lbs., and the stronger London beers seldom exceed 10 lbs. When fine, it is vatted in large quantities to improve its body.

VATTING PORTER.—The spontaneous and gradual decomposition which takes place in a large vat, creates a peculiarly grateful kind of acerbity and fulness on the palate, which is not to be found in new or unvatted porter; it also creates an amalgamation of distinct flavours which have emanated from the temperatures and management of the gyles during fermentation, with that of the article which it may be advisable to blend with it, to effect flavour and taste of age, be it of whatever description it may. This mode of preparation is properly denominated *mellowing*, a word significant of becoming *ripe*, and which lexicographers derive from *mel*, honey; and it is this mellowing and reduction of the bitter, from which the pre-eminence of large stores arises.

Ure's Delusions.—False construction is more readily attainable than correct demonstration, and men's minds are more apt to censure without cause, than to reflect and afterwards to decide wisely; and though Dr. Ure, in his Dictionary, under the article "Beer," has attacked the London brewers with more causticity than discretion, his credulity is less to be blamed than the fatuity of a class of practical brewers who in their writings have avowed themselves adulterators. Had the Doctor rested here, the subject might die and lie buried in his book without controversy; but in his "Supplement" to the Dictionary, recently published, he has renewed the assault with implacable antipathy, and the Mechanics' Magazine, for December, 1844, has given an echo to his accusatory declamations, which have been copied into several provincial organs of the press. The author, on perceiving the course thus taken, addressed a letter to the Magazine, which will be found in No. 1121, of the date February 1, 1845. The Doctor has published a process for porter-brewing, which, were it known to the trade, would be utterly disreputable and ruinous; but which, as it stands, is fallacious, erroneous, and injurious to the brewer, in principle, practice, and detail. The following is a correct copy of the recipe, which, after a partial and meagre recantation, he imputes to the London brewers, except those which he calls "the most respectable establishments."

"*Components*:—

530 bushels, English measure, of good barley malt.
10 ditto of kiln-browned malt.
12 cwt. of *essentia bina*, *caromel*, or sugar fused over a fire into a dark brown or black syrupy mass.
1500 lbs. of hops, or about 3 lbs. to each bushel of malt.
10 quarts of *calfini*, a preparation made with the oil distilled from the outer bark of the birch.
5 quarts of good porter yeast.
Finings of isinglass dissolved in sour beer."

This he madly boasts of as a discovery or "statement of the process for brewing *genuine* London porter," broadly "believing it to be more nearly that really practised than any formula hitherto published."

1. We will take five of the first London houses as an epitome, each of which on the average consumes 70,000 quarters of malt annually. Two-thirds of this consumption may be fairly estimated as the quantity used for porter, so that each of these firms must employ, according to his view, 422 tons 13 cwt. of *essentia bina* every year, all of which they must necessarily *smuggle* into each of their respective breweries!—And all escape? Cannot the Doctor find *one* vigilant exciseman or traitorous workman in so many, willing to receive an informer's hire?—Does he imagine that men so "respectable" as he admits these brewers to be, would be silly enough to subject themselves to the penalties inflicted by the statute of the 1st Geo. III. and several others above named?

He allows nearly 2 *per cent.* of "browned," not mentioning *black* malt; but the quantity consumed is about 4 *per cent.*; so that each of the breweries in question runs through 15,000 bushels, and all the London houses about 156,000 bushels annually, of an article of which a travelled author, who professes to give a prescription for *genuine* London porter, does not profess to know even the existence.

2. With respect to the introduction of the drug which he terms "*calfini*," most of the trade have now seen this vituperative tirade of the Doctor's, and all of them to a man, whether in town or country, declare themselves ignorant of its name, quality, and substance. Moreover, like the essentia, it must be surreptitiously introduced to the *trifling* amount of 18,500 gallons a year: an exploit which magic alone could conceal.

3. "For 180 barrels of brown stout, containing from 80 to 85 parts of malt extract in 1000 by weight," he recommends "5 quarts of good porter yeast," which is about $\frac{1}{24}$th of the quantity which absolute necessity requires to move the fermentation, and furnishes an indubitable proof that *Dr. Ure is not a brewer.*

4. With respect to hops. The quantity of malt consumed by the brewers of the United Kingdom, averaging the last 4 years, was 3,689,645 quarters a year, and assuming, as before, that one-third was spent in ale, the London brewers having used up 694,753 quarters a year, 463,168 quarters remain for porter brewing. Then, according to the Doctor's arithmetic, the quantity of hops required to be used with the malt, at 24 lbs. *per* quarter, would be 11,136,032 lbs.; and as the average growth of these 4 years was 43,265,423 lbs., no more than 32,049,391 lbs. remain to be used in brewing the 3,226,477 quarters of malt brewed into ale in London and in different ways throughout the country, being

less than 10 lbs. to the quarter, or $1\frac{1}{4}$ lb. to the bushel! Pursuing his correptious fulmination a little further, we will assume that which is as near the truth as possible, namely, that 150,000 quarters of malt are now annually converted into bitter ale, and that the quantity of hops required for *this* purpose is *really* 3,600,000 lbs., he then leaves us 28,449,391 lbs. of hops on hand, to yield their flavour, and give preservation to the produce from 3,076,477 quarters of malt, *or nine pounds four ounces to the quarter*, instead of 8 lbs., which is about the average quantity really used in brewing both ale and porter, excepting export beer. And this egregiously miscalculating dupe, thus drawn into unpardonable error, was the actuary (*vid.* p. 242) of the "*British National Brewing Company*," whose concentrative powers were to swallow up the trade!

In Chapter VIII., p. 237, &c. herein, allusion is made to the humuline extract by Heck and Co., to the English patent by Newton, and to the foundation of this great commercial association, in which Dr. Ure became thus personally interested. As the subject has been fully discussed in the Mechanics' Magazine, No. 1199, by some editorial criticisms, and subsequently by a warm controversy between a Rutlandshire 'Brewer' and a Surrey (*per* pun *sorry*) 'Chemist,' in which the present author's name has been somewhat unceremoniously blended, with a compliment on one side and a sarcasm on the other; and as several of his readers may not take in that periodical, he embraces this opportunity to reflect upon the circumstance, though he has little more to say than he has already done, in advocacy of the sentiments advanced by the 'Brewer,' in order "to protect society from imposition:" a duty which the 'Chemist' shrank from performing; for when the former had ascertained by experiment that he could sell a stronger, livelier, and more palatable beverage for 31*s.* than the Concentrated Extract Company for 52*s.*, the 'Chemist' boisterously, and with considerable dexterity, parried off his challenge upon this vital point, in the old declamatory strain, accusing the public brewers, on such authorities as Accum and Hartley! of numerous adulterations, particularly in the porter department, just in Ure's own blindly prejudiced style; at the same time admitting that the Society added sugar, honey, and rice, to the original cost, as estimated upon by his antagonist, and that the invention is old as the days of Bergman, "as far as a century back." He also introduces the name of Brande, though with what degree of consistency must be evident from his own statement, that this eminent professor throws the odium of adulteration upon the retailers of weak beer. To sum up, and that a real champion to his cause may not be missing, he brings forward Dr. Secretary Ure himself, who has ventured to assert that their cordial is "free from those noxious ingredients, too frequently present in beers, porters, and ales of commerce." To these vague declamations the 'Chemist' appends a long string of hypotheses, as, "*Suppose* the medical faculty to recommend it to mothers," "*if* our colonies take it, and breweries are set up," "*imagine* it spreading into Ireland, and superseding whiskey,"—and "*suppose* the Company, by skill and management, making great improvements, becoming popular, and growing liberal:"—a sign that all those desirable things remain undone. Undone they are; and no man of good understanding, with the facts before him, could anticipate otherwise: for if when "Bergman recommended it to mariners for use at sea, as an antiscorbutic beverage," it would not convince the world of its merits, neither can the efforts of a "British National Malt Extract Company" make a phœnix of its dissipated ashes.

The 'Brewer' whom his opponent chemically designates "an animated clog" and "simple man," possessed of the gift of politely "taking the bull by the horns," very properly suggests that personal recrimination will neither enlighten the subject nor add credit to the controversy; and draws the natural and candid inference, with regard to drugs, that "the party subjected to the least restriction, and possessing the greatest opportunities, is the most likely to use them;" and in a brief and pithy epistle, a third time invites the 'Chemist' to competition in price and quality, and to confute his original argument. Here the drama has closed; its first representation has tied down its curtain for ever; and the Concentrated Society, so extolled by Dr. Ure and the Chemist of Kennington, for their "genuine and most useful article," the "utility" of which was "only beginning to be felt," and would, according to their prophecy, "become very *extensive*" (*expensive* would have read better) and "most promising as a profitable investment of capital," soon afterwards closed also, in the manner that bubble schemes usually do, swollen with air till they burst asunder and disappear.

The extensive convenience for storing, the large stock of all ages constantly kept on hand, the regularity of the system with which every thing is conducted, the tolerable perfection at which they have arrived in the various departments of the art, through their enlarged practice and skilful competition, are the principal causes of that superiority which distinguishes the porter of the London breweries from that of the provinces, where these essentials are not yet combined.

Porter is recommended by medical men to their poor convalescent patients, in lieu of port wine, which antidote is exclusively appropriated to the wealthy. Here we may take the liberty of suggesting, that both classes of such invalids may advantageously now avail themselves of a yet simpler, more nutritious, and less alcoholic renovator than either, merely by a temperate imbibition of a moderately attenuated fresh *pale beer*, of about 20 or 24 lbs. gravity, or such as is retailed at fourpence or sixpence *per* quart. This beer contains the essentials required by both doctor and patient, and which may be looked for in vain in either wine or porter; for besides containing water, gum, alcohol, and carbonic acid gas, in common with black beer, it possesses some glutinous matter and a fair proportion of nutrimental sugar; and its gum is rendered digestive by retaining its vigour and original elements; it is also better suited to weak stomachs and to medicinal and strengthening purposes than any black beer can be, since it contains less carbonaceous matter, and consequently more nutritious food, and is easier of digestion; whereas porter contains such a large share of this heavy mucilaginous matter, that it is better fitted to hardy and healthy constitutions, such as workers in metal, soil, or mortar, whose exercise enables them to carry it advantageously through the physical system; and, as regards port wine, little or perhaps none that reaches this country is free from adulteration with foreign alcohol, which is added to it either at the close of the fermentation, or immediately prior to its enshipment, and is never completely incorporated with the natural juice of the grape and its native spirit, notwithstanding all the art of "fretting in," of which the exporters are masters as adroit as they are fraudulent. However desirable the tartar of grape-juice is, as a component of wine, so little of it remains after bottling, that it cannot avail as medicine; whereas the tartar or gluten of malted barley answers the desired purpose, because it exists in sufficient quantity, and partakes of the same essential properties. The constitution of porter differs from that of pale beer by containing carbonised gum, little sugar or gluten, and is comparatively an indigestible beverage.

Of the effect which gum has upon the animal frame, we are furnished with a serious but interesting truth in the admitted indigestibility of rice with some persons, and in an account given by Park in his Travels, of the emaciated condition of a certain uncivilised African tribe, who, during a scarcity of other food, live upon the gum which exudes from the stock of an indigenous tree, and which is of such difficult decomposition by the human organs, that it creates pains, and very often brings on endemic disease, which subsides only on their partaking of some animal or vegetable food which contains the azotic element, necessary to the exercise of the digestive functions. Here is little difficulty in seeing that symptoms of extreme debility must in many cases have occurred, attended, no doubt, with violent dyspepsia; and if gummy matter is so unfit for the support of the animal constitution when the appetite is keenly on edge, how much more dangerous must it be to us at home, when administered to persons already sick and weak! Although starch gum is not imbibed from beer in very large quantities, yet its highly carbonised, and consequently inconvertible condition, makes it quite objectionable as food for invalids, whatever service it may afford to the healthy and strong; and notwithstanding that the gum which forms the fulness of porter, is admitted to yield more to the assimilative action in consequence of the accompanying bitter of the hop, &c., yet it is still obstinate during its digestion, even with some healthy people, as is also coffee, though aided in like manner by its own bitter principle and other matter conjoined with it. In both cases, the presence of the carbonised gum is indisputably the cause of the obduracy.

Ale differs from porter as much as tea from coffee, both in lightness and in stimulus; but neither of the high-dried kinds of beverage contains the nutriment incidental to the paler infusion, without the addition of some artificial matter; nor do they produce the same cordial and exhilarating refreshment; yet where is the doctor who prescribes coffee in preference to tea, under circumstances of debility, depression, or indigestion? Strange as the truth may be, and observation assuredly establishes it in practice, gentlemen trained to the study of medicine pay too little attention to organic chemistry to bestow on this subject the serious consideration that it eminently deserves. In short, they perfer porter to ale, or as they say, black beer to pale, because the former is generally in a sounder condition, and less disposed to acidity, and perhaps because it contains less *saccharine* matter; but, to avoid both extremes, the whole of the pale materials may be brewed into a species of *dry ale*, like that prepared for the Indian market, though it is not less saccharific; and it is now notoriously remarkable that though India ale was originally intended wholly to be sent abroad, yet, by the advice of the faculty, some of whom have suddenly discovered its intrinsic excellence, it is now extensively prescribed as a medicine in cases of impaired appetite, weak digestion, and the like, which has given rise to its occasional and gradual introduction where means command access to good things, for the improvement and protection of health; but as this breaks the spell of custom, it is made to constitute the leading topic of a separate chapter.

CHAPTER XVIII.

EXPORTS.

ESSENTIAL QUALITIES OF STOUT—RECTIFICATION—AUSTRALIAN AND CANADIAN TASTE AND CLIMATE—BITTER ALE—QUANTITY AND QUALITY OF ITS HOPS—ORIGINAL AND CORRECT MODE OF FERMENTING IT—PROGRESS OF ATTENUATION—HOME CONSUMPTION—MEDICINAL VIRTUES—ULTIMATE STRENGTH AND BRIGHTNESS—SPECIMENS—CALCUTTA MARKET, AND MALT LIQUOR IMPORTS.

The materials and manipulation necessary for the production of porter in general, have been somewhat fully enlarged upon in the foregoing chapter; therefore a brief review of a few principal points more particularly bearing upon the subject which now presents itself for re-inspection, viz. the chief features of porter or stout designed for exportation, may now suffice.

Of the various productions of the British brewery sent abroad to the many nations and climes with which our merchants hold intercourse, the principal are those exported to our Australian, Canadian, Indian, and West Indian settlements; and these, in consequence of the diversity of climate subsisting between those colonies and states, and not a little from the constitutional habits and taste of the several classes of consumers, are required to vary a little in composition. For the uniform mildness of Australia, and the changeable seasons of North America, a good fair article of porter, called stout, of about 28 lbs. *per* barrel, or something less than three barrels to the quarter, will suit, to obtain the drawback of duty on materials. The grist from which such export beer is drawn, as well as the hops intended to flavour and preserve it, should be somewhat better than a good medium quality; and it is found necessary to use only one description of malt, except the colouring preparation, and neither under nor over-dried, but of the purest *amber*. A winter's vatting seasons it for the voyage, and renders it fitter for exportation than if shipped immediately after it is brewed, however fine and spirituous it may be in its maiden state; but the stout intended for the East or West Indies, should be more alcoholic from the commencement, and requires from 10 to 15 *per cent.* more bitter. About 14 lbs. may be sufficient for the Australian market, and 15 or 16 lbs. for the Canadian; but the Indian will require 20 lbs.

The custom of mixing a native thin-brewed beer of inferior quality, and not unfrequently a mere compound of water and molasses, with the imported stout, is a common fraud with some of the Australian and American dealers, who, by thus impairing the strength and flavour of the genuine import, and thereby increasing the quantity in their stock, enlarge their profits accordingly; by which misconduct they not only rob the consumer, but sometimes heap odium upon the innocent brewer, particularly if an honest and emulant man, his name and fame going hand in hand, and the former being usually labelled upon the vessels containing his stock. He may, in some instances, have been ordered by the exporter to make the colour of his produce some shades darker than usual, as a false token of strength, by an additional allowance of patent malt, although it may conspire to shield the anticipated deception at the expense of his individual reputation. The consumption cannot be increased by this time-serving and mercenary trickery; but an exposure and a good brisk competition may do much towards abolishing it, since the latter course remedied an evil in the market of Calcutta, now some years back.

The ultimate attenuation of the export stout should vary according to the climate it will have to encounter; the Indian supply may have about 4 lbs. unattenuated; that for the milder and uniform climate of Australia, about 5 lbs.; and the stock intended for the more fluctuating, and often extremely hot or rigidly cold seasons of Canada, may have 6 lbs. unattenuated; and it is imperatively necessary that all extraneous vegetable matter, which forms the yeast, lees, &c., be removed; because the agitation during the voyage would otherwise provoke extreme fretting, leakage, and premature acidity. If the rumbling of a carriage in a gateway will acetify the beer stored in a cellar underneath, much more so will the rocking at sea, if due precaution have not been taken. Also, the nature of the materials employed, in order to supply a greater quantity of carbonic acid gas than can be generated by paler beer, demands an adequate number of vent-plugs, which should be made of a peculiar red oak, almost as porous as cane; and from four to six will not be too many, if the pores be partly choked up by yeast or other ejected matter. This plan is greatly superior to the iron vent nail, which indeed is now but rarely seen in any establishment professing to have embraced improved principles.

Bitter Ale.—After the explanations and intelligence that have been given within the body of this work, on the subjects of boiling, mashing, fermenting, and the rest, no more can be required in further elucidation of the practice of brewing, than that which is directly applicable to the best available means of obtaining the necessary properties and peculiar characteristics that distinguish a malt liquor made for exportation, and used as a medicine at home, from that which is manufactured for ordinary and general home consumption. In the foregoing chapter, allusion has been made to the introduction of pale beer by the faculty as a medicinal cordial. This practice has induced brewers to prepare an article that may be exclusively appropriated to domestic consumption, now commonly known as *Bitter Ale*, which differs from other ale only in the quantity of material engaged in its production, that for the home market being somewhat less bitter and spirituous, than such as is exported to India. The bitter of the hop appears to have all the properties of the coriander in its pungency and flavour, and also to possess, like some other exotics of the umbelliferous tribe, a stomachic and carminative power, without having the torminal attributes of senna and other drugs of pharmacopolists. According to a brewing writer who lived in the hop country, the spirit of that flower is "truly cordial and warm, exciting in the third degree, aperitive, abstersive, subastringent, digestive, discussive, diuretic, stomachic, and sudorific;" so that it has more real good qualities than have even been ascribed by Nicholas Culpeper, the prince of quacks, to his favourite wormwood: at all events, the hop acts as a tonic, antispasmodic, and cathartic medicine; and its aromatic bitter, when properly administered, restores the abused appetite. Hence the medicamentous properties of this beer of physicians may be in part attributed to the absence of saccharine, mucilaginous, and general amylaceous superfluity, but principally to the highly tonic property derived from the quantity and quality of its hop, which corrects unwholesome nutriment, promotes digestion, and, in a singularly powerful manner, increases the nutritive virtue of all food united with it, without undergoing any perceptible change while thus officiating in its passage through the animal system. It is particularly successful as a stimulating remedy for the deranged functions of the stomach, and acts upon the sympathetic organisation, so as to restore the debilitated system in general, and ultimately to give strength and vigour to the mental faculties and physical powers.

Like all other worts, those intended to form this unique medicine require speedy cooling, which will prevent too voluminous an absorption of oxygen; and hence the imperative necessity of an efficient refrigerator. They do not require more yeast than other worts of the same gravity, but it would be almost futile to attempt their fermentation without an attemperator, during the warm season; for it is absolutely necessary to conduct this process with the nicest regularity, since the ultimate purification and brightness will otherwise never be perfected.

The malt should be of first-rate quality, perfectly dried, and very pale, colour being the first consideration in point of importance; and the hops should therefore be of the palest growth; and in selecting those that impart the least colour, their maturity should not be overlooked. The quantity must vary inversely with the quality; but as the flavour of this kind of ale emanates more from the aroma and bitter of this flower than from any other material, from the ultimate extreme decay of the malt extract, it is advisable that the hops should be of the description which contains the greatest share of condition in the smallest bulk; reasons for which qualification have already been assigned (*vide* p. 222). Such as those designated *Goldings*, *Farnhams*, and the very best *East Kents*, may be used with advanattenuation has pograded to within one-half of the original density, the heat should not be allowed to rise above 62°. The remainder of the process will require very close attention ; for as the attenuation approaches the crisis for its cleansing and purification from excrementitious matter, three-fourths of its saccharum being converted, the thermometer appearing rather below than above 64°, about one-half of the yeasty head may be skimmed away, and at the same time the tap of the attemperator may be turned off. When 2 lbs. more have disappeared, the skimming may be resumed, and about three-fourths of the head may be removed. The density will now be 6 lbs., and at least 2 lbs. more should be attenuated before the fermentation can be considered complete, and which, it is presumed, the previous skimming will not prevent. If any obstinacy is experienced on this account, so much early skimming must be afterwards avoided. When, however, only 4 lbs. remain undecomposed, the gyle should be skimmed quite clean, and the cooling powers of the attemperator should be appealed to.

The stream of water and the heat of the gyle must continue to pass gently away ; and the cleansing skimmer should be put into requisition whenever the light head thickens to within an inch deep.

All that now remains to be done, is to expedite the clarification ; and as we know that heat, or calorific repulsion, is a power opposed to aggregation, being as such repellant, a separater of particles, the attemperator should now be put in requisition to extract the caloric, and thereby encourage the natural affinity of each remaining azotised particle for the others, that through their gravitation, and combination, and ultimate quiescence, a speedy precipitation may take place, so that by remaining in this cool state a few days, it may be fit for its destination. To make this peculiar process the more perspicuous to the inexperienced, the author subjoins a few figures from the end of a brewing of his own, which may be taken as an example and tested as a guide. The square contains 200 barrels of wort, the *gravity* at pitching (commonly called *density*) was 24 lbs. *per* barrel, and the hop employed was East Kent.

Hours in Square.	Heat of Gyle.	Attemperator tap.	Attenuation.	REMARKS.
0	57°	off	0	With the aid of finings, this ale became quite bright just 10 days after racking.
10	57½°	on		
22	58°	on	19·1	
36	59½°	off	17·5	
48	60°	on	16·	Much admired by all. Self not pleased with the hop. Try Farnham.
55	60°	on	15·3	
62	61°	on	14·	
72	61½°	on	13·	
78	61°	on	12·2	
83	62°	off	11·2	
90	63°	on	10·	
96	64½°	on	8·5	
102	64½°	on	7·6	Partially skimmed.
113	65°	off	5·	Skimmed closer.
120	66°	off	4·3	Do. quite close.
134	60°	on	4·	Do. do. clean.
150	52°	on	3·9	Do. do. do.
160	50°	on	3·9	Do. do. do.
190	50°	on	3·8	Vatted one-half. Sent half out.

This precise time of fermentation is impracticable with such waters as are termed "hard," or such as the Burton brewers use. In these cases higher pitching heats and a higher fermentation are necessary for general practice, or where it is desirable to complete the attenuation without vatting, on account, as before observed, of the obstinacy with which worts ferment when so constituted; but with soft or medium water, the above Table may be followed with confidence and accuracy.

If found desirable, the attenuation may be carried a pound or two lower, as before suggested; and by proper management, the trial may be made with safety. To avoid premature acidity after its arrival at the place of its destination, all matter tending to its turbidity should be removed by attraction and precipitation, and it should not be racked for exportation until it has become perfectly bright. About two pounds of new hops *per* barrel might now be added. The very small quantity of unattenuated matter yet remaining, should be no more than just sufficient to supply enough of carbonic acid gas for the requisite effervescence during its limited decay, without causing the slightest turbidity at any time; and to prevent its accumulating in excess after shipping, and endangering the safety of the cask, a porous plug or two should be inserted into the shive or near it, through which the surplus gas may escape.

As regards the Indian market, it is presumed that the following information, given by a commercial firm of great respectability and experience in Calcutta, will be found as acceptable to the reader as it has been to the transcriber, as much from its novelty as from its undoubted correctness.

"Great Britain must always be the source whence British India is to be supplied with good wholesome malt liquor. Attempts have been made by the French, Americans, and Germans, to supply it, but it has proved to be quite unsuited to the Indian palate: in fact, very bad. There is nothing to be dreaded from them; and although it is not impossible to brew good table beer in Upper India, yet it is not likely to succeed permanently, for various reasons. No person of capital would run the risk of losing it, as it is only whilst prices are high that he could be handsomely repaid; and in that case, the English brewer would be in the market, and upon equal terms at least. The cost of apparatus, materials, labour, and interest on capital, added to the expense of transportation from Muttral, or any other of the colder stations, to the principal towns of the central and lower provinces of Bengal, would be much greater than the English brewer's charges to accomplish the same object.

"Previous to the years 1816 and 1817, the demand for beer in India was nothing, compared with what it has become during the last seven or eight years. The pressing calls in 1821 for an increased supply, led Hodgson, of London, to enlarge his brewery, and induced some to enter into arrangements for monopolising the market: this, as usual in such cases, ended in severe losses to all concerned. Beer has for many years been an article of extensive consumption in Bengal, and it is highly probable that a greater increase would take place, were it not for the very high price to which it has frequently risen: this, however, could not be guarded against, as long as Hodgson exclusively had the supplying of the market; but now that other brewers can furnish equally good beer, there is no fear of a short supply, or of being subject to monopolies, such as were tried some few years ago. The great fluctuation in the price of this article has been caused entirely by the irregularity of the supply, and the plans laid down by Hodgson, and some of his moneyed neighbours, to keep the others out of the market. So entirely dependent were the public upon this brewer, that he in a great degree regulated the price and the quantity imported. Others who attempted to introduce their beer into the market were compelled to withdraw, having lost very considerably by their speculations; for Hodgson, when he

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"In 1825 and 26, several brewers tried the market. and as the spell had been broken, met with liberal and fair encouragement. The most successful of them were Allsop and Son, Bass and Ratcliff, Ind and Smith, and Charrington, with a few others. It being therefore clear that England must furnish the supply, and it being the interest of the brewers to keep the market steadily supplied, we shall now give some data to guide the brewer or shipper.

"It will be perceived that since 1830-31, (the 30th of April terminating the Indian Commercial Year,) the imports of Beer and Porter into Calcutta have increased nearly 100 *per cent.:* this in a great measure arises from the moderate rate and little fluctuation there has been in prices, whereby a taste for beer has been more generally diffused throughout the poorer classes of British inhabitants, which having once acquired, they will continue to indulge as long as prices remain moderate.

"*Imports of Beer and Porter into Calcutta.*

Year ending April 30.	Butts.	Hogsheads.	Dozens.
1830–1......	418	5,556	2,105
1831–2......	111	5,946	1,167
1832–3......	252	7,916	2,293
1833–4......	322	7,193	2,028
1834–5......	244	6,282	2,632
1835–6......	140	4,519	1,392
1836–7......	404	9,544	3,241
1837–8......	841	11,356	2,102
1838–9......	606	8,937	719
1839–40	391	10,779	671
1840–41	824	11,808	2,989
1841–42	669	11,035	6,457
Total in 12 years....	5,222	100,871	27,796

"The beers now most saleable, and which command the highest quotations, are those of Messrs. Allsop and

Son, Bass and Co., and Ind and Smith, especially the former, on account of the superior lightness and brilliancy of their shipments: there is, however, a wide field for competition, and we have little doubt that by caution and care, one of the most lucrative and extensive businesses might be opened with the port. The first point for consideration is, quality, a few remarks on which may not, we trust, prove uninteresting. The ale adapted for this market should be a *clear*, *light*, *bitter*, *pale* ale, of a moderate strength, and by no means what is termed in Calcutta 'heady;' it should be shipped in hogsheads, which we need scarcely observe should be most carefully coopered, and small shipments and frequent, in preference to consigning heavily at one time; as the natives, who frequently purchase on the invoice (which by the by should always be made out at an advance of prime cost of 50°/₀, as invoices are sold taking the rupee at 2*s.* 6*d.*, and generally at a discount of from 5 to 10°/₀), cannot often raise funds to take off the same. Another point is, that by frequent consignments you acquire a *name*, which, as you may be aware, is every thing in India."

This highly interesting and instructive commercial letter says so much on this subject of *British Pale Ale*, that the author of this work would be deficient in common politeness, were he to offer any other commentary upon it, than to repeat his best thanks to the intelligent writer of it; and with this simple observation he is contented to leave the subject in the hands of his readers, while he attends to some other matters.

CHAPTER XIX.

STORING.

OLD AND VATTED BEER — SPONTANEOUS PRODUCTION OF ETHEREAL STRENGTH—THREE SYSTEMS—AMALGAMATION BY REPLENISHMENT —REGENERATION—REMEDIES FOR ROPINESS—THE OILY SHIELD— EVAPORATION IN STORES—CELLARS AND RESERVOIRS CONSIDERED— SYMPTOMS IN STORES—WASHING CASKS—PAYNE'S PRESERVATIVE PATENT—STEAMING CASKS—DAVISON AND SYMINGTON'S CLEANING APPARATUS.

In consequence of a general change of the public taste in many places, from new beers to old, a stimulus is given to the consideration of the subject, and the most desirable means to be adopted for the uniform production of a pale, bright, aged, and sound article.

Without entertaining any of the expedients to which recourse is had by a few of the victuallers in Birmingham and elsewhere, and probably in some breweries also, to give to fresh ale the flavour of old, the author would recommend the employment of as much additional capital as will enable the proprietors to store largely, and to ferment accordingly, which will well repay them in the end. He has often observed, with a degree of astonishment, the great difference in the quantity of carbonic acid gas which escapes from ales that have been fermented very low, and from those wrought at high heats, original and final gravity agreeing. The intoxicating effects of the former have perhaps been exaggerated by some writers, though such highly gaseous drinks certainly are fuller on the palate, more refreshing in the quenching or assuagement of thirst, and more exhilarating in their stimulus, and of course more alcoholic or ethereal.

Where the trade is extensive, and vat-room is of consequent importance, large stocks of old ale and porter being required to supply the consumptional demand, *underground tanks*, made of brickwork, and lined with slate, to contain from 500 to 5000 barrels each, will be found convenient, and will be considerably cheaper than wooden vats of like capacity. The expense, whether 24 or 36 inches thick, is easily estimated. The tanks, for ordinary purposes, should be about the depth of cellars constructed for the usual storage of barrels.

In treating on the subject of old beer, the author may perhaps be pardoned, should he name certain localities which have attained celebrity from their mode of storing and preserving it. The ales sent from Wiltshire, Somersetshire, and some parts of Hampshire, to London, are generally old vatted stuff; and the observant brewer can scarcely pass through a street in the metropolis without beholding some such inscription as one of these, decorating some public-house front or end wall,—"Sparkling Wiltshire Ale," "Splendid Alton Ale." Marlborough and Devizes are noticed by travellers for the excellent quality of their pale-coloured sixpenny "beer," fourpenny "ale," and twopenny "slap;" but other towns furnish superior breweries. Berkshire also sends her cargoes up to town, and the greater part of these are not new, but manipulated and stored with peculiar care, and are truly excellent, as are likewise some of those from Nottingham, equal in repute with Burton XXX; and to the getting up of a commodity like these, the author is convinced that the system which he has herein propounded is most particularly and appropriately adapted. To do this in perfection, adequate means, as already hinted, and as in other undertakings, are indispensable; amongst which means may be included talent and experience; for novices are not the workmen, in any trade, to give the master-stroke to a prime article. The materials should be of the palest and best description, and the colour of the extract is best preserved by gentle steam-boiling. All malt liquors intended to partake of the character induced by long keeping, require extra hop, both in quantity and quality, and should be attenuated as freely, and at such heats, as the circumstances of their ultimate disposal, their connexion with other beers, the temperature of the stores, the duration of their storage, and other considerations, may demand, and for which no positive instructions can be laid down beyond the test proof of skill and experience.

The amelioration of vinous liquors by age, or the changes which their constituents undergo before the full development of their most agrêeable qualities, does not appear to be understood: indeed, it is a subject so darkly wrapped in obscurity, as to render a present satisfactory result of the enquiry next to impossible. Under some circumstances, we may suppose that the aqueous portion escapes by absorption and evaporation, though in other instances the spirituous parts appear to be thus lost, notwithstanding that the vinosity and mellowness are at the same time improved. One extraordinary fact may, however, be demonstrated, which is, that time deprives all vinous liquors of a great proportion of their alcohol, while it wonderfully increases their exhilarating powers. The attribution of this singular acquisition of potency, to the diminution of the alcohol and the formation of a cereal or *demeteric* ether, by some peculiar and newly acquired state of combination of the former alcoholic elements, or rather of their return to a retrogressive union, has been undertaken in Chapter XVI. of this work (p. 398); and experience, aided by reflection, strongly tends to substantiate the idea. A gradual dissolution of the constituent principles of vatted beer appears to be continuous and universal; and although the elements for a considerable time virtually increase the alcohol, they are either acting under a new kind of arrangement, or they afterwards, through the agency of time, contact, decay, or other inexplicable cause, assume an ethereal character, in some measure identical with that former spirituous state which had its origin in the gyle-tun.

In preparing old beer, the fermentation and general management may be variously conducted; but three distinct systems shall here be particularised. The density, of course, depends upon the price that it must reach, and on its original cost, but is seldom under 30, or above 40 lbs. *per* barrel. By the first of these systems, the worts may be pitched at about 55°, where the temperature is not constant, if the various circumstances elsewhere noticed will permit; and it must be well blended with just sufficient yeast, at the option of the experienced operator; for the process of fermentation has been sufficiently dilated upon to preclude the necessity of repetition here. Let it then suffice to say, that all surplus caloric generated during the fermentation above 68° to 72° should be extracted, and that the attenuation should be continued till it is as low as is consistent with the security of the gyle, which may be from 4 to 6 lbs. *per* barrel; for the lower any beer is attenuated, the more easily it will incorporate with other beer. Where that almost indispensable contrivance, the attemperator, is still wanting, a judicious seizure of the cleansing point must be observed, to avoid the dangers and evils attendant on a low attenuation without this instrument. Beer brewed and vatted entire in the month of March, will probably be in a fit condition for consumption in the following spring; but if brewed in November, it will require two winters to ameliorate and become all that is desired; but then it may be approved more than March beer. To prevent too rapid a decline during the summer months, it would be advisable, towards the end of March, to fine and rack that which has been brewed at the commencement of winter into another vat, adding to it some new hops. When such beer is in a fit condition to rack, the lid ought to be removed from the manhole; and a few gallons of good finings, dispersed evenly over the surface, will expedite its brightness, if not quite perfect it, and tend to ensure the permanency of its good qualities.

The second system may be continued like the first, through its whole process, as far as vatting, when in lieu of storing it by itself, the following plan may be adopted. Rack from a vat that is in a desirable condition for consumption, one-sixth of its contents, and fill it nearly close to the manhole with the new gyle, which we will suppose just sufficient to fill the vacancy. Let the process of racking and refilling immediately follow each other, and let this drawing be repeated once every two, three, or six months, according to the period enforced by the temperature of the stores and other circumstances that affect the amalgamation, and control the arrival of the beer at maturity. These replenishments should be inserted through the middle taps, that they may ensure a perfect incorporation with the old beer remaining in the vat; because the assimilation will thereby be greatly accelerated. When the bulk already in the vat exceeds five-sixths or six-sevenths of the fresh supply, and the draught is repeated every three months or less, it would be better, in any locality, to pour the new upon the old, through the manhole in the head of the vat. Where the practice of replenishment can be carried out to advantage, the quality of the beer may be kept uniform, and maintain its peculiar character, the aroma of the new materials agreeably commingling with the ameliorated state and ethereal strength of the more aged for an unlimited period. Such is the power of contagion, that a good stock of old beers may thus be kept on hand for a constancy, and at a most economical rate, storage-room, time, and capital all included.

The third is a spontaneous process, a description of which, to those who never tried it, or speculated on the theory of their profession, may probably appear doubtful, and perhaps a little extravagant, if not impracticable. It consists in merely vatting the worts directly from the coolers, trusting to their native ferment, and that left by the former gyle, for their gradual decomposition. The worts are seldom pitched by themselves, and rarely into a recently cleansed vat ; but a safer and more economical method would be to draw as much from a matured vat at once, as would be immediately replaced by the new worts. One thing must be observed, namely, to take care not to add the worts to any beer containing a superfluity of acetic acid ; and it is also essential that the temperature of the vaults containing the vats or stores be not subject to great variations, otherwise ropiness and other evils will be created by the process ; and though it necessarily occupies considerably more time than usual, the yeast gradually forms when in a mild and stable temperature, and accompanies the old grounds, giving to the beer peculiar properties, which undoubtedly distinguish it from all other sorts. But where, be it asked, is the brewer, especially in London, who possesses storage, cellarage, or vault-room, at all adequate to the object of thus preparing his liquors? Here, again, the author cannot refrain from adverting to that greater security in which that man may work, who either possesses a naturally formed store, or who has incurred the expense of excavation in providing one ; for, with such a place to ferment and store in, his beers may be made to surpass every other beverage, and accordingly to merit and obtain universal approbation, and, as Dr. Johnson remarked, to realise "the potentiality of growing rich beyond the dream of avarice."

Having above mentioned ropiness, it may now be well to point out both its cause and its cure. This malady is never evinced in beers sufficiently attenuated and free from glutinous compounds and improper acid mixtures. Whenever the quantity of mucilage is large, it is accompanied by a superfluity of undecomposed gluten also ; and these chiefly constitute the body and fulness of malt liquor ; and their mutual affinity for oxygen is so great, that an extraordinary absorption of that gas takes place, bearing proportion to the quantity presented by acids or otherwise ; its absorption is also facilitated by the heat which the process developes, or is imparted to it by the atmosphere. In this case the glutinous and mucilaginous properties appear to have united, and they partake of new constitution, form, and appearance, in consequence of possessing this influx of oxygen, and the consequent abstraction of a portion of the carbon : hence the viscid and oily effect termed "the rope," which may be remedied by either of the following means. Add about one-fourth of new wort, of such a heat as will raise the temperature of the whole to about 70°, and put to the mixture one pound of fresh yeast, and one ounce of cream of tartar, *per* barrel; rouse well together, and keep tolerably close: this will not only cause a fermentation of the new wort, but a decomposition and recomposition of the rope, by abstracting the superfluous oxygen, and imparting the necessary carbon. The second medicament is this;—To every 100 barrels of the diseased beer, rouse in from 25 to 40 lbs. of ground mustard-seed, previously liquefied, and a few days afterwards steep half a cwt. of good hops in hot liquor, and strew them over the surface; in the course of a week or more, a few gallons of finings will render it sufficiently pure to be mixed with a better article at racking for sale and early consumption. This latter plan is, for many reasons, particularly where much acidity exists, the more advisable.

The contents of a vat are always stalest in the upper part; a proof that the decay of beer is the most rapid where least compressed and most exposed. A flask or two of olive oil, poured on the surface of vatted beer about the beginning of April, will effectually exclude the oxygen on that quarter, and be of more real service than could be expected from a shield so cheap and simple.

The subject of waste incurred by the use of wooden vats of different sizes, seems hitherto to have been overlooked by the trade. The loss arising by evaporation and absorption is nevertheless very considerable, and increases in proportion to the length of time occupied in the storage; and the smaller the vat the more wasteful it is, because the area of its several surfaces is greater in proportion to its capacity than in one of larger dimensions. In ordinary store-rooms, for example, and particularly in those where the vats are perched up as near to the sun as possible, notwithstanding the expedient of double roofs to such places, a vat of 100 barrels will lose by evaporation from 2 to 4 *per cent. per annum*, while one of a 1000 barrels will not shew a deficiency exceeding 1 *per cent.* from the same cause; but still this is sufficient to prove the inexpediency of storing in vats of so porous a character as wood. Much of this loss might be prevented by furnishing each vat with a small valve, opening outwardly, and loaded with a pressure of about 1 lb. *per* square inch, whereby the expansion of the gases would find relief, instead of forcing the liquids through the pores and joints, or endangering the safety of the vessel and its contents. The best cellars are slightly humid, and ought to be dug as deep as local circumstances will permit. Dry cellars will evaporate from 50 to 75 *per cent.* more of the spirituous contents of their stores than those that are damp.

Washing Casks.—Previously to racking, it is of the first importance to be assured of the sweet condition and sound state of the casks; for should any be otherwise, it will injure the beer, and perhaps make it undrinkable. Some casks, through lying in warm and open places, shrink and ultimately leak; while others, though less neglected, have grounds, hops, and such vegetable matters, investing their pores and channels, till in the last stage of putridity, which engender noxious gases, and create mould and other ruinous consequences to the wood, and every thing in contact with it.

Casks that are not kept long on ullage, and that are speedily refilled, need no other cleaning than rinsing with boiling liquor; but those that become mouldy and otherwise foul, whether through age, situation, neglect, or other causes, avoidable or unavoidable, stand in need of some more searching power, as by mechanical friction, or by chemical re-agents, such as chloride of lime, long black pepper, charcoal, sulphuric acid, or some such *nostra* as have been adverted to in the preceding chapter. Every writer who has touched upon this apparently simple subject, after cautioning the young brewer against the use of unclean casks, has imperatively enjoined the necessity of their *dryness*, and has extended the same advice with respect to vats, &c. Certain as it is that large quantities of well-brewed and excellent beer are spoiled by being put into foul casks, yet it is extremely questionable whether a dry barrel is preferable to a moist one, and for these reasons:—Experienced men well know that only a few years back all brewing utensils were washed with hot liquor, and that the coolers, especially, were swept off by a whole posse of men, as speedily as possible, to admit of their being mopped perfectly dry while hot. How different is the practice now! Every where, in the metropolis at least, is cold water substituted for hot, except where some obstinate and peculiar kind of contamination requires a deviation from the course; and the coolers, in particular, are purposely kept wet till the worts are admitted to cover them; and the obvious reason of this change is, that the pores of the wood may be occupied by water rather than by atmospheric air.

The effects produced by worts on porous coolers and their displayed aërial contents, have already been adverted to in Chapter X. (p. 276—279), and the same observations apply to porous casks for beer, though the remedy is not always so readily available. If beer that is put into wet casks does not ripen and sparkle so soon as the contents of dry ones, the difference may more correctly be attributed to the absence of air than to the presence of water; for ales impregnated with atmospheric air decompose with facility, and, as we have shewn, or as is well known to experienced persons, next to heat, as an incentive to every species of decay, is oxygen, so that the brewer ought to avoid it as much as possible: hence, then, no harm can arise from filling a *sweet* moist barrel, but some injury may be inflicted by a sweet dry one.

In all properly regulated establishments a system is pursued, and a part of it is, that the duty and responsibility of examining the casks, and turning into the store-room no others than are clean and sound, devolves on a cooper or other competent person, whose duty it is also, in many cases, to tap and plug them for use, and to return to the wash-house or cooperage all that he finds in an unfit condition. Where steam is not to be had, stinking casks need unheading and scrubbing out with hot liquor; and if they are scaled, or harbour the mould or other filth, the foul part requires paring off; and they often undergo scraping, and even firing; but as a cure is not always effected by such means, though ever so skilfully applied, or as it is attended with great expense and delay,—when the head has been replaced, a few gallons of sweet grounds, with a little sulphuric acid, and a few ounces of chloride of lime, may be put in, and the cask, being immediately filled nearly full with boiling liquor, and bunged down close, must be rolled over two or three times, when the internal commotion caused by the decomposition of those contents of the cask, added to the internal pressure from the expansion of the liberated gases, will completely neutralise and dissipate all putrescence; for the searching powers of this remedy reach a considerable distance into the pores of the wood. A moderate "stinker" may be rendered perfectly sweet by being kept in this condition a few days, if occasionally turned over, and then put to stand on its end, so as to subject every stave and piece to the influence of the correctives.

Admirable as the construction of a barrel is, to afford strength, durability, and ease of locomotion, it is still capable of very considerable improvement, either in the material of which it is made, or by the adoption of such means as render the wood harder and less porous. The German brewers, who have the repute of being far our superiors, have doubtlessly seen the inconvenience arising from the casks absorbing the beer, and inflicting injury by admitting the atmospheric air through their pores, both casks and contents suffering upon the decomposition of the imbibed fluids, and the consequent acidity of the wood. Hence their precaution of lining their casks with pitch. No such protection is taken by other brewers; but notwithstanding that such or any similar "new-fangled notion" may be jeered at by the anti-innovators of the British brewery, the subject assuredly deserves a little thought; and the author suggests that brewers' casks may be rendered more durable, and their pores may be effectually stopped, by subjecting all casks, whether old or new, to the following process.

PAYNE'S PATENT FOR PRESERVING TIMBER, granted July, 1841, for "*improvements in preserving vegetable matters, when metallic and earthy solutions are employed.*"

The wood to be preserved is placed within a strong vessel, and the air is then exhausted by air-pumps both from the vessel and from the interstices of the wood; after which the vessel is filled with the metallic or earthy solution proposed to be employed, and after standing a short time, this solution is forced into the pores of the cask by force-pumps or columnar pressure; and when the wood becomes sufficiently impregnated, it is drawn off, and the vessel is refilled with a second solution, suitable for decomposing the matter of that which was previously employed, by double or single decomposition, according to the result desired. He does not confine himself to any particular bases, but gives illustrations of his mode thus:—Firstly, he impregnates with a strong admixture of sulphate of iron, which he forces into the pores, either hot or cold, by exhaustion and pressure, from a solution of any of the carbonate alkalies, or of any other substance which will decompose the salt, and render the oxide of iron insoluble; and, secondly, he impregnates the wood with a strong body of alum, which he decomposes by applying carbonate of soda, of a strength suitable to effect that purpose. In order to obtain the matters of the first solution in a more concentrated form within the substance of the wood, he sometimes partly dries the wood, between the two processes; by which device he likewise disposes of some of the aqueous matter, thereby facilitating the latter process of impregnation and decomposition.

The patentee recommends the application of his process generally to "ship and house building, public works, piers, sleepers for railroads, engineers', *coopers'*, and millwrights' work, wood pavements, cabinet work, hop poles, and *wherever* wood is used;" extending it also to canvas and cordage, such as "sails and rigging of ships, canvas for tents, tarpaulings, and for an infinite variety of purposes," which "are by this means effectively protected and improved" against fire, wet, and dry-rot, and the ravages of insects, through "a complete change effected therein, capable of resisting external influences, and effectually stopping internal decay." Moreover, he asserts that "the most porous, the softest, and of course the cheapest woods, are rendered equal in point of usefulness, durability, and *strength*, to the hardest and best of timber:" it is also "susceptible of the finest polish, and by the use of given solutions, can be dyed throughout with many of the most approved colours."

If all this is true, (and we must take that as a postulate till we can disprove it,) it must be an admirable acquisition to exporters; and for that reason the author, at the time of publication, has succeeded in a series of experiments with casks thus prepared; being induced to do so from the idea of the iron and alkali undergoing such decomposition within the pores of the staves and ends, as to become insoluble; for should this asserted insolubility be proved, the benefits arising from the permanence of the material must be immense, because of its inability to impart any injury to the beer. In speaking of the imbibition of liquors by casks, he can add, that this property is much greater and more injurious in its results than is generally attributed to it: for instance, he has assisted in extracting as much as six quarts, and even two gallons, of fine rum from an empty puncheon, and a full quart of acetic acid from a void beer barrel! We cannot expect to find out at once an universal antidote for all the mishaps and losses to which the trade is liable; but if these observations should lead to beneficial results, it is *one* step gained towards perfection, and should encourage us onward to the discovery of something else that might so far avail, as to lead to some hidden truth of greater magnitude. The proprietors, Messrs. Payne and Loder, of Whitehall Wharf, admit that "the machinery, from its strength and great care and nicety in putting it together, is necessarily very expensive;" but as it appears to have been adopted by the Board of Ordnance, and by the Commissioners of Woods and Forests, it bids fair to turn out a very valuable speculation, especially as a piece of deal thus prepared was carried out to India in June, 1841, and put upon the floor of an out-office, where it remained unmolested in May, 1843, though the white ants had "established a large colony beneath the under-surface of it," and had attacked an unprepared piece within six inches of it, on the second day after its deposit, till "on the eighth day scarcely a vestige of it remained."

Steaming Casks.—Instead of washing casks in the common way, many brewers now avail themselves of the advantages of steam in the wash-house, by means of an apparatus arranged and applied in the following manner:—Across the middle of a long trough, made like a stillion, a square hollow flat bar is fastened, on the middle of the upper side of which a perfect brass cone is fixed; a steam pipe enters one end of the hollow bar, and a liquor pipe the other; and by turning on the steam and liquor taps, the contents of both meet at the base of the cone, and make their exit through its perforations, either together or separately. When a cask in ordinary condition is to be "blown off," the workman, having withdrawn its tap and drained it, places it with the bung-hole downwards, over the cone, and turns on the steam-tap, and in the course of a few seconds turns on the hot liquor tap also. The steam now keeps the liquor in a boiling state, and disperses it with considerable force round the interior of the cask, until it is about a quarter full, when it is rolled off the cone, washed on the outside, emptied, and stacked to drain. This method, though an expeditious way of cleaning an ordinary cask, will not cure a foul one; but a remedy has been found.

It is well known (*vide* p. 419) that new oak contains a large quantity of gallic acid and tannin; and it is the disengagement of these principles from the staves and ends of new casks, that imparts hardness, roughness, and badness of flavour and colour, to such pale beers as are sometimes imprudently placed within them; and hence some few coopers are accustomed to subject their new casks to a kind of seasoning before they deliver them to the brewer; after which the latter often considers it necessary to fill them two or three times with inferior beer or other cheap commodity, before he ventures to entrust them with his best ales; but all this troublesome precaution, expense, and risk, may be avoided, and the injurious acids and tannin may be removed in a most effectual and surprising manner, by a judicious application of the searching and volatilising virtue of steam.

Some brewers of the old school object to the principle of steaming casks in any way, on the ground that the timber is injured thereby, and rendered less durable; but the present author for himself deposes, that having paid some little attention to this department of his business, in common with others, and having steamed and washed both his old and his new casks *for many years*, he hopes to be pardoned for dissenting from that ancient doctrine. He has also found that the healthiness and durability of a cask depend very much upon the kind of water used in the operation of brewing, and that the interior of all casks is much more protected from acidulous and vegetable formations, when water containing either the carbonate or the sulphate of lime is used, than such as is deficient of these properties; because the incrustation formed by the deposition of such calcareous matter protects both the wood and its contents by self-insinuation, whereby it renders the pores antiseptic; and casks that have had their interior charred to blackness possess the same qualities. In either case, the most perishable constituent of the timber, which is its albumen, is either rendered imperishable, or is totally destroyed. It is only necessary that organic bodies should commence decaying in the smallest imaginable degree, and be a little moist and warm, to cause the seeds of the all-pervading *cryptogami*, such as the *fungi*, *musci*, &c., commonly known as mildew, mould, moss, toad-stools, dry-rot, and a long tribe of other names, to develope and reproduce themselves by a singular species of vegetation; and the rapidity of their growth is strikingly exemplified in the interior surface of a washed barrel, sometimes even within a few hours after leaving the wash-house. Casks which have been steamed by a proper chemical process, are exempt from these vegetable propagations, because the superior dry heat of the steam has not only destroyed and dispelled the germs that previously existed, but the cask having been made hotter, all superfluous moisture has evaporated and left it perfectly dry, and without a basis of food for the renewal of vegetation.

Now a mould, fungus, or whatever it be called, notwithstanding its insignificant appearance, acts the part of a ferment on vinous liquor; and as a moisture is its chief propagator and harbinger, the necessity of immediately filling a barrel after it has been washed, must be as evident as the superiority of steaming; and the author, in furtherance of this subject, makes bold to assert, from direct experiment, that such casks as are sufficiently and properly steamed, as above mentioned, are far more durable than those that are merely washed or rinsed; and he knows no scheme so applicable and efficient for the purpose of either brewer or distiller, unless it be the following, which is strongly recommended in the Mechanics' Magazine of May 25, 1844, as "comparatively speaking cheap, and in respect of efficiency subject to no drawbacks," but "a very common-sense-like improvement, and one which, now it has been thought of, every one will (as usual) wonder was not thought of before." This device consists in the substitution of *hot air* for steam; so that in administering heat, in which alone the editor avers that the purifying virtue consists, "free from the moisture which accompanies it in the state of steam," and which he says, though erroneously, "is found to do more harm than good;" because, of course, when not properly managed, "the wood imbibes from the steam a quantity of moisture, which helps to reproduce those very fungous impurities which it is the special purpose of the process to get rid of." This new contrivance is the production of two London Civil Engineers, and is entitled,

Davison and Symington's Patent Method of cleansing, purifying, and sweetening Casks, Vats, and other Vessels: patent issued in November, 1843. In the use of this apparatus, the patentees have the twofold object of, 1, freeing the wood of casks and other vessels, while being manufactured, from any injurious colouring or flavouring matter contained within the pores; and, 2, purifying them when finished and in use, from mould, must, fungi, or other like matters collected on their inner surfaces, by means of a machine which may be applied inside them without removing their heads, "partly by *rinsing*, and partly by causing currents of hot air to pass rapidly through them."

First. The casks or other vessels are manufactured in their green state, which allows them to be afterwards bent without blistering; they then block them off with temporary fastenings, making due allowance for after-shrinkage, and subject them to the rapid current of hot air, which constitutes the principle of their patent, till the natural sap is as nearly exhaled as can be, after which they hoop and finish them for use in the customary manner. This hot-air apparatus consists of a furnace, with a number of horizontal pipes extending along its side, from which pipes issue others of a crescent form, communicating vertically. The atmospheric air is propelled through them by means of a fan; and a number of "nozzles" are fixed upon the main outlet pipe, on which the casks are placed to receive the current of heated air.

Second. To purify casks which have been in former use; they place them upon a frame, having four or more upright standard supports, within which it revolves when in operation, having bearings and a rigger which communicates motion to this inner frame, from a driving pulley fixed on a horizontal shaft, over which a chain passes. The cask to be cleansed being put upon the frame or "cradle," is furnished with springs or "palls," and secured by a lever and chain, which lever is held by a kind of catch. An inclined plane is also attached, and causes the lever to act upon ratchets, and a clutch handle throws the whole apparatus in or out of gear, as opportunity may require. A plug in the shape of a conical frustum fits the bunghole, of whatever size it may be, and has a few inches of common chain containing a swivel, suspended from a staple or eye, inserted in the plug and made secure. At the lower extremity of this chain is a ring, from which they again suspend three or more other chains of a peculiar construction, each about three feet long; and to each of these lengths of chain, by means of a ring as before, are attached three more pieces of a smaller kind, and about a foot in length. Then when the machine is put into action, through the horizontal shaft or driving pulley, the rigger, as before stated, causes the frame and its cradle to revolve; and as soon as the ratchet and lever affixed to the spindle of the cradle reach the bottom of the machine, the lever comes in contact with the inclined plane, causing it to act upon the ratchet, thereby moving the cradle in a sidewards direction, to the extent of a tooth of the ratchet; and for every revolution made by the outer frame, the cradle again moves on in the same direction, and to the like extent, the chains, by means of their numerous angular points, that while removing whatever substance may have adhered to the interior surface of the cask.

This process, and a subsequent rinsing with a little of the beer with which it is intended to fill the cask, they deem usually sufficient; and any number may be put in revolution at the same time, recourse being had to a little alteration in the mechanical means, which may be done by any person possessing a knowledge of driving pulleys; but in the case of spirit casks, or such as have become extremely foul, they employ the hot air apparatus, as in the case of new ones, first removing the corks, &c., to give free passage to any aqueous or other vapours generated by the action of the hot air; and they add, that where an exceedingly high temperature is requisite to remove an excessive impregnation with noxious matter, such as must or char, "it may," after all, "be found useful to introduce along with, or in addition to the hot air, *a small quantity of steam;* and for this purpose a boiler is placed over the heating pipes, having a pipe furnished with a sluice cock, through which the requisite supply of steam may be conveyed in the hot air exit pipe.

Where casks in large numbers are daily under the operations of rinsing, steaming, and scrubbing, it would certainly save considerable manual labour to apply this new apparatus, and the ordinary number would be cleaned in less time and more efficiently, besides the perfect manner in which they would be dried, and the evaporation of any effluvia that might lie lurking in the pores. This alone should induce its adoption in every brewery, large or small. The author cannot do less than express his cordial approval of the plan, and to repeat, that should further information be required concerning this or any other invention connected with his profession, he will at all times be happy, if within his power, to furnish it in the most candid and explicit manner within the scope of his understanding.

CHAPTER XX.

RACKING.

HOPPING — OPPOSITE PRACTICES SCRUTINISED — NETS AND BAGS — CLARIFICATION—THE FLOATING RACKER—ISINGLASS; SORTS, SOLUTION, AND OPERATION — MISAPPLICATION OF FININGS — WYNN'S CLOSE RECEIVER—USE AND ABUSE OF ANTI-FERMENTS—NECESSITY OF CHEMICAL KNOWLEDGE—CONCLUDING APOLOGY—THE BREWER'S LEXICON.

MUCH good judgment is required to assist the brewer in ascertaining the precise time when a gyle or vat of malt liquor is in the fittest condition to be racked off for consumption; and the manner in which it is commenced and completed is of some consequence; for the most objectionable constituents of the decomposed fluid have either naturally or designedly been carried to the bottom of the square or other vessel containing the beer; and as the racking tap, or a loose tube in its inner end, is made long enough to project some few inches above the bottom of the vessel, for a good and specific purpose, such means as are beneficially applied to aid the main object should not be frustrated, nor should other useful provisions be neglected. Hence the use, as precipitants, of such materials as will remove the cause of cloudiness, but keep the sediment stagnant; and hence the utility of a more perfect racking-engine than such as are in ordinary use. The only ingredients that can be employed with manifest advantage in effecting clarification, are hops and isinglass, the application of which is very simple, though a difference of opinion exists with respect to the former, and a little knowledge allows some imposition in the choice of the latter.

Some brewers "hop down" with new hops, and others with such as are half-spent, whereas a third class use none whatever. The last-named of these customs is preferable to the second, but the first is the most judicious of the three, because a certain design is therein understood and acted upon, under the impression that it will produce definite results. They who have read the brewing treatises brought out by Black and by Roberts, will recollect that the former of these authors is a strong advocate for rousing the worts when in the hop-back, for the grand purpose, as he says, of disengaging the lupuline from the flower, that it may flow away with the worts, and protect them on the coolers; but the latter either denies the utility of this measure, or merely issues his *ipse dixit* in condemnation of the plan. Both parties may be right in a portion of their respective ideas, but neither of them has gone far enough into the subject.

It appears reasonable, that the rich nectarium residing in the lupuline, is prevented by the dense worts from exuding through its fine porous prison wall into such worts; so that, in order to avail ourselves to the fullest extent of its antiseptic presence upon the cooler, we must, under the circumstances represented by Black, rouse the hop-back, that we may liberate these partially exhausted little pellicles, to float through the false bottom and run off in the wort. This is reasonable enough, if only for the sake of economy; but it is more than probable that, beyond this, the mighty process of decomposition and amalgamation to which these additional portions of the hop are subject after they leave the coolers, is of more considerable importance than their previous effect on the coolers. Probably the latter idea, with a view to economy in contriving the plant, gave rise to the use of hop-nets, instead of backs, in some few country places; which was an excellent contrivance. The hops intended to be consumed at a brewing are broken up, and loosely distributed in two or three fine but strong nets, or by some in wicker baskets, and suspended in the worts from pulleys placed a few feet above the copper, and just previously to turning out, while the wort is in ebullition, the hops are drawn out of the copper; and remain suspended over it, draining and waiting to be lowered into the forthcoming wort. Thus is Black's principle virtually carried out, and is perhaps open to further and deeper censure on the part of Roberts's admirers, though upon what plea, that author leaves us uninformed. Mr. R. may not object to the hop-dreg in reality, but perhaps to some other, such as a malt-dreg, consisting of coagulated albumen, gluten, &c.; these are certainly kept back in very large quantities when the worts are permitted to filter unmolested through the hops. He advises that the worts may remain in the hop-back until the heat descends to 180°, before they are let run into the coolers; and in doing this he is, no doubt, actuated by the same reasoning, to give time for the deposition and entanglement of the feculences amongst the leaves of the hops; and undoubtedly the properties he wishes to avoid, consist of a superfluity of perishable and contaminating albuminous gluten, starch, and other unconverted matter of the grain; but he does not speak out with that candour and confidence which he shews elsewhere.

Evidently half-spent hops cannot be of much utility in malt liquors after racking; for whether all their *stamen* be roused out of them by the Blackites, or whether they be surcharged by the refuse of the grain, the pristine promoter of acidity, as recommended by the Robertsian school, they are equally objectionable in either way, in any liquor intended to be bright and sound; and, besides, it is wasteful in another way; for they generally retain a richer fluid by absorption than that which they are intended to preserve. These are the reasons why dispensing with hops altogether is preferable to using those that are half-spent; and as some considerable benefit arises from the use of hops at racking, none but new ones should ever enter a bung-hole or a manhole; for the attributes which they possess, of entering into affinity with floating atoms, of caustically subduing gluten, &c., and the antiseptic nature of their oil and resin, then in full vigour and action, render it important that no others should be employed, because they would be destitute of the prime essentials for effecting the purpose in view; but, were it not for legislative prohibition and public prejudice, equally efficient and harmless ingredients could be used to the same advantage, and with greater economy.

Whatever be the modes of fermenting and storing malt liquors, or indeed any others, that will still be a matter of choice, dependent on taste, locality, means, and management; but racking will generally be found a necessary act, prior to ultimate transition. Frequent racking, on the contrary, must be injurious to any fermented liquor, because it thereby not only incurs flatness by the expulsion of its carbonic acid gas and ether, but is exposed to atmospheric air, and consequently to its dangerous oxygen; and this element does not remain in a latent or primitive state, but instantaneously or eventually, according to the amount of caloric present, unites with either the alcohol or the carbon, forming acid and renewing the gas, at the expense of the body, spirit, and flavour of the article; and by the power of secondary action, the decomposition and dissipation of the most desirable properties of the liquors are facilitated, and the road to destruction is gradually run, as the rackings are repeated.

Having advanced these arguments in favour of a final racking after a state of quiescence in store, the author, that he may ensure a permanent and brilliant beverage in the hand of the consumer, begs to introduce to his readers his last little invention, which, though simple in itself, is nevertheless an integral part of his Patent Brewing Apparatus, and is not so trifling in importance as it is simple in construction; inasmuch as by it the misfortune of disturbing the sediment of the liquors during racking is totally avoided. This instrument he has denominated

The Floating Racker.

This little and cheap contrivance is constructed and acts as follows:—A tube a few feet long, made of gutta percha or caoutchouc, for the advantage of elasticity, though a little metallic one will answer the purpose, is bent at right-angles, or jointed, if need be, so as to have a square elbow at some eight inches from its nether extremity; this end is inserted into the inner orifice of the racking tap, and the upper is closed and mounted with cork, or with a spherical metallic buoy, similar to a float used with a ball-cock, or indeed with any other substance that will swim upon or near the surface when the tube is immersed. A little below this buoy the tube is perforated by a hole on each side, or perhaps two, if found desirable. When it is intended to rack off the contents of a fermenting square, settling-back, store-vat, or other vessel, while the racking tap is turned on, the liquor will flow through the bent tube, entering into it by means of these perforations; and as the quantity of liquor left in the square or other vessel decreases, so will the apparatus gradually lower, and by means of its buoyancy maintain a proper position throughout, permitting the uppermost and finest of the beer to pass freely away, without any admixture with the grosser particles below, or with any refuse that may rest on the top.

The author has no better opinion of too many hoppings than he has of too many rackings, though some brewers may recommend and practise "hopping in the vat,"—"hopping in the cask,"—"racking into the vat for stores,"—"racking from the stillions for sending out;" and, again, "racking for immediate use,"—"general hopping,"—and "racking in general,"—enough to frighten a person of ordinary nerve. The "disagreeable rankness" which some would dissipate by repeated hoppings, they thereby increase through the rawness of the antidote; and moreover many rackings, like those that are used to torture animals, dismember the body till it becomes lifeless. The less locomotion and shifting malt liquors undergo, the sounder will their constitution continue to be. Richardson justly observed in his instructions of old, that whether ale were racked from vats, or merely from cask to cask, the operation gave it a tendency to go flat. He preferred the use of three pints or two quarts of warm hops which had passed through the first wort, to be added to each barrel three or four days from cleansing; but he admits that "the hops thus added give some rankness to the flavour;" therefore, in advice on racking "keeping ale," he does not hesitate rather to promote the practice of mixing the old with "a sixth to a fourth part of new ale, taken from the gyle-tun, in a state fit for cleansing," which he would purify by filtration through a flannel bag; and says that a quart to the barrel added in this way, raised it from flatness till "it produced all the liveliness of bottled ale, without having in the least injured its purity:" but the experiment will not always prove successful; and it seems that he "had little occasion to pursue the practice."

In order to expedite the depuration of malt liquors, and to clear them from that turbidity consequent to the first fermentation, particularly under mismanagement, changeable weather, or imperfect materials; and to prevent a further decomposition of the turbid particles, and stop their influence over the remaining saccharum and saccharific parts; it is commonly found necessary to add a precipitant whose affinity for the glutinous particles is greater than that exerted by any other principles in contact. The substance used to perform this is *gelatin*, from its purity and aptitude for the purpose, as well as being an allowed commodity. This substance exists in a variety of forms, but is always prepared from the solid parts of animals, such as their tendons, cartilages, skins, hoofs, horns, &c. The ultimate elements of that species of gelatin which is commonly termed *isinglass*, are C. 50·557, O. 23·750, H. 6·903, N. 18·790, as given by Scherer, and copied by Liebig, who remark that gelatinous tissues generally have a similar composition; hence another analysis of good gelatin has C. 47·8, O. 27·4, H. 7·9, N. 16·9. It is a nutritious article of food in certain conditions, soluble in water and most of the acids, but not in alcohol, and its solution is facilitated by heat.

Isinglass, which is the preparation used by the brewer, is derived from the Dutch, *hyzen*, to hoist, and *blas*, a bladder, and is therefore an English corruption of *hyzenblas*, an air bladder, which was its original signification in its native tongue. When first brought into this country from the shores of the Black and Caspian seas, where it was manufactured by the Tartars from the *swims* or *sounds* of the *acipenser*, a species of sturgeon, it was called *fish glue.* The skins, fins, and tails of other fishes, were afterwards found available ; and in 1763, a Mr. Jackson took out a patent for making "British Isinglass" from such as he chose to call British materials, and in 1765 he wrote a book on the subject, in which he complained that, in consequence of a prejudice raised against this article, he could only sell about 6 tons a year, though the brewers used 25 tons. This appears to have been *book* isinglass, so called from the skins or other materials being folded like leaves in a book. Many years afterwards, the chief distinction in this commodity was into *long staple* and *short staple*, according as it was produced from large or small fish, or such parts of fish. At present, the best is said to be imported from Russia, where the sturgeon retains its celebrity. The price depends as much upon the form and the degree of its purity, as upon its intrinsic worth. The principal varieties, besides the staple and the book, are *leaf*, *pickings*, *cross-key*, *purse*, *pipe*, *soleskin*, &c. &c., as the pieces are folded or produced, of which the most profitable, considering price, produce, and effect, are—

Of the finer sorts, Russian pickings and fine leaf ; and of the commoner kinds, soleskins, which are used to much advantage, effecting great economy in many large establishments in town. Isinglass, and especially the inferior, should always be examined, and all the damaged parts, or such as smell offensively, should be carefully picked out or pared off, and thrown away.

The usual method of dissolving or "cutting" isinglass, which is sometimes also the most convenient mode, is by steeping it in sour beer, such as returns, or a kind which is brewed and acetified for the purpose. The smaller the quantity of acid *that will properly cut* the glass, the better for the beer fined with it: it should pass through a fine hair-sieve without much rubbing, and the necessary degree of solution should then be made by adding fresh table-beer, rather than any thing containing acids or disagreeable flavours. From experiments made in dissolving isinglass in the various acids, both concentrated and dilute, the vegetable kinds, such as the *acetic* and tartaric, operate the most readily, and in proportion to their relative acidity. These acids act merely as solvents; whereas the action of those from mineral bases, as the sulphuric, for example, is more strictly chemical, suddenly destroying the matter. The distilled acetic acid, although just double the price of ordinary *sours*, is the cheapest solvent of any, owing to its purity and efficacy: that which is the most highly concentrated may be added to weak returns, &c., with considerable advantage.

The inferior descriptions of isinglass require stronger acids than the best sorts, and are also much longer in dissolving; and the acid often disappears before the common glass is half cut; in which case the liquid should be poured off the surface, and a sharper acid should be applied, often roused, and kept as close as possible.

This article, which generally forms an important item in the expenses of the brewhouse, may be considerably economised by being kept in air-tight casks, after being cut and sifted in the usual manner, being there improved by the retention of the acetic ether, and its more intimate connexion with the gelatin; and a more minute solubility is also aided by the internal pressure consequent on the confinement of the generated gases. The efficacy of this treatment and extension of time is first evinced by the equal distention of the gelatinous matter, and its disinclination to subside in the menstruum; and, in the next place, a much smaller quantity suffices in consequence.

This communication will be appreciated by the thoughtful; for to such it must be clear that the smaller the particles are, the greater is their number within any given bulk, and the more diffuse and diversified are the points of attraction presented to the particles of floating yeast; and each separate atom of glass being attenuated equally with the others, the more simultaneous, uniform, and complete, must be their desired action.

The quantity requisite will depend upon its consistence and the quantity of matter to engage it; considerations which are seldom entertained by the persons to whom the discretion of its application is usually entrusted. A quart to the barrel is about the universal *quantum*, and is often full 50 *per cent.* more than either porter or vatted ale requires.

No fresh malt liquor should be bunged down too soon; for if its brightness is not perfected before racking, the pressure arising by the accumulation of heat and gas will re-dissolve the yeast and dross, which, immediately on the relaxation of the dissolving force, will rise and be again diffused through the bulk, rendering its depuration by the finings more difficult than before. No precipitant should be applied until the beer has reached its final destination, or, at the earliest, just before loading. It would also be better not to fine a second time until the beer has been racked off its old finings and their accompanying lees; nor should any isinglass be ever used, except in beer that will not conveniently become bright without it. Finings of some sort are however admitted to have become almost universally necessary, and especially for new beer, and where the ales are hastened for ready consumption; for although some will become tolerably fine in a short time, they will not always so speedily brighten without some precipitant to clear them. Some beers are too stubborn to submit to isinglass, and can only be clarified when put under the surveillance of alum, or some other prohibited ingredient.

Wynn's Close Receiver.—This is an apparatus resembling the bellows of an organ, for which a patent was obtained in April, 1837, to diminish evaporation in vinous, alcoholic, acetic, and "other volatile" vapours, and to prevent the absorbing of noxious effluvia by such fluids as malt liquor, cider, perry, wine, spirits, or vinegar. The instrument is "suspended in a proper frame" over any vat or cask, &c., when being drawn off for consumption, the upper side of the bellows being constructed so as to be lifted, and to fall in the usual way, or "according to circumstances." The two sides of the bellows are flexible, being made of Mac Intosh cloth, joined at the edges by a caoutchouc varnish, except in cases of having to act upon spirits of turpentine, ether, or such other bases as will produce a volatile vapour of the caoutchouc, where he substitutes leather and glue. The connexion between the evaporating vessel and the bellows or "receiver," is by means of pipes and stopcocks, so contrived that as the vessels evaporate or emit gas, such vapour or gas, instead of escaping, is received into the bellows, which have a safety-valve on the top, and the stem is in contact with the frame.

The mode of action is this:—The liquors, as they are drawn off, "can" always be kept under a pressure sufficient to fill the casks, to obtain which the patentee inflates with carbonic acid by means of a force-pump, preferring the gas to atmospheric air; and as the bellows act, they draw in the escaping vapours till they reach the extent of their expansibility, when the safety-valve opens, lets out the surplus, and shuts as the bag collapses; and, of course, whatever is useful may be collected as it escapes through the valve.

Several distinguished brewers entertain the idea that finings invariably float when the beer is in a fit condition to receive them, and that they descend only in stubborn beer; though the opinion is not supported by direct experiment; for the principal portion of the finings gradually sink in all ales, and carry with them the impurities that come within the sphere of their attraction throughout the line of their descent, while other particles of the glass, of less specific gravity, and those that are overpowered by the buoyancy of the globules of carbonic acid gas that attack them, naturally swim on the surface, remaining there until their supporters disappear, when some of them again are disposed to fall downwards. Indeed, the specific gravity of the best isinglass is seldom exceeded by that of any malt liquor properly attenuated; consequently in these only, where seldom wanted, can the inferior kinds of finings descend.

Although transparency is the immediate object and effect of fining beer, the ultimate consequences of its operation are of equal moment with the formality of merely "pleasing the eye," the palate having likewise a pleasure of its own. One chief object is the preservation of the article from cloudiness and acidity; for the principal preventive of these maladies in a body properly reduced by attenuation, is undoubtedly a prompt and perfect removal of the most perishable among the constituents of the liquid, be it the extract of either fruit or corn.

Antidotal means and things in great variety have been proposed with the intention to check an undue decomposition; but few of them, even in skilful hands, can be advantageously used, or at all applicable to wholesale establishments; these are sulphate of lime, often before noticed, sulphate of potash, sulphurous gas, sulphuric acid, alum, pine resin, olive oil, oil of mustard, manganese, oil of turpentine, oil of creosote, oxalic and prussic acids, corrosive sublimate, verdigris, and red precipitate of mercury; a precious laboratory of poisons, which no respectable victualler would dare to touch, much less a brewer, whose capital is at stake equally with his honour and reputation. A careful and judicious mash and fermentation, upon the principles that have herein been explained, will produce a sound, bright, and properly matured extract, adequate to every object of durability, without any foreign appliance whatever; though it may not be superfluous to remark, that whether the object of mineral or vegetable additions be to effect clarification, to maintain it, or to preserve spirituosity, a previous knowledge of the components of the brewing water employed is imperatively necessary before any thing of the kind can be safely attempted; for to proceed in darkness is to risk the perpetration of injury far worse than the existing evil. For instance, to add alum to a fluid containing carbonate of magnesia, nitrate, muriate, carbonate of lime, muriate of barytes, or any of the alkalies, will cause a mutual decomposition of those salts. A correct chemical knowledge of these matters would direct a right application, and in some cases to a very profitable extent, particularly in a brewery where custom is the only guide, as much in the preservation of beneficial agents naturally existing, as in the destruction of injurious properties; which fact is demonstrated in the following examples: —Alum will not affect the sulphates, as that of iron for instance, nor is it affected by them; sulphate of iron is incompatible with alkali, or carbonate of magnesia, or muriate of barytes; whereas both the nitrate and the muriate of the same lime decompose alkaline carbonates, carbonate of magnesia, and the sulphates, except that of lime: hence the danger of dabbling in chemical experiments without a chemical knowledge commensurate with the undertaking.

The author having now concluded all that he has practically to advance in illustration of the principles and practice of brewing, must again bring his volume to its close. In concluding, therefore, this review of the most important features of the various machines, plans, and implements, connected with the art of brewing, the proprietor does not desire to shield himself, or any of these his matured contrivances, from the test of candid judgment; nor does he seek to excuse his repeated or continued temerity by any subterfuge of incapacity: he has gone deliberately through his examination of the art, and has had the gratification of seeing his machinery in beautiful operation, and still improving, not only in old and new establishments in London, but in a great number of provincial breweries, also in many parts of North America, Prussia, Australia, France, &c. &c.; therefore, without egotism, he *knows* that by means of the Patent Brewing Plant and Octuple Cleansing Apparatus invented and erected by him, a stronger, a more wholesome, a more endurant, and a cheaper article of consumption, as stimulant beverage, can be produced from the same quantity and quality of materials, than by any other extant process. To the world at large, then, he stands confidently prepared to say that he has not been actuated by mean or mercenary motives, nor by a love of popularity, but by a genuine desire to serve the community. Being aware that "Every tub must stand upon its own bottom," he certainly has a wish to "keep the copper safe;" he therefore again submits himself, his patents, and his book, for each to have its due share of encouragement, but no more; for by plain reasoning, and the voice of experience, he is willing that all three should be assayed, weighed, and measured.

APPENDIX.

The most modern and curious invention relating to the art of brewing; shewing proportions of twenty-one original ingredients and combinations to produce a new beverage that was intended to supersede beer.

COPY OF SPECIFICATION.

EXTRACTING A DRINK OR BEVERAGE FROM VARIOUS ANIMAL OR VEGETABLE SUBSTANCES.

(This Invention did not proceed to the Great Seal.)

Complete Specification filed by Patrick O'Malley at the Office of the Commissioners of Patents, with his Petition and Declaration, on the 15th July, 1853, pursuant to the 9th section of the Patent Law Amendment Act, 1852.

I, Patrick O'Malley, of the City of Dublin, Brewer, do hereby declare the nature of the said invention of "A New Liquid Beverage," to be as follows :—

My invention consists in extracting from various vegetable, floricultural, animal, and other substances occurring in nature a useful and agreeable drink or beverage.

And my object is effected by boiling various herbs or other substances possessing nutritive and useful qualities in water, with other products or substances having like useful properties, or calculated to give an agreeable aroma or taste to the liquid, and subjecting this liquid to various processes as hereinafter described.

In order that my invention may be most fully understood, I will proceed to describe the manner in which I prepare a quantity of my improved beverage, but I nevertheless do not confine myself to the exact quantities or substances which I am about to mention, as same may be somewhat altered to suit certain circumstances.

Assuming that it is desired to obtain about six hundred gallons of my beverage, I place the following materials in the following quantities in a boiler of suitable size:—

First, seventy pounds weight avoirdupois of common heath or heather, such as grows on mountainy or boggy soils, and which I have found in large quantities on the Wicklow mountains; fifty pounds of bog-bean, otherwise called buck-bean; ten pounds of mountain sage; six pounds of dandelion; four pounds of gention; two pounds of sautry; six pounds of common watercress; twelve pounds of the seeds of tongue grass, otherwise tongue cress, otherwise known as garden cress; forty pounds of honey or other saccharine matters, as hereinafter explained in lieu thereof, and five hundred weight and three-quarters of a hundred weight of the best sugar or other saccharine matters; forty-five pounds of common table salt; fifty pounds of an inferior corn, known as buck-wheat or rivery, or, in case this cannot be obtained in sufficient quantity, fifty pounds of the best oats. To these I add eighty pounds weight of any of the following fruits or berries, viz.: eighty pounds of wild or common blackberries, or eighty pounds weight of wild berries known as fraughans, better known in some parts of Ireland, particularly in county Tipperary, as "hurts," or other similar berries, or if these berries cannot be obtained I employ eighty pounds of garden apples, or eighty pounds of raisins or preserved grapes. I also add four pounds of caraway seeds, three hundred and sixty hen's eggs, counted in the trade as three hundred eggs, prepared as hereinafter mentioned. I also add for the purpose of giving taste, aroma, and colour, six pounds weight of common cowslip flowers, and half a pound of nastertions or nastertion flowers, or one pound weight of saffron in lieu of the cowslips and nastertions. To these materials I add from nine hundred to one thousand gallons of water. I boil the whole at about boiling heat, or something under it, for a space of two hours and a half to three hours. The subsequent processes and treatment of the materials in order to form my beverage is very similar to the treatment and processes employed in the brewing of beer. The liquid in the boiler after boiling, as mentioned, for the space of about three hours, is drawn off into coolers, as is well understood by brewers. When the whole is cooled to about sixty degrees Fahrenheit the liquid is received in the fermenting tun or vat. It is allowed to remain in this vat about seventy hours. After the liquid has been placed in this vat fermentation shortly commences; when the fermentation begins to subside, the liquid is racked off into cleansing vessels or rounds, similar to those used by brewers, and in these the vinous fermentation is completed. The liquid is then stored in store vats, or may be bottled.

I would now observe that I have described the most simple way of carrying my invention into effect, but I am also well aware that an economy of materials and time may be effected by preparing the various ingredients used by me, by grinding or otherwise reducing them previous to subjecting them to the action of hot water in the boiler; and also it may be found advantageous not to pour in all the water at first, but to add various quantities of water to the materials at different temperatures, according to the strength of liquid required; also it may be desirable to keep such materials in a state of agitation while boiling by suitable stirring, agitating, or rousing apparatus, so as to cause them more readily to part with the useful and agreeable properties it is desired to obtain from them.

I have mentioned honey as an ingredient for making my beverage. I prefer to use honey, but it may be desirable for the sake of economy or other causes to substitute other saccharine matters in lieu thereof, in which case the quantity used must be accommodated to the sweetening qualities of the substance employed.

Before adding the eggs to the other materials I prepare them in the following manner:—I place them in any suitable receptacle, and cover them with vinegar, and bury the vessels containing the eggs and vinegar in the earth for about three days. By this means the shell of the eggs is very nearly, if not wholly dissolved, the whole are then beat up and added to the other ingredients in the boiler.

Having now described the nature of my invention, and the manner in which the same may be carried into effect, I wish it to be understood that I do not confine myself to the exact materials or ingredients, quantities or processes hereinbefore mentioned.

But what I claim as my invention is, the extracting of a liquid beverage possessing useful and beneficial qualities from the materials hereinbefore described, or some of them, or from similar materials, by subjecting them to the action of boiling water, and the other processes hereinbefore described, or to similar processes.

In witness whereof, I, the said Patrick O'Malley, have hereunto set my hand and affixed my seal, this Fourteenth day of July, One thousand eight hundred and fifty-three.

PATRICK O'MALLEY. (L.S.)

Signed, sealed, and delivered by the said Patrick O'Malley (party hereto) in presence of

J. B. FERRITER,
of 41, Great Brunswick-street, Dublin.
THOMAS TRAINOR,
14, Whites-lane, Dublin.

THE BREWER'S LEXICON.

The reference *a* denotes that the subject is analysed; *d*, that the word is derived or defined; and *e*, that its elements are chemically declared from authority. *T.* signifies technical, or belonging to the *art*, and not commonly derivable from books.

Acclination: from *ad* and *clino*, to bend or lean towards; travelling in a certain direction.

Acerbity; acer, sharp or sour; harshness of manner; sourness of taste.

Acetify; from the same, and *fio*, to be done; to become acid or sour.

Acetification; act of souring.

Acetous; from *acetum*, vinegar, same root; containing sourness.

Acidify; to cause acidity.

Acidulate; to create a little acid.

Acidulous; containing *some* acid, the termination *ulus* or *ulum* being subtractive of signification in the root of the word.

Acrospire; *acer* and *spira*, a wreath, turning, or twist. This word ought to apply to the root instead of the stem.

Adjutant; *ad* and *juvo*, to render aid to; assisting.

Adventitious; *ad* and *venio*, to come to; acquired by other than ordinary means.

Aërated; *aër*, air; filled with that fluid.

Affinity; *ad*, to or until, *finis*, the end; permanent alliance.

Albumen; *albus*, white; commonly the white of an egg; that portion of a seed which acts as its reproductive matrix.

Albuminous; containing albumen.

Alcohol; pure spirit of wine, *d*.

Aldehyde; dehydrated spirit, *d*.

Aldehydic; arising from aldehyde.

Aldehydinous; partaking of aldehyde in composition.

Ale; nutritious beverage, *d*.

Alegar; ale degenerated into acid, *d*.

Alkali; *al* and *kali* (Arabic), seaweed called glass-wort, from its use in making glass; a powerful chemical preparation.

Alkaline; consisting of an alkali.

Alumina or *alumine*; alum.

Aluminous; containing alum.

Amalgamation; ἁμα, with; *al*, the whole; γαμεω, to marry; a consolidation of several in one.

Amber; native word; light brown; a peculiar colour in malt, next to pale in its shade.

Amidin; αμ and ιδιν, same as ιδια, a word expressive of privacy; the interior of starch.

Ammonia; αμμος, dirt; fœtid matter, the essence of manure.

Some derive it from Jupiter Ammon, and pronounce it urinous.

Amorphous; α, negative, and μορφη, form; shapeless, or of any shape whatever.

Amylaceous; containing amylin.

Amylin; α, negative, and μυλη, a mill; unground, not dissolved; the shell of starch, *d.*

Amylous; having the properties of amylin.

Anhydrate; αν, negative, and ὑδωρ, water; deprived of water.

Animo-vegetable; partaking of properties common to plants and animals.

Annihilate; *ad*, to, *nihil*, nothing; utterly to destroy.

Anomalous; αν and ομαλος, equal; discrepant or contradictory.

Anthracite; a peculiar kind of coal that burns without flame, *d.*

Antiseptic; *anti*, against, *septicus*, putrefactive; preventing decay.

Apotheme; απο, from, and τιθημι, to place; a substance deposited from another.

Apparatus; *ad*, for, and *paro*, to prepare; machinery employed in conversion.

Aqueous; watery; from *aqua*, water.

Argil; *argilla*, clay; properly a white kind, called potter's earth, *d.*

Article; from *ars*, power, come *artus*, a joint or limb, and *articulus*, a small one, or a part where *artus* expresses the whole; a finished preparation.

Astringent; *ad*, to, and *stringo*, to tie or collect; of a binding nature.

Attemperator; *ad*, to, and *tempero*, to rule, regulate, or alloy; a regulator of heat by creation, diffusion, or abstraction.

Attenuate-ation; *ad* and *tenuo*, to thin or make slender; decrease of gravity by fermentation.

Automaton; αυτος, self, and μαω, to seek: a self-acting machine.

Axiom; αξιος, worthy; that which is self-evident.

Azote; nitrogen, so called from killing all animals that breathe it alone; α and ζωη, life, *d.*

Azotic; consisting of azote; azotised, implanted with azote.

Back; *T.;* any fixed vessel used to hold liquor or must, before, after, or intermediate to mashing or fermenting.

Barm; yeast wrought upwardly, *d.*

Barrel; *T.;* 36 gallons; no other application is correct.

Beer; malt liquor of any kind, *d.*

Bicarbonate; *bis*, twice, and *carbo*, which *vide;* doubly carbonated.

Blow off; *T.:* to purge a cask.

Blowing off; *T.;* expulsion of ether from the worm of a still.

Blown; *T.;* malt puffed up by a regular process.

Boas; serpents that entwine round objects or each other.

Brew-ed-er-ery-ing; preparation by infusion, *d.*

Broach; *T.;* to tap, or otherwise to open a cask.

Bung; *T.;* a large cork; also a term for a brewer.

Bunghole; the orifice in which a bung is fitted to a cask.

Butt; *T.;* three barrels in capacity.

Calcareous; *calcarius*, pertaining to lime.

Caloric; *calor*, heat, from *caleo*, to be hot; the matter of heat.

Calorific; *calor* and *fio*, to be done; producing caloric.

Carbon; an ultimate element, *d.*

Carbonaceous; consisting of carbon.

Carbonate; from *carbo;* a mineral salt.

Carbonic acid gas; an aëriform fluid, derived from the admixture of oxygen and carbon.

Carbonise-ed-ation; reducing to carbon, or blackening into cinder.

Carburetted; *carbo* and *uro*, to light up or set on fire; street gas.

Caromel; colouring matter, *d.*

Caustically; *causticus*, able to burn; irritating.

Chalybeate; chalybs, steel; hardened by native iron.
Chambers; interior cavities of utensils.
Char; T.; to blacken by heat.
Charge; T.; to fill a vessel.
Chimera; chimæra, a poetical monster; an unattainable end.
Cleanse; T.; to clear an article from barm.
Coagulate-ed-ation; con, together, and *ago*, to act, with the diminutive termination; to adhere together in small quantities.
Cockspur; T.; having a sharp point like a cock's heel.
Come off; T.; to quit a tun after process.
Combings; T.; rootlets and particles detached from malt.
Concatenation; con and *catena*, a chain; a linking together.
Concentrate-ed-ation-ing; con and *centrum*, middle point; rendered pure and compact.
Condition; condio, to season; the farina of hops in maturity.
Congelation; con and *gelu*, frost; hardening together.
Connoisseur (French), a person of accurate taste.
Consignificantly; con and *signum*, a sign, with *fio:* meaning the same thing.
Contagion; con and *tango*, to touch; acquired by touching together.
Contraband; a mongrel word, signifying contrary to bond or law.
Copper; T.; a circular boiling back.
Copperside; T.; the interior of a brewery.
Coppersmith; who *smiteth* copper.
Correptious; con and *repo*, to creep; rebuking slily.
Corrugated; con and *rugo*, to rumple or wrinkle; laid in folds.
Cosine; a trigonometrical sine is a perpendicular upon the diameter of a circle, demitted from the extremity of any arc whose other termination is the end of that diameter; and the cosine is the distance from the sine to a second diameter drawn perpendicular to the former.
Cotyledon; part of a kernel, *d.*
Couch; T.; a frame for draining barley after steeping.
Cream; T.; a light compact substance on the surface of wort or ale.
Cryptogami; κρυπτω, to conceal, and *γαμεω*; an accumulation of matter latent within the pores.
Crystallised; made bright like crystal.
Cuticle-ular; cutis, skin; diminutived; having a thin skin.
Cutting; T.; dissolving isinglass.
Cylinder; cylindrus, properly a roller; any round vessel of uniform width.

Decapitate; de, from, and *caput*, the head; to take the head off.
Decimation; decem, ten; dividing into tenths, hundredths, &c.
Decrement-al; de, negative, and *cresco*, to grow; decreasing by a gradual law or rule.
Deliquescent; de, from, and *liquesco*, to melt; becoming soft or liquid.
Depuration; de and *purus*, pure or clean; fining beer.
Desiccated; de and *siccus*, dry; rendered solid.
Dextrine; dexter, the right; so called from its peculiarity in polarising light.
Diastase; a principle in germinated seeds.
Dogma; dogma, a decree; received opinion.
Dreg; T.; dust and refuse of malt or hops.
Dynamic; dynamis, power; great or perfect.

Ebullient-ition; e, from or out of, and *bullio*, to boil; bubbling up.
Egotistical; ego, I, and *iste*, this; abounding in self-praise.
Eliminate; e and *limes*, a bound or limit; to release.
Empty; emptus, from *emo*, to buy;

bought out; technically a cask from which the contents have been abstracted.

Empyreum-alic; εν, in, πυρ, fire; tasting as if burnt.

Entire; all of one quality.

Equator-ial; æquo, to make equal; an imaginary plane, dividing the earth, &c., into north and south.

Equinoxes; æquus, equal, *nox,* night; time of equal day and night.

Eremacausis-tical, d.

Ether-eal-ise; properly pure air; from *æther,* the region of the sky; a volatile liquor, transparent, colourless, fragrant, pungent, and light, boiling at 98°, or *in vacuo* at 20°.

Euphony; εν, well, and φωνη, sound; an agreeable arrangement in pronunciation.

Examen; Lat., signifies a flock, shoal, or swarm; any substance under test or trial.

Excrementilitious; ex and *cremor,* a thick juice from barley; substance cast out by fermenting.

Extract; ex, out, and *traho,* to draw; any thing drawn out.

Fæcula; dimin. of *fæx,* sediment; grated potato.

Fæculencies: resembling *fæcula.*

Farina-ceous; Lat. flour, dust.

Ferment; fermento, to leaven or make light, *d.*

Firkin; T.; nine gallons, or quarter of a barrel.

Flakes or *flocks; T.;* albumen, &c.

Flange; T.; a flat rim round the end of a tube, to secure it on the outside by bolts or screws.

Flints; T.; hard unmalted corn.

Flocculent; flocculus, a small flock of wool; containing flakes.

Floor; T.; the bottom of an utensil; likewise a steeping of malt at a certain stage of its process.

Flush; T.; a bright brown colour, peculiar to the best porter.

Fob or *cauliflower; T.;* frothy head.

Fox; T.; a very foul and rank taste and odour in malt liquor.

Frame; the same as couch.

Fret in; T.; to introduce alien matter during fermentation.

Friable; frio, to crumble or break into small pieces; easy of severance.

Galvanic-ised; containing the principles discovered by Galvani in relation to electricity; coated with zinc.

Gelatin-ous-ising; gelatus, frozen; a hardened jelly.

Geological; γη, the earth; λογος, a discourse; describing the substances forming the earth.

Gill; a measure; a much disputed word, *d.*

Glass; T.; isinglass dissolved, *d.*

Gluten; a principle in corn; commonly glue or paste.

Glutin; glutinum, a variation of gluten.

Glutinous; containing gluten.

Goods; T.; malt wetted in the mash-tun.

Grains; T.; goods deprived of their juice.

Graminous; of the nature of grain, *d.*

Gramme; a French measure of weight, of which 454 are a pound avoirdupois British.

Granular-ation; granulum, a little grain; resembling fine sand.

Gravimeter; gravis, heavy, and *metior,* to measure, *d.*

Gravity; weight of wort above 1000 ounces to the foot, *d.*

Grist; contraction of *grindest, d.*

Gum; Lat. *gummis,* an adhesive convertible substance, *a.* 39; occurs in 30 pages under different circumstances.

Gyle; the quantity brewed from a mashing of goods, *d.*

Gypsum; Lat., white sulphate of lime or plaster.

Hepatic; hepar, the liver; applied to that part.

Hogshead; T.; a barrel and a half.

Hordein-ous; consisting of farina like that of barley, *d.*
Hot Masher; the mashing attemperator.
Humus; Lat., moist earth; decayed animal and vegetable matter.
Huscarles; Sax., household servants.
Hydrate; ὑδωρ, water; containing that liquid in excess.
Hydrogen; an ultimate element, *d.*
Hygrometer; ὑγρος, humid, soft, and μητηρ, measure; an instrument to measure indications of moisture.
Hyperbolical; ὑπερ, above, and βαλλω, to throw; overshot or spoken beyond bounds.
Hypothesis; ὑπο, from, by, or under, and θησω, to place; a supposition.

Impetus; *in* and *peto*, to require; motive, force.
Increment; *in* and *cresco;* the rate at which an increase graduates.
Indigenous; *indigena*, not from abroad; native.
Integumentary, *tegumentary;* *in* and *tego*, to cover, wh. *tegmen*, a covering; covering in.
Intersectional; *inter*, between, and *seco*, to cut off; having a space between, or cut across.
Intrinsically; *inter*, in, and *seco*, on the inner part; reality.
Iodine; ιον, a violet; a chemical preparation from kelp, &c.
Isinglass; a mercantile gelatin, *d.*
Isothermal; ισος, equal, and θερμος, heat; of equal temperature.

Jigger; *T.;* a forcing pump to convey beer from the fermenting vessel to the tun-barrels or store-vat.

Keep safe; *T.;* to prevent the burning of the copper.
Kernel; Sax. dimin. of corn; the substance within the shell, *d.*
Kilderkin; *T.;* half a barrel.
Kilogramme; a French weight, of which 38 make 84 pounds British avoirdupois.
Kleber; a German term for glutin.

Lag; the channel at the bottom of a copper.
Legerdemain; Fr., sleight of hand.
Legumens; Lat., all kinds of pulse.
Length; *T.;* quantity brewed.
Lexicographer; λεξικον, a vocabulary, γραφω, to write: a maker of dictionaries.
Ligneous; *lignum*, wood; containing woody matter.
Lignine; the matter of wood.
Liquescency; liability to become liquid.
Liquor; water ready to brew from.
Litmus; *T.;* a cheap blue.
Liveries; Fr., *livrer;* an allowance or hire.
Loomer; *T.;* a Scotch term for a retailer.
Louvres; *T.;* malthouse and brewhouse blinds.
Lutean; *luteus*, pale yellow, wh. *luteum*, yolk of egg.
Lymph; *lympha*, water; the matter of inoculation.
Lymphine; yielding lymph.

Macerate-tion; *macero*, to soften by steeping.
Magnesia-n; μαγνησια, from μαγνης, loadstone; from a property which it has been supposed to possess.
Manhole; *T.;* a hole large enough to admit a man.
Manipulate-tion-ing; *manipulus*, a handful; to pass through the hand.
Mashing; any infusion of goods in liquor, or the mode of using them, *d.*
Matriculate; dimin. of *mater*, mother; a collegiate term to express progress in education.
Mawkish; *T.;* flat and insipid.
Mead; Old English for *meadow;* a liquor prepared from honey.
Medicamentous; *medicamen*, inward or outward medicine; cordial, healing, dispelling pain.

Mellow-ness; freedom from harshness of taste.

Menstruum; mensis, a month, *struo,* to flow. In its Latin application this word signifies "a monthly allowance for maintenance," and, as the representative of plain *water,* is grievously and irregularly misapplied.

Mephitic; mephitis, a damp or foul gaseous smell.

Meridian; medius, middle, *dies,* day; an imaginary great circle encompassing the earth overhead, directly north and south.

Metamorphosis; μετα, trans, passing over, *μορφη,* form; a transformation.

Metheglin; μεθυ, wine, *γελαω,* to laugh; the cheering drink of the ancient bards. See *Mead.*

Millemetre; a French measure of length, 305 of which are an English foot; compounded of *mille,* a thousand, and *meteri,* to measure; a 1000th of a metre, or of 3 feet 3·34426 inches*.

Mobile; Lat., *mobilis,* movable.

Mobility; movableness, activity.

Monopoly; μονος, alone, *πολυς,* much; engrossing a commodity by one person to sell it dear.

Mucilage; muceo, to be flat or to abound with dregs, *d.* Castle's Lexicon defines mucilage a simple solution of gum in water, thick and adhesive.

Mucilaginous; consisting of mucilage.

Mucous; mucus, slimy.

Multifarious; multus, much, *fari, for;* in many ways.

Muriate; muria, brine or pickle; a liquid salt, particularly volatile and brackish, incombustible, and little subject to the action of fire.

Muriatic; creating a muriate.

Must; wort under fermentation, *d.;* also a foul earthy odour.

Nappy; T.; producing sleep.

Narcotic; ναρκη, torpor, lethargy; producing numbness.

Nectar-eous; nectar, in mythology, the drink of the gods; delicious.

Nectarium; same root; in hops, *d.*

Nescience; ne, not, *scio,* to know; ignorance.

Nicotin; nicotiana tabacum, tobacco; from *νικαω,* to overcome; essence of tobacco.

Nitrate; nitrum, saltpetre; a crystal salt capable of supporting combustion, and furnishing, by the action of fire, oxygen gas mixed with azote.

Note — Carbonates, muriates, and nitrates, are severally formed by the combination of carbonic, muriatic, or nitric acid, with an alkaline, earthy, or metallic base, and each has three classes accordingly.

Nitrogen; one of the ultimate elements, *d.*

Nitrous; containing nitre.

Nozzle; T.; a short spout.

Nude; nudus, naked.

Oar; T.; an implement formerly used to stir the goods in the liquor.

Oast; T.; a kiln for drying hops.

Oil; Lat., *olea,* an olive tree or its fruit, wh. *oleosus,* full of oily substance; an adhesive slippery liquid.

Oleaginous; olea and *gigno,* to produce; yielding oil.

Olfactory; oleo, to smell, and *facio,* to make, do, or cause; having the sense of smelling.

On; T.; charging with liquid matter.

Outcast; T.; increase of bulk.

Oxygen; an ultimate element, *d.*

Oxygenated; supplied with oxygen.

---

* This was taken from the Englishman's Almanack for 1849, which states that a metre is 3 ft. 3·371 inches, 92 metres 100 yards, and 305 millemetres a foot, which results do not agree; for as 305 : 1 :: 1000 : $\frac{1000}{305} = \frac{200}{61}$ = 3 ft. 3·34426 in. :: 92000 : 3·0164 ft. = 3 ft. ·1968 of an inch; or it is 39·34426 × 92 = 36·1967 inches.

Panification; panis, bread, and *fio*, to be made; bread-baking.

Paragon; παρα, beyond, besides, *αγω*, to lead; one who excels all others.

Parallelopipedon; παρα, near, *αλληλων*, one another, *πιπτω*, to fall together, or lie along; a solid with six plane surfaces, having each pair parallel or equidistant at every point.

Paralysed; παρα and *λυω*, to loosen; debilitated in nerve.

Parenchyma; παρα, εν, and *χυμος*, juice or sap, from *χυω*, to shed or diffuse; a juicy inner skin.

Party-gyle; T.; a mixture or division of brewings.

Percolate; per, through, and *colo*, to cleanse or strain; to drop through.

Peripatetical; περι, round about, *πατεω*, to tread; travelling in a circle.

Permeates; per and *meo*, to go or pass; to pass through; impermeable.

Petal; Gr., *πεταλον*, a leaf, from *πεταω*, to extend; the leaf of a blossom.

Petroleum; πετρος, a rock, or stone, and *ωλα*, perished; a kind of mineral pitch used by japanners.

Phenomena; pl. of *phenomenon; φαινω*, to exhibit, and *μενω*, to remain; observed appearances.

Philosophist; φιλος, a friend, *σοφιστης*, a skilful workman, from *σοφια*, wisdom; an irony, implying an ignorant pretender to philosophy.

Philosopher; same roots, and Sax. *wer*, a man; a lover of wisdom.

Philosophically; dependent on philosophy.

Philosophy; love of wisdom.

Phosphate; a salt formed by phosphoric acid with a base as before. The phosphates are crystallisable, fixed, fusible, vitrifiable, phosphorescent, and soluble in nitric acid without effervescing, but are not decomposable by charcoal.

Piece; T.; a quantity of malt collected on a floor.

Pirate; pirata, a robber; stolen, or to steal.

Pitch; T.; to put yeast to wort.

Plant; T.; arrangement of utensils in the brewery.

Plumula; Lat., a little feather; first shoot in vegetation.

Phosphoric; producing phosphorus.

Pontoon; T.; a small secondary fermenting vessel.

Porter; porto, to carry, *d.*

Porter malt; black malt.

Postulate; post, after, dimin. gives *postulo*, to require; that which we admit can be done.

Potable-ation; poto, to drink; that which a person may drink.

Precipitate-ion-ant; præ, before, and *caput*, the head; originally headlong. To throw down.

Prime; primus, first; of the best quality.

Problem; προβλημα, from *προ* and *βαλλω*, to cast; a performance proposed.

Propagator-tion; προπας, the whole, from *προ*, before, and *πας*, all, to which is added *ago*, to act; that acts so as to produce.

Proteic; Proteus, a sea-god, who could transform himself into any shape; changeable.

Pseudo (brewers); *ψευδω*, to deceive; mere pretenders.

Pulverulent; dimin. of *pulvero*, to dust over; consisting in a fine dust.

Pyrotechny; πυρ, fire, and *τεχνη*, art; exhibitions of fireworks.

Rack; T.; to draw off beer from a vat or cask.

Radiating; radio, to emit rays; dispersing influence.

Refrigerate-tor-tion; re, again, *frigeo*, to make cold; to reduce temperature.

Reins; T.; the guidance of those employed in the brewery.

Replenishment; re, again, *pleno*, to fill.

Resin-ous; resina, an exuding gum.

Retrogressive; retro, backward,

gradior, *gressus*, to walk; going back.
Return wort; T.; a weak wort blended with the following mash.
Rope-iness; T.; a viscid substance in beer.
Round; T.; a cylindrical fermenting tun.
Rouse; T.; to agitate briskly.

Saccharific-fier-ed; saccharum and *fio;* producing sugar.
Saccharine; consisting of sugar.
Saccharise-ing-ation; conversion into saccharum.
Saccharometer; saccharum, and *metior*, to measure, or set out.
Saccharum; sugar in fluidity, *d.*
Safe; T.; a place of preservation.
Saline; sal, salt; containing salts.
Selenite; selenites, an Arabian stone, becoming more or less white as the moon fills or wanes, identified as a species of gypsum.
Serial; series, connected order; proceeding by a regular law.
Sesquicarbonate; sesqui, half as much added, and *carbo;* a common carbonate further digested.
Set; T.; to become pasty, like dissolved starch or sago.
Set tap; T.; to turn a cock, that the liquid may flow through it.
Shive; T.; a wooden bung, usually cut level with the surface of the cask.
Siccous-city; siccus, dry; *siccitas*, dryness.
Silent; T.; unemployed.
Silica; silex, flint.
Singlings; T.; foul and weak liquor from a still.
Slack or *slacken; T.;* to diminish heat.
Sleepers; T.; corn that will not germinate freely into malt.
Solanin, essence of potato, *d.*
Solstices; sol, the sun, *sto*, to stand; when the days are longest or shortest.
Sophisticated; σοφιστης, a deceiver; disguised by fraud.
Sparge; to sprinkle.
Sparsion; act of sprinkling.
Specific gravity; specio, to view, and *fio*, with *gravis*, *d.;* absolute weight.
Spigot; spico, to sharpen; a plug used to stop an orifice in a vessel.
Spin; T.; to obtain too much length.
Spissitude; spissus, thick, clammy; clogginess.
Spumous; spumo, to foam; exhibiting froth.
Square; T.; a four equal-sided and equiangular prismatic vessel.
Starch; Sax., *starc*, stiff; a stiff substance produced from farina, *a.;* convertible into saccharum, *d.*
Start; T.; to run from one vessel into another.
Starting back; T.; a vessel to receive beer when running from the fermenting tuns.
Steely; T.; hard, so as not to submit to solution.
Steep-water or *liquor; T.;* that in which barley has been steeped for malting.
Stillion; T.; a trough to catch the overflowings from fermenting casks.
Stingo; T.; containing sting or pungency.
Stinker; T.; an offensively foul cask.
Stoker; T.; the workman at the fire.
Store; T.; stock kept on hand; also a Scotch term for barm.
Stout; T.; strong superior porter, *d.*
Stratification; stratum, a bed of thickness, or layer, and *fio;* formation of the earth into successive beds of materials one above another.
Strig or *strombile; T.;* the stalk on which the hop flower grows.
Subcarbonate; sub, under, and *carbo;* so called from some of the elements uniting with other substances instead of the carbonate.
Subject; sub and *jaceo*, to lie; wort under fermentation.
Submerged; sub and *mergo*, to duck or sink; sunk in water.

Succinate; succino, sub and *cano;* to sing under.
Succulent; succus: juice, juicy.
Sulky; T.; heavy in appearance.
Sulphate; sulphur, brimstone; a salt formed by uniting sulphuric acid with an alkali, earth, or oxide of metal. A perfectly but not over-saturated base is termed neutral, as sulphate, phosphate, &c.; but if the acid is more than sufficient, the term *super* is prefixed, but with a predominant base it is called a *sub salt.*
Sulphuric; consisting of sulphur; chiefly applied to the acid.
Sulphurous; containing sulphur.
Superlative; super, above, and *latum,* supine of *fero,* to sustain; in the highest degree.
Surreptitiously; sub, under, and *repo,* to creep as a serpent does; done in a clandestine or sneaking manner.
Synopsis; συν, with, *οψις,* the eye; an abstract view.
Synthesis; συν, and *θησω,* to place; the art of construction; the reverse of analysis, which is the science of separation or demonstration.

Tackle; T.; appendages to machinery.
Tangential; tango, to touch; forming a tangent.
Tannin; T.; an astringent principle in certain vegetables, which has the power of tanning hides.
Tetricity; teter, foul; offensive smell.
Thermometer; θερμος, heat, *μετρον,* measure; an instrument to ascertain temperature.
Thermometric-try; relating to the use of the thermometer.
Thinner; T.; made poorer.
Thread; T.; one of several kinds intermixed; also an adhesive substance drawn into a line.
Through; T.; heated throughout.
Tissue; τιταινω, to stretch out; an exceedingly fine thin flat solid substance.
The trade; T.; that of brewer.
Trader; T.; a dealer in excisable articles.
Transmute-ant-ation; trans, beyond, *muto,* to change; thorough change.
Triturated; tritura, pounding, rubbing, or grinding, from *tero, tritum,* to bruise, crumble, or wear.
Tun; T.; a mashing or fermenting vessel.
Turbid-ity; turba, a variety; a mixed muddiness.
Turn over or *under; T.;* to let in fresh liquor at the top or bottom.
Turn out; to remove wort.
Turn on or *off;* to open or close a tap.

Ullage; uligo, moisture; the liquid in a vessel which is not full.
Umbelliferous; umbella, a round tuft, *fero,* to bear; having flowers collected in clusters, as yarrow, parsnip, chervil, carrot, &c.
Underback; T.; a back placed below a mash-tun to receive raw worts.
Utensil; utensile, any tool or implement, from *utor* to use; any vessel employed in the brewery.
Utile-ity; Lat., *utilis,* useful-ness.

Valvularly; valvæ, gates or doors which close by pressure; as if containing little valves.
Vat; T.; a fermenting or store vessel.
Vatting; depositing in a vat for store.
Vent; ventus, wind or air; an orifice for the escape of gases, or to admit air.
Vinous; vinum, wine or spirit; containing spirit of wine.
Vinosity; the vinous state.
Virus; any thing strong; from *vis,* force; venomous matter.
Volatile; flying off.
Volatility; inclination to escape.
Volume; volumen, a wave or folding, from *volvo,* to roll; the quantity collected.

Waste; T.; loss of property by mismanagement.

Windcake; T.; a dry brown crust.

Work; T.; to ferment.

Wort; T.; unfermented extract of malt.

Yeasty; T.; any kind of ferment.

Yeast-bite; a peculiar bitterness, the result of a bad fermentation.

Zein; ζεια, *far;* any kind of corn or flour, with *farina.*

Zimome; ζιω, to seek, μωμος, a blemish; the interior substance of starch, or *amidin*, found only by breaking the shell.

INDEX TO ANALYSIS.

Acetic acid and alcohol, 315. 349.
Albumen, 54.
Alcohol, 391. 345. 349.
Aldehyde, &c., 345. 392.
Atmospheric air, 256.
Barley meal, 88. 249.
Barm, 317.
Beans, 52.
Burton water, 114.
Carbonic acid, 352.
Gelatin, 490.
Gluten, 54. 44. 91.
Grain and pulse, 26.
Gum, 38.
Honey, 92.
Hordein, 60, 61. 91.
Isinglass, 490.
Kentish water, 109, 110. 122. 124.
Mais or maize, 49.
Mucilage, 40.
Peas, 368.
Principles of malt, 92.
Shannon water, 107, 108.
Starch, 37.
——— of malt, 60. 98.
Sugar, or saccharum, 31. 98. 352.
——— of grapes, 98.
Sulphate of lime, 112.
Wheat, 44.
——— gluten, 324.

LATINITIES.

Ab initio; *from the commencement.*
Aqua pura; *pure water.*
—— regia; *royal water.*
Cæteris paribus; *on equality with the rest.*
Desideratum; *thing wished for.*
Essentia bina; *double essence.*
Ex parte; *from one side.*
Glomeramina; *small spheres.*
Gummi modo candidum; *clear, in the manner of gum.*
In se; *within itself.*
In toto; *in the whole.*
In vacuo; *in void space.*
Ipse dixit; *himself has said.*
Locus; *place.*
Lupo salictario Germani suam condiunt cervisiam; *the Germans prepare their beer with* a bitter (plant) *from the willow grounds.*
Maximum; *the greatest.*
Minimum; *the least.*
Minum; *a drop.*
Modus operandi; *manner of working.*
Ne plus ultra; *no more beyond.*
Nidus; *a nest, hive, &c.*, or its contents.
Nostra; *for our (benefit).*
Per annum; *by the year.*
Plus, *more;* minus, *less.*
Potus coctus; *cooked drink.*
Primum mobile; *movable first principle.*
Principium; *beginning.*
Punctum summum; *highest point.*
Quantum; *as much as.*
Secale cornutum; *horned rye.*
Sic parvis componere magna solebam; *thus I was wont to compare great things with small.*
Stamen; *that which holds fast.*
Status; *standing, command.*
Summum bonum; *highest good.*
Ultimatum; *the farthest point.*
Veto; *a forbidding.*
Zero; *nothing.*

INDEX TO SPECIFIC GRAVITIES.

Acetic acid, 344. 353.
Alcohol and ether, 344.
Carbonic acid gas, 411.
Ether, 397.
Gum, 37.
Gypsum, 117.
Saccharine juice, 197, 198.
Slate, 405.
Water, 126. 187. 280.
Woods and metals, 280, 281.

INDEX TO TABLES.

Acetic transitions, 345. 349.
Alcoholmetric losses, 208.
Apparent gravities, 202.
Atmospheric elements. 256.
Attenuation of India ale, 457.
Barley and malt, 249.
Burton water, 114.
Calcutta imports, 461.
Cosines of latitude, 375.
Elements of sugar, &c., 349.
Examples of brewings, 152.
Excavations for level heat, 381.
Extract by Bate and Allan, 193.
Gluten and albumen, 54. 325.
Imbibition by hops, 265.
Maidstone water, 109, 110.
Porter grists, 434.
Power of steam, 235.
Reduction of gravity, 201.
Results of experiments, 152, 153.
Saccharine productions, 158.
Series of expansions, 203.
Shannon water, 107, 108.
Specific gravities of woods, 280.
Starch and hordein, 60.
Substances analysed, 26.
Temperature at Nine Elms, 290.
Transmutation of malt, 91.
Treatment of malt, 80.
Water tests, 123. 125.
Weight of solid extract, 199.

INDEX TO HEADS OF SUBJECTS.

Acetic acid and alegar, 445. 448.
Adulteration by dealers, 421—424.
Advice on boiling, 266.
African gummy diet, 447.
Albumen examined, 54, 55.
Alcohol annihilated, 342. 345. 349. 352.
Alcoholmeter and acetometer, 205.
Aldehyde described, 391. 393.
——— analytically considered, 344. 346.
Alkalies and lime in water, 113.
Allan's saccharometer, 188. 193. 199. 201.
Amalgamation by replenishment, 463.
Anecdotes illustrative of water, 113. 118.
Anti-boiling, 248. 250. 254. 257. 261. 263. 266. 361.
Anti-ferments, 351. 496.
Apotheme and minor properties of plants, 46.
Artificial ferments, 339.
Atmosphere, 275, 276. 283. 287.
Atoms of spirituosity, 345. 351.
Attenuation perfected, 415.
Australian and Canadian taste and climate, 450.

Bangor quarry slab, 406.
Barley examined and described, 60. 69.
Bate's saccharometer, 193. 196.
Bavarian ladies, 220
——— fermentation, 331. 402. 359.
——— latitudes, 293.
Benefits of attemperation, 145. 154.
Bitter examined, 45.
—— ale, 451.
Black or porter malt, 89. 430. 432.
Blackening of vessels, 282.
Blown malt, 88. 421.
Boiling point, 203. 205. 287.
Books on frauds, 426, 427.
Bouchardat's new light, 336. 339.
Brewer's Lexicon, 505.
British temperature, 287. 290.
——— malt cordials, and wines, 354.
Brown malt, 87.
——— stout, 420.
Burton water, 114.

Calcutta market and malt liquor imports, 461.
Carbonic acid gas considered, 315. 396. 409.
Caromel, 432.
Catharine Refrigerator, 304.
Causes of testing hops, 221. 224. 225.
——— perfection in ale, 274.
Caution in fermenting, 412.
Cellars and reservoirs, 471.
Character of albumen, 54. 56.
Chemical elements, 27.
Choice hops, 225.
Clarification of matured beer, 490.
Coated utensils, 283.
Commercial comparisons, 160. 166.
Comparison of gauges, 199.
Composition and value of flakes, 254. 260.
Concluding apology, 497.
Condition in hops, 224.
Conflicting opinions on water, 103.
CONSTANT TEMPERATURE VAULT, 373.
Constitution of malt, 91.
Constitutional properties of beer and porter, 445. 447.
Corn examined, 42. 55.
Correctives in fermentation, 360. 368.

Couching, 70.
Creamed worts, 276.
Critical remarks, 5. 9. 16.
Cure for stubborn beer, 494.
Curious customs, 10. 15.
——— facts with ferments, 318. 335.
Custom fallacious, 183.

Danger of new opinions, 179.
Davison and Symington's cask apparatus, 480. 483.
Deductions from new theorem, 204.
Demeteric ether, 398. 465.
Derivations of brewing words, 6—11.
Destruction of diastase, 255. 429.
Diastase examined, 55.
Dicas's saccharometer, 184.
Dilution of wort, 172. 260.
Discovery of diastase, 4. 17.
Distilling, 227.
Division of gluten, 43.
Doctrine of expansions, 200.
Doctrines of philosophers, on ferments, 335. 337.
Dring and Fage's saccharometer, 185.
Dry and sweet wines, 213.
Drying malt, 82. 86.
Dublin brewers and materials, 432.
Duties and altered circumstances in porter, 421. 423.

East India pale ale, 451.
Economy in boiling, 231. 246.
Effects of low temperature, 273, 274.
Egregious errors in estimating produce, 189. 193. 199.
English excise laws, 191.
——— beer laws, 422. 425.
Essential qualities of stout, 449.
Ethereal principle explained, 399.
Evaporation in stores, 470.
Evidence of loss in boiling, 247. 249.
Evils of boiling, 254. 259.
——— black malt, 430.
Examination of constituents, 26. 29.
Examples of brewings, 152. 457.

Experiments in temperature, 288. 290. 375.
Extractive examined, 45.

Faculty embarrassed, 448.
Fans and pipes, 303.
Fibrous matter examined, 51, 52.
Filtering mash, 174.
Filtration of water, 108.
Flakes examined, 252. 255.
Floating Racker, 488.
Flooring, 72.
Flush porter, 420.
Food and parts of plants, 34. 42. 47, &c.
Fox taint, 276.
Frauds in hops, 223. 240.

Galvanised worts, 284.
General principles of fermentation, 292. 303. 315.
Genuine London porter, 436.
Gluten, 43. 347.
Grains, 175.
Gravity and density, 182.
Gum examined, 38. 40.
Gypsum water, 117. 120.

Hales's experiments, 402.
Hard and soft water, 105. 107. 111.
History of brewing, 5—17.
——— the hop plant, 220. 223.
——— isinglass, 490.
Home consumption of pale ale, 451.
Hop-Convertor, 229.
Hopping on the rack, 485.
Hordein examined, 59, 60.
Humuline, patent, 236. 239.
Husk examined, 48. 50.
Hydrometics, 183.

Ill effects of heat, 352. 354. 264.
Imperial act of parliament, 186.
Imposture overcome, 178.
Increased profits by new practice, 154.
Influence of sun, 296.
——— elevation, 297.
——— sea, } 298.
——— aspect, } 298.
——— mountains, 299.
——— soil, 300.
——— cultivation, 301.
——— winds, } 302.
——— season, } 302.

Initial heat of mash, 135. 142.
Introduction of the subject, 1.
———— of hops, 215.
Inutility of dome coppers, 259.
Irish porter, 437.
Isinglass, 490.

Kilns in variety, 82.
Kleber, 357.

Legitimate flavour of porter, 439.
London porter brewers, 436. 438.
——— and Dublin houses, 432. 437.
——— tipple described, 435. 437.
Long's saccharometer, 195. 199.
Losses by imbibition avoided, 265. 267.
Lupuline, 225. 227.

Malting, 61.
Malt mills, rolls, and makers, 96.
Management, 275. 133.
MASHING ATTEMPERATOR, 141. 154. 160.
Medicated malt, 95, 96.
Medicinal virtues of pale ale, 446.
Metallic coolers, 280.
Mineral waters, 119.
Misapplication of finings, 493. 495.
Misrepresentations by coppersmiths, 233.
Morocco and Gum, 355.
Mould in barley and malt, 67.
Mucilage examined, 40. 42.

Name and character of alcohol, 391.
Natural cooling, 272.
Nature of wort, 30.
———— saccharum, 28—1.
——— superior to art, 271.
——— of gentle fermentation, 413.
Necessary qualities of a refrigerator, 304.
Necessity of alcohol, 26.
———— malting, 59.
———— chemical knowledge, 496.
Nectarium, 225.
Neutralising acetometer, 206.
New mashing system, founded on practice, 142. 154.
—— London mode of boiling, 252.

Octuple Cleansing Apparatus, 412. 416.
Œnanthic ether, 344.
Oil examined, 48.
Oily shield, 470.
Old notions on brewing, 4—10.
—— and new opinions on hops, 215. 221. 227.
—— entire defined, 433.
—— and vatted beer, 418.
Opiates, 273.
Opinions and tests, 349. 352.
Opposite hopping practices scrutinised, 486.
Organic matter in water, 107—111. 122.
Origin, history, and use of instruments, 182. 185.
———, name, and history of porter, 417. 419.
Original and correct mode of fermenting India ale, 457.

Pale malt, 87.
—— beer, 453.
Party gyles, 176, 177.
Payne's patent for preserving timber, 474.
Phosphates examined, 54.
PNEUMATIC LIFE-PROTECTOR, 410.
Poole's patent, 86.
POTENTIAL FERMENTING SQUARE, 404.
Practice in boiling, 263. 269.
Prevention of acidity in wort, 174.
Progress of chemistry with brewers, 144, 145.
——— and history of hops, 214—219.
Pulse examined, 52.
Purifying and steeping barley, 68.

Quantity and quality of mashing materials, 134.
—————— hops for India ale, 453, 454.
Racking, 489.
Rain, 105.
Recovering damaged malt, 95.
Recovery of malt in mash, 165.
Rectification of exports, 450.
Reflections, admonitory, 129. 133.
———— on boiling, 243.
Refrigeration a great boon, 304.
Remarks on climate, 296.

Remedy suggested, 20.
——— for ropiness, 469.
Requisite properties of a refrigerator, 304.
Requisites in fermenting, 412.
Resin and oil of malt, 90.
Return worts, 174. 177.
Rivers considered, 107. 109.

Saccharum examined, 28.
Salt in water, 104.
Schemes and failures, 19. 22.
Scotch excise laws, 187. 190.
——— frauds, 424.
Security of alcohol, 250.
Seeds of hops, 225.
Shannon water, 107.
Slates and slabs, 406.
Snow, 106. 110.
Sorts, solution, and operation of isinglass, 491.
Sparging considered, 170. 181.
Specific gravity of water, 125.
Specimen of India ale brewing-book, 457.
Spontaneous production of ethereal strength, 465. 468.
Springs and wells, 106.
Sprinkling and anti-sprinkling, 76. 84.
Stability of alcoholic strength, 399. 401.
Standard mashing-heat, 145, 146.
Starch examined, 31. 37.
State and character of constituents in mash, 136. 140. 150.
Steam pipes and heated furnaces contrasted, 229. 238.
Steaming worts, 232.
——— casks, 477.
Steepwater, 68.
Storing, 463.
Sun and air acting on water, 118.

Table of porter grists, 434.
Tea, 214.
Testing worts, 161, 162.
Tests of barley samples, 65.
——— malt, 96, 97.
——— water, 107. 110. 123. 127.
——— hops, 225. 240.
Theorem on thermometers, 291.
Theory of ethers, 395. 399.
Thermometric scales, 291.
Thermometry, 290.
Thrashing machines, 67.
Three great principles in anti-boiling, 246.
Transmission of caloric, 280. 284.
Transmutation of ingredient substance, 145. 151.
Treatment of malt, 96.
Tubers examined, 33. 36.

Ultimate strength and brightness of India ale, 458.
Ure's delusions, 440.
Use and abuse of anti-ferments, 496.
——— of hops, 210.
——— boiling, 267.
Uselessness of pulse in brewing, 54.

Value of thermometer, 143. 147.
Variation in boiling point, 205.
Vatting porter, 439. 445. 470.
Virtue of hard water, 111. 113. 120.
Volatile matter examined, 33. 50.

Washing and tea water, 110.
——— casks, 471.
Wheeler's patent, 87.
Wind-cake, 227.
Wonders of diastase, 56. 60.
Wooden coolers, 276.
Wynn's Close Receiver, 494.

Yeast, 317. 322.
Yielding opinions on boiling, 259.

Zinc vessels, 283.

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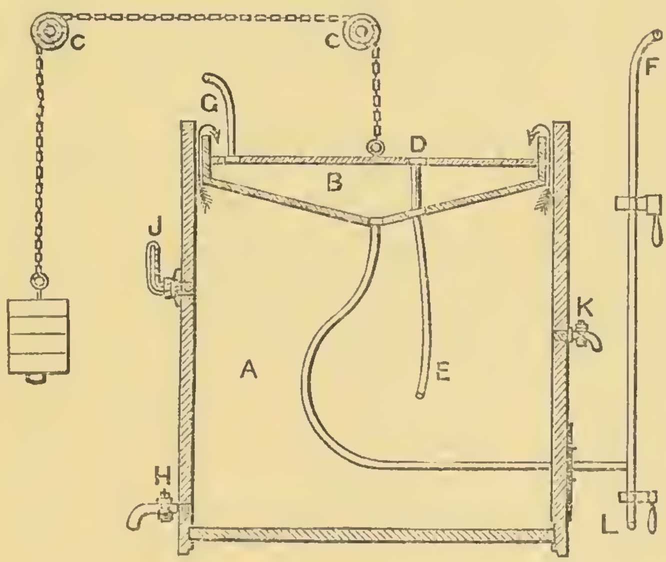
PART IV. Testimonials of practical men respecting the character of Mr. Tizard's Publications, especially the larger, alphabetically arranged.



BY W. L. TIZARD,

Operative Brewer, Mechanical and Consulting Engineer, and Coppersmith;
Patentee of the Mashing Attemperator, Hop-Convertor; Octuple Fermenting Apparatus; Conical Threshing Machine; Malting, Acetifying, and Rectifying Apparatus;
also, Author of the "Theory and Practice of Brewing," &c. &c.
late of the Brewery at Nine Elms.

CITY OFFICES, 12, MARK LANE, LONDON, E.C.

LONDON.—1858.

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PART I.

PROSPECTUS OF THE OCTUPLE FERMENTING, CLEANSING, ATTEMPERATING, AND PRESERVING APPARATUS, A MODERN INVENTION OF

W. L. TIZARD,

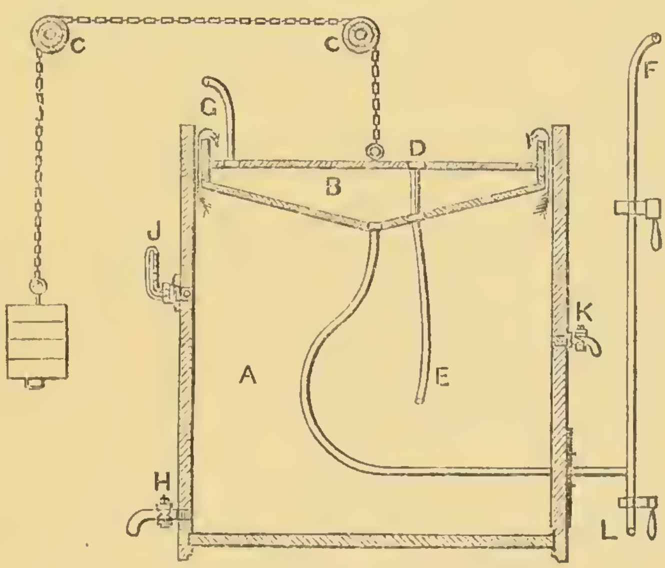
THE INVENTOR OF THE STEAM BREWERY, MASHING ATTEMPERATOR, &c.
AUTHOR OF "THE THEORY AND PRACTICE OF BREWING ILLUSTRATED," &c. &c.

City Offices, 12, Mark Lane, London.

THE OCTUPLE enables the operator to place a running sheet of cold water between the whole surface of his worts and the yeast rising therefrom, and so conduct the vinous fermentation in a closed, or nearly closed, vessel; to keep his fermenting worts in a state of circulation by natural means only; to secure the yeast more free from beer than heretofore; to prevent excessive evaporation of the aroma and spirit; to save at least five *per cent.* in malt alone; and to control the temperature of the fermenting wort without hot water.

Hence the OCTUPLE performs the several functions of Cover, Barm-back, and Attemperator, either together or separately, excepting that it cannot be either unless it is a cover.

The OCTUPLE consists of a double metallic vessel, which nearly fits the interior of the fermenting square or round, somewhat conical or convex on its bottom, and flat, or slightly concave, on its top, its outer edge rising a few inches above its surface, as shown in the following sketch.



A, square; B, the OCTUPLE or double cover; C, C, pulleys and chain, by which it is lowered or raised; D, a tube through which the beer drains and passes to near the bottom of the tun through hose E; F, ingress water-pipe to take a flexible tube; G, egress water-pipe; the bent arrows show the direction the yeast takes; H, racking cock; J, thermometer; K, sample cock; L, cock by which the OCTUPLE is emptied of water.

Its *modus operandi* is briefly thus:—

The OCTUPLE, B, is lowered to within a foot or two of the bottom of the square, and cold water passed through it by means of the pipe, F. The pitching yeast is put on the cover, B. The worts from the cooler or refrigerator flow over the surface of the attemperator, B, and pass down the tube, D. The floating cover, B, now rests on the surface of the wort and receives the yeast as it rises up round its sides and falls on its surface. The yeast does not present its usual light and bulky appearance, in consequence of a large portion of its attendant gases and beer being squeezed out during its passage up the narrow channel.

The beer that accompanies the yeast flows away and re-enters the gyle-tun, A, through the tubes, D. When the beer is sufficiently attenuated, plugs are placed into D to prevent any more yeasty beer passing into the gyle-tun.

The yeast now rises sparingly and in a more solid state, and continues to be retained on the barm-back, B. Just before the close of fermentation the plugs are partially withdrawn a few minutes to allow the clean beer which may have subsided on the precipitated yeast to run down into the square. The yeast soon becomes comparatively solid, and may remain on its cool plate, B, always fresh and ready to be taken off as required either for sale or use.

The heat of the gyle never need be raised 5° F., even when pitched at 56°.

Cold liquor may always be flowing through the OCTUPLE in a small stream (beer will deposit its yeast, or fine, best from 56° to 58°), and the beer racked sufficiently clean from the square, either the whole or part of a gyle at once, the remainder being kept cool, and covered from the air until wanted, or the carriage casks are ready to receive it.

Extreme temperatures cannot affect a gyle protected by a sheet of cold water.

The OTCUPLE is allowed to descend during the process of racking. The square being drained, a man gets in on the OCTUPLE and washes all within his reach. The apparatus is now raised high enough above the edge of the fermenting vessel to enable the man to wash the bottoms of both.

The peculiarities of this apparatus, and the very superior advantages attending the foregoing operations, and their immediate results, are as follows :—

1. The OCTUPLE takes all the yeast from the beer, and all the beer from the yeast.
2. Performing in *one vessel* the processes of fermenting, cleansing, and purifying.
3. Begetting cleanliness, a lively and expeditious process, and early brilliancy.
4. Enabling any Brewer to achieve that peculiar fermentation so essentially productive of Bitter Ales, either for exportation or home consumption.
5. Escaping the annoyance and often fatal consequences of excessive heat and cold, peculiar liquors, errors in pitching heats, and other circumstances which usually impede the process.
6. Avoiding the waste attending every other plan of fermentation, particularly with cleansing casks, stillions, pontoons, yeast-troughs, settling-backs, skimmers, &c., to say nothing of the splashings, slops and loss, by filling up and oxidation, and the residue in every kettle, tub, and vessel, besides accidents, and the inevitable injury of the article subjected to so many transportations, divisions, vicissitudes, and atmospheric influences.
7. Great economy of room and labour in the brewery.
8. Giving the operator full control over the most delicate, precarious, and important processes in the art of brewing, enabling him to produce, at all seasons of the year, an article of uniform quality and character.
9. Facility of collecting all the yeast in one solid bulk without the usual accompaniment of waste beer, which often amounts to three *per cent.* on a gyle.
10. The general applicability of the apparatus, and facility of its adaptation to old fermenting squares, rounds, or ovals.
11. The OCTUPLE is the only cleansing apparatus that adjusts itself to long and short lengths alike, and prevents the radiation of caloric, and evaporation of aroma and spirit during fermentation.
12. Increasing the generation and preservation of aromatic oil, alcohol, and ether, which adds to the pungency, flavour, and strength of the article without additional malt.
13. In short, the OCTUPLE is managed and cleaned with ease and facility ; is less costly than, embraces all that is valuable in, and avoids the imperfections of, every other apparatus and system. It fills the long existing void, supplies the great want in the Brewer's laboratory, and affords mental and physical relief to the operator.

Finally, the OCTUPLE condensing and confining the alcohol and the aroma in the beer, it follows that a very superior beverage results from its employment, which the Public will be sure to appreciate.

The inventor was led to enter upon the course of experiment which resulted in the production of the remarkable apparatus the advantages of which are above described, by the troubles experienced by numerous brewing friends during a summer season. His first OCTUPLE was an exceedingly rude and imperfect instrument, being only a flat board, having a coiled attemperator attached to its under-side ; but beneficial effects were found to result from the use of even a contrivance so simple as that. Thus constituted, however, the OCTUPLE had many imperfections, and performed only a few of the uses which it was the inventor's object to enable it to perform ; and he was therefore led, after many experiments, to perfect it, by substituting for the solid and flat wooden board a hollow metallic float, shapen on its under-side something like an inverted cone, and thereby not only supplying all the deficiencies of the wooden float, but likewise superseding all necessity for the use of the coiled attemperator, by enabling the float itself to act also as an attemperator, of much superior effectiveness. This great improvement added incalculably to the value of the apparatus, and increased the benefits resulting from its use to an extent surpassing the inventor's most sanguine expectations; but while thus immensely augmenting the utility of the OCTUPLE, it also augmented the cost of constructing it; and as some brewers always prefer the lowest-priced instruments, Mr. Tizard is prepared to supply, not only the perfected OCTUPLE, but also the OCTUPLE as originally constructed. In the latter shape,—the shape, namely, of a wooden barm-back, with a coiled attemperator suspended beneath it,—its cost is about one-half of that of the metallic OCTUPLE; but the following comparison will show that it is not to the brewer's interest to select the lower-priced instrument, since its inferiority to the metallic OCTUPLE is far too great and too important to be compensated by any difference in the cost of construction.

A few of the more marked advantages of a hollow metallic float, capable of being kept filled with cold water, as compared with a solid wooden one, destitute of that capability, are the following. In the first place, the metallic OCTUPLE applies attemperation to the *surface* of the fermenting wort,—the portion of the wort to which *alone* attemperation *ought* to be applied, in order to the proper conduction of the vinous fermentation; whereas when the coiled attemperator (or any other that can be suspended from the wooden float) is used, the attemperation is *not applied to the surface at all*, but is applied instead to a portion of the wort lying some distance *below* the surface, since the coiled attemperator must necessarily be immersed *in* the wort, instead of floating *on* it, as the perfected attemperator, or metallic OCTUPLE, does. The latter has also greatly the advantage of the former in the superior ease and facility with which it can be cleaned, and also in the fact that it exercises its refrigerating influence, not only upon the surface of the wort beneath it, but also upon the yeast and beer which rise up round its sides, and fall upon its barm-back, or upper face. The stream of cold water flowing through the metallic OCTUPLE keeps this upper face, or barm-back, always cold, and thereby effects several most important, and hitherto unparalleled, beneficial results. Amongst others, it ensures the *complete* separation of the yeast from its accompanying beer, causing in due course the precipitation of the *whole* of the yeast, and thus so thoroughly freeing the beer from yeasty admixture, and at the same time cooling it at so low a temperature, as to preclude the possibility of its imparting, when it redescends into the gyle-tun, either the yeast-bite, or the slightest acid impregnation. When the OCTUPLE is constructed of wood, the case is very different. No attemperating influence can then be applied to its upper surface, or barm-back; and the temperature of the barm-back is therefore entirely beyond the control of the brewer, being dependent, not—owing to wood and fluids being each bad conductors of heat—upon the attemperator suspended beneath it, but partly upon the temperature of the atmosphere, and partly upon that of the overflowing yeasty wort. The consequence is that in summer time the temperature of the barm-back is so high, that two very objectionable results accrue. On the one hand, the beer and yeast of which the wort which flows on to the barm-back consists, are separated so imperfectly that the beer which returns into the gyle-tun carries with it many yeasty particles, which are liable to be dissolved by the alcohol of the wort in the gyle-tun, and thus to impart to it a yeast-bitten character, while, on the other, instead of the fermentation of the wort which flows on to the barm-back being there checked, it is so accelerated that part of its alcohol flies off into the atmosphere as alcoholic ether, while much of the remainder is converted into acetic acid, which, on descending into the gyle-tun, contaminates its whole contents. Nor are these the only respects in which the wooden OCTUPLE is greatly inferior to the metallic one. When the metallic instrument is used, its conical bottom provides an inclined plane, up which the globules of carbonic acid gas, which are the vehicles by which the yeasty particles are conveyed to the surface of the wort, can easily work their way to the sides of tho OCTUPLE, and thus ensures that the *whole* of the yeast shall be removed from the wort, and collected upon the barm-back; but with the wooden OCTUPLE this is not the case. The wooden instrument may be made *more* conical on its under-side than the inventor at first constructed it, but it cannot be made *so* conical as the metallic OCTUPLE, since to make it so would render it too cumbrous and unwieldy for use, unless it were made in parts, in which case it would be liable to constant derangement, and premature destruction; and it consequently presents, owing to its necessarily greater flatness, much inferior facilities for the flow upwards of the little globules, or "balloons," of gaseous yeast, and is exceedingly apt, especially in hot weather, to press prematurely out of them the carbonic acid gas which buoys them up, and thus to cause a great part of the yeast to collect at the bottom of the gyle-tun, instead of at the top of the barm-back, thereby occasioning considerable loss both of yeast and beer, and increasing the danger of the beer becoming yeast-bitten. If to all this it be added that when the wooden OCTUPLE is used, the wort will in many cases require occasional rousing,—which may be effected either by passing the handle of the rouser through the wooden float, or through a stuffing-box, fixed in any convenient part of the fermenting vessel,—while the low temperature at which the metallic OCTUPLE cools the wort on its barm-back adds to its many other advantages that of obviating this necessity, in all but very extreme cases, since the cold streams of wort which return from the barm-back into the gyle-tun, through the tubes passing through the OCTUPLE, acquire by the cooling operation such an increase of density that they at once descend to the bottom of the gyle-tun, thus causing the warmer contents of the vessel to ascend, and go through a similar process in their turn, and thereby keeping the wort in a proper state of circulation, without the aid of any "rouser," the great superiority of the metallic apparatus over the wooden one will be sufficiently apparent. The wooden OCTUPLE, in a word, is a useful instrument, but falls far short of perfection; the perfected, metallic OCTUPLE *leaves nothing to be desired.*

There are other remarkable circumstances to which it is important that attention should be directed. The cauliflower head which presents itself during the earlier stages of the process of fermentation, when conducted in any of the ordinary vessels, emits an exceedingly delicate and pleasant odour, which is owing to the escaping carbonic acid gas being impregnated with the finest and most volatile aromatic oils of the materials, especially those of the hops. The rocky-shapen head which succeeds this emits a stronger scent, being accompanied by both vapourized aromatic oils, and vapourized alcohol. To these aerial products, ether is added during the latter stages of the fermenting process, and it is owing to the vast quantities in which alcohol and ether are now evolved, that the atmosphere in the immediate neighbourhood of the fermenting vessel becomes so pungently suffocating that the strongest man could not breathe it without endangering his life. All the *odorous* exhalations from the fermenting wort, during whatever part of the process of fermentation they may be evolved, therefore consist of the most precious constituents of the brewer's materials,—a fact which had hitherto remained undiscovered, but which is demonstrated by the OCTUPLE, of the unapproachable superiority of which apparatus nothing could possibly be more conclusive than the fact that when it is used NO *odorous exhalations are given off*, the process of fermentation becoming absolutely imperceptible by the sense of smell. As much carbonic acid gas, which is not condensible, except under enormous pressure, escapes from each gyle as escapes from a gyle of similar quality when the OCTUPLE is not used; but all other vapours, whether the vapours of aromatic oils, the vapour of alcohol, or that of alcoholic ether, are condensed by the cold under-surface of the metallic OCTUPLE, (for the wooden instrument of course constitutes a less perfect condenser,) and are thus returned to, and caused to be retained by, and thoroughly incorporated with, the beer, instead of being allowed to fly off into the atmosphere. A perfection of quality is thereby attained excelling any thing ever produced by any other means, and a greater saving of materials is at the same time effected than any brewer who has not actually experienced it would readily credit. In fact, taking this and all the other merits of the metallic OCTUPLE into consideration, it is not too much to say that it realizes the *beau ideal* of a fermenting apparatus, accomplishing every purpose that the brewer could desire such an apparatus to accomplish, and apparently leaving no room for further improvement.

Another great disadvantage attending the wooden OCTUPLE, whether made flat or conical, consists in the circumstance that the yeast adheres to its bottom in considerable quantities, and is thence liable to fall down into the otherwise clear beer upon the slightest change in its temperature; whereas the metallic OCTUPLE, on the contrary, always comes out perfectly clean and white. Another previously unknown fact is thus demonstrated: the fact, namely, that a strong affinity exists between the albumen of wood and the albumen of yeast,—the union of which, in the case of the wooden OCTUPLE, is doubtless strengthened by the porosity of the wood.

Still another noticeable point in connexion with this invention remains to be mentioned. It supplies, for the first time, an answer to the long vexed question, "Why does ale that is skimmed drink colder and thinner on the palate by two or three pounds per barrel, than ale that is worked off in puncheons?" This question has hitherto puzzled the whole trade; but the OCTUPLE proves that skimmed ale possesses the characteristics alluded to *in consequence of the rude skimmer having stolen its oils, and a greedy atmosphere* having devoured its spirit.* In other words, the inferiority of ale skimmed in the ordinary way is owing to the skimmer having deprived it of the finest of its aromatic oils as they ascended to the surface of the gyle with the yeast, and to the atmosphere having drunk of its alcohol, and absorbed other good volatile qualities, during the period of its nakedness and cruel exposure.

Finally, the inventor need only remind brewers of the extent to which light and currents of air exercise a prejudicial influence upon worts undergoing the vinous fermentation, particularly where the skimmer is used. Practical men are well aware of these drawbacks; nevertheless, they prefer to skim, instead of to cleanse on stillions, on account of the comparative economy in labour, room, and cleanliness. How great, then, must be their preference for a system of skimming which is not only more economical, being self-acting, but also more cleanly, and which moreover adds at least ten *per cent.* to former profits!

The OCTUPLE is manufactured *and sent on trial* by its Inventor and Patentee, W. L. TIZARD, Brewers' Engineer, Architect, and Valuer, 12, Mark Lane, London, where models of the most modern and meritorious machines pertaining to the brewery may be seen. Although it was only patented in January 1857, the inventor has already received the following testimonials from persons using it:—

I.—*From Messrs.* HARE *and* SON, *Brewery, Stonehouse, Plymouth, September* 28, 1857.

"You ask me my opinion of your fermenting apparatus. I can only say that no brewer who scientifically understands the requirements of a gyle of beer undergoing fermentation ought to be without it. The character of the beer is decidedly improved from non-exposure to the

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* The expression "a greedy atmosphere" may appear a strange one, but to the writer it seems perfectly legitimate. We know that the atmosphere takes up immense quantities of moisture from the earth, rivers, lakes, and seas,—from the latter sometimes with such avidity as to swallow up the inhabitant fishes and frogs.

atmosphere, and the yeast is every thing that can be desired, both in colour and consistency. During the past trying summer I have always found the beer fermented under the influence of the 'OCTUPLE' less prone to acidity than that worked in the ordinary way. Are you sure you have the proper dimensions for the other OCTUPLES we have ordered ?"

II.—*From Mr.* S. WILLIAMS, *Ship Hotel*, *Crediton*, *October* 19, 1857.

"I have the greatest pleasure in subscribing my humble name to your scientific method of fermentation. I believe your last patent, the OCTUPLE, to be *perfect*. And let me add my best thanks for your unwearied exertions in bringing out such a valuable apparatus for the brewer's benefit. I need not add more, as Professor Muspratt has spoken so favourably of your other inventions for the brewery."

Mr. Tizard takes the liberty to add here the following copy of an order from Mr. ALFRED TOOTH, making the *fourth* order received from one or another member of his family :—

"14, Mincing Lane, Nov. 10, 1857.

"Mr. W. L. TIZARD,

"Dear Sir,—In addition to the Steam Brewing Plant ordered by me to be put into our Stores at North Woolwich, I have decided to order seven of your patent OCTUPLES, or Cleansing Apparatus, and likewise suitable Squares, of such dimensions as you may consider necessary. "ALFRED TOOTH."

Mr. TIZARD will be glad to reward any persons informing him of infringement of his Patent, by the manufacture of either wooden or metallic OCTUPLES.

Agents who understand the brewing business are wanted to introduce the OCTUPLE. A liberal commission will be allowed.

W. L. TIZARD, Brewers' Engineer and Architect, 12, Mark Lane, City, E.C.

ADDENDUM.—MR. TIZARD'S LATEST INVENTION.

MR. TIZARD has succeeded in constructing a self-acting Indicator, by means of which, when placed on the outside of the fermenting vessel, the gradual attenuation of the worts *may be seen at a glance*, without samples, or use of the ordinary assay jar and saccharometer. This Indicator may be had fitted either with blind scales or private indexes. It is strong, simple, easily cleaned, and not liable to derangement; and its price is moderate.

PART II.

LIST OF PRICES OF THE MASHING ATTEMPERATOR, AND TESTIMONIALS FROM PERSONS USING IT.

City Offices, 12, Mark Lane, London.

THE MASHING ATTEMPERATOR is a patented invention by the sole manufacturer, Mr. Tizard, so constructed as to admit of steam or hot water being passed through it, diffusing an equable temperature of any required degree throughout a mash, without increasing its fluidity. By another patented arrangement the hollow arms or rakes are perforated so as to inject either steam, hot air, or other gases, or hot water directly into the mash itself; the chief effect in all cases being to purify and concentrate the extract, and thereby to ensure a brilliant and sound article, with an increase in the extract amounting to 10 or 15 *per cent.*

Dimensions of Machine in Quarters of Malt	3,	4,	6,	8,	10,	12,	15.
Prices in Pounds........................	£33,	40,	47,	53,	60,	74,	87.

Quarters......	20,	25,	30,	35,	40,	45,	50,	100.
Prices.......	£93,	100,	107,	113,	120,	127,	140,	260.

The principles of mechanism and the great efficiency of this machine, which may be wrought by steam, horse, or any other power, according to dimensions and convenience, are fully detailed in Mr. T.'s Treatise hereinafter named, and in his minor work entitled, "A Voice from the Mash-tun," price, post-free, 5*s.*; and the effects of its operation stand exemplified in the following, amongst many other highly respectable

TESTIMONIALS

from Gentlemen employing the new Machine, some of which, having appeared in the former series, are now abbreviated.

I.—*From Messrs.* Davidson *and* Bowman, *Patent Steam Brewery*, *Woolwich*, *Kent.*

"In reference to the Patent Mashing Attemperator, we can say with pleasure and confidence, that it far surpasses the old machine, and fully realizes our expectations, giving much more extract from the malt than we ever previously obtained."

II.—*From Mr.* George Arnold, *St. Margaret's Patent Steam Brewery*, *Norwich*, *February* 21, 1850.

"I cannot state terms too high relative to the powers of the Hot Masher or Mashing Attemperator. I have now worked it long enough to speak with confidence. The quantity of extract I am obtaining exceeds my expectations; and its quality is certainly of superior richness. The brilliancy of the taps, their ultimate odour, and the soundness of the article, show forth the great points obtained in the first mash. I am so satisfied with the results of the Machine, and Mr. Tizard's system generally, that they have my unqualified approbation."

III.—*From the Hoegate Brewery*, *Plymouth*, *Devon.*

"Messrs. Scott, Evans, and Scott willingly bear testimony to the efficiency of Mr. Tizard's Mashing Apparatus, which effects an increase of from *ten* to *fifteen per cent.* in the density of the worts, as indicated by Dring and Fage's Saccharometer."

IV.—*From Messrs.* W. B. Edwards *and* Son, *Patent Brewery*, *Stamford*, *Lincoln*, *August* 5, 1846.

"Having now had considerable practice with your Patent Mashing Attemperator, we can no longer, with justice to our own feelings and your invention, forbear to express our entire satisfaction with its operation. The expectations which we formed of it, though sanguine, have been more than realized by the effect it has produced, being now enabled to obtain an extract of a finer quality and flavour, and from *ten* to *fifteen per cent.* more in quantity than we could without its assistance."

V.—*From Mr.* James Lawrence, *Patent Brewery*, *Colnbrook*, *Bucks*, *November* 18, 1847.

"I find an advantage of from *twelve* to *fifteen per cent.* in extract and quality; and my establishment is now worked with less labour and fuel than on the old principle, and with less expense for repairs."

VI.—*From Mr.* GEORGE BIGGS, *Patent Steam Brewery, Heavitree, near Exeter, June* 24, 1853.

"I willingly bear testimony to the excellence of your Steam Brewing Plant. Since using the MASHING ATTEMPERATOR my extracts have much increased, and invariably proved rich, sound, and transparent. Boiling by steam is very efficient and expeditious, and nothing can exceed the perfection and regularity of my fermentations. In fact, the whole process is unrivalled for efficiency, cleanliness, and economy."

VII.—*From Mr.* M. P. READE, *Patent Steam Brewery, New York, U. S., November* 17, 1852.

"I am now making very good ale which meets with universal approbation, and it affords me pleasure to state that your MASHING ATTEMPERATOR works to my *entire satisfaction*, and I consider it a valuable acquisition to any brewing establishment; and in connexion with boiling by steam *it is the most perfect system of producing malt liquors* that I have ever become acquainted with."

VIII.—*From Mr.* SAMUEL MATTHEWS, *of Plymouth, June* 12, 1846.

"Having had your MASHING MACHINE in operation for more than twelve months, I can no longer deny myself the pleasure of expressing to you my perfect satisfaction with its operations. It has quite reached the high expectations I had formed of it before subjecting it to the unerring test of practice. I am now able to produce an increased extract varying from *ten* to *fifteen per cent.*, and of much superior quality, flavour, and soundness, than I could obtain without its invaluable assistance."

IX.—*From Mr.* DAVID PAINE, *Navigation Patent Brewery, Derby, June* 21, 1853.

"I am satisfied that Steam boiling quite supersedes the old plan of boiling in metal coppers, and the MASHING ATTEMPERATOR has a decided advantage, not only in giving brilliancy to the worts, but in producing an article that will keep sound. The Self-acting Barm-skimmer is also a great advantage, saving much labour."

X.—*From Mr.* JOSEPH SUTCLIFFE, *Fency Bridge, Huddersfield, Yorkshire, July* 14, 1852.

"Your MASHING ATTEMPERATOR I have used about eighteen months, and would not like to be without it, and consider it to be the greatest improvement introduced into the Brewery; its use will, I have no doubt, become universal when its advantages are more fully known."

XI.—*From Mr.* HENRY COX, *Patent Steam Brewery, Maiden Newton, Dorset, June* 9, 1852.

"Having now had your Patent Steam Brewing Plant in operation for some time, I take much pleasure in informing you that it continues to give me entire satisfaction: I would add, the HOT MASHER has more than realized my expectation, not only in the amount of the additional extracts obtained, but also in its brilliancy, soundness, and flavour."

XII.—*From* T. M. BERRY *and* Co., *Ecclesall Brewery, Sheffield, Yorkshire, June* 9, 1852.

"Having now used your HOT MASHER for five months, we are decidedly of opinion we are benefited by it, and recommend it accordingly."

XIII.—*From Mr.* WILLIAM OKELL, *Patent Steam Brewery, Douglas, Isle of Man, May* 11, 1853.

"After a careful trial of your MASHING ATTEMPERATOR for several months, all my previous ideas of its merits have been more than realized. For purity, richness of flavour, and preservative properties, the worts are unequalled, and, what is of far greater importance, a skilful manipulator may by its means secure a constant uniform quality. I am also a strenuous advocate of the non-boiling system, first introduced by yourself; indeed, I have no hesitation in declaring that my unboiled ales have invariably given more satisfaction than those which I boiled for even a short period. It is my intention to give this plan a *summer* trial, as I feel confident of the result."

XIV.—*From Mr.* I. H. SMITH, *Patent Steam Brewery, Derby, June* 25, 1853.

"It is with great pleasure I now contribute my testimony in favour of your most valuable inventions, particularly the MASHING ATTEMPERATOR. I have used the latter machine in three establishments, of eight, twenty, and forty quarters respectively, and after carefully watching every operation, and comparing results with the old system, I am prepared to state its great superiority in producing quantity, quality, soundness, flavour, and uniformity in fermentation; and I am convinced, where your plans are skilfully carried out, they add considerably to the brewers' profit and peace of mind, and give greater satisfaction to his customers than any other method.

"I should most decidedly recommend steam boiling to those who study convenience, economy, and cleanliness."

XV.—*From Messrs.* HUGHES *and* BISHOP, *Liverpool*, *June* 10, 1852.

"We have great pleasure in testifying to the great efficiency of your Patent MASHING MACHINE, which we consider the greatest improvement which has ever been introduced into the Brewery: it does its work equally as well as the old-fashioned machine, and the benefits of the 'Attemperator' are beyond all conception. We get at least ten *per cent.* more extract, and of a very superior quality and flavour. The colour of our ales has much improved by your Steam-boiling apparatus; it is equally as efficient as a furnace, with the great advantage of extreme cleanliness, and also a great saving of time, as our worts are boiling before we get them all into the back."

IMPORTANT TO DISTILLERS AND OTHERS WHO USE RAW GRAIN.

XVI.—*From Mr.* J. P. OSBORNE, *Colchester*, *March* 18, 1850.

"I have been brewing with the new MASHING ATTEMPERATOR for some months, and I have much pleasure in bearing testimony to the excellence of the invention. I get a much larger extract from the goods than I did on the old principle, and of a purer and better quality. I could not have believed it possible that so great a difference could arise, had not unquestionable experience convinced me of the fact: indeed I feel quite satisfied that if the merits of the Attemperator were generally known, it could not fail to be universally adopted.

"In justice to the invention and process, it may be necessary for me to add that the worts flow as freely *from mixed grist as from malt alone;* and that *the service of the Hot Masher is not required after the mash is made;* and that the Sparger unceasingly, speedily, and effectually completes the operation."

XVII.—*From Mr.* JAMES FARREN, *Battersea Park Brewery*, *London*, *March* 4, 1848.

"Having had, for a considerable time, your MASHING ATTEMPERATOR in use, I fully concur in all that I have heard, or read, as to its merits; and I have great pleasure and much satisfaction in adding thereto my belief, that the produce is very superior to what was got by heretofore-known methods, more particularly as to its soundness and flavour, freedom from acidity, or vapidness; and the best proof in confirmation of my opinion is, that from a brewing of full-flavoured Ale, made the hottest day in August last, I had an eighteen-gallon cask on tap for three months, *the last drop of which was perfectly good and free from any imperfection.* Wishing you all the success your inventive genius, zeal for the good of the brewery, close observation, and application to business deserve—"

XVIII.—*From Mr.* R. J. BENTLEY, *Rotherham Old Brewery*, *Yorkshire*, *May* 3, 1850.

"After twelve months' trial of the PATENT MASHING ATTEMPERATOR, I feel no hesitation in saying that its use produces an increased extract. The worts run brighter from the Mash-tun, and, *cæteris paribus*, produce an ale possessing longer keeping properties than when not attemperated.

"I may also add, that the utensils supplied and work done by you for us seem of the best quality, and I consider your charges reasonable."

XIX.—*From Mr.* T. D. BROOKS, *Basingstoke*, *Hants* (formerly of the Stratford Brewery), *March* 22, 1850.

"Having conducted every brewing in this house for some years past, I am happy that I have it in my power to add my testimony to the great advantage derivable from the MASHING ATTEMPERATOR, in operation here upwards of three years, having obtained much greater extracts than in any previous year, with improved flavour, and the results in every respect most satisfactory."

XX.—*From Mr.* R. E. KNOWLING, *Devonport*, *Devon*, *February* 6, 1850.

"My trade, I am proud to say, has already outgrown my plant, and without wearing out the MASHING ATTEMPERATOR, which (with other portions of the plant) you erected six years ago; you will therefore make me another HOT MASHER, for a twelve-quarter tun, as soon as convenient. Your Steam Breweries are much more expeditiously and economically erected than others, are worked at considerably less expense *per* quarter, and produce the soundest ales in the country, particularly during the summer and autumn. I hope this order will be as convincing to the sceptical, if any exist, as it is gratifying to him who sends it."

New and Important Application!—To the Nobility and Gentry.

XXI.—*From Mr.* Joseph Wakefield, Sir John Reade's *Establishment, Shipton Court, Chipping Norton, Oxon, March* 27, 1850.

"After having thoroughly tried the little Steam-brewing plant you put up and started for us, I am happy to say that your machine is a capital *masher* and *warmer.* Not the smallest lump ever appears in the grains, and the mash is warmed from 138 to 164 degrees at the rate of one degree *per* minute. The worts are luscious and rich in the extreme, and the ale is very good, indeed generally all that can be desired, and we certainly make more and better beer from the malt than before. I also find boiling the worts by steam a cleanly and convenient mode; and your Catharine Refrigerator enables me to cool all the worts as fast as they can run away into the cellar, by which much time and wort is saved: in short, your whole apparatus is so simple and economical, that it cannot be too strongly recommended to *noblemen* and *all private families* who consume twenty quarters of malt yearly.

"I should also add, that I not only use my little Steam Engine and Boiler for Brewing, but for driving a circular saw, by which building materials, posts and rails, &c. for agricultural purposes, are cut out with precision, expedition, and economy."

XXII.—*From Mr.* Joseph Clissold, *Patent Brewery, Nailsworth, Gloucestershire, June* 12, 1852.

"In answer to your inquiry relative to my opinion of the Hot Masher, I feel pleasure in stating it to be every way favourable. I don't know that I can say more than that it fully realizes my expectations (which I may add were somewhat sanguine), and quite justifies the description you gave of it in your published work on Brewing."

XXIII.—*From Mr.* John Crowson, *Patent Steam Brewery, Oakham, Rutland.*

"Every Brewer who studies his business must welcome the Attemperator as a most valuable ally. I am convinced that every one who neglects to avail himself of the Patent Mashing Attemperator is blind to his own interest. My Brewery, fitted up with your Steam Apparatus, being now in full work, it affords me the greatest pleasure to bear testimony to the advantages accruing from it; indeed, the increase of trade since I have commenced in my own new Brewery sufficiently testifies the superiority of the article I am now sending out. I feel convinced, having had several eminent men in the profession to look over my plant, all of whom have expressed their delight and approval of the mode in which it is fitted up, that Tizard's Patent Mashing Attemperator, which gives from seven to twelve *per cent.* additional extract, must be used in all Breweries to enable one Brewer successfully to compete with another."

A second Machine of improved construction having been erected seven years afterwards, elicited the following gratifying letter:—

"*January* 13, 1853.

"We find your New Galvanized Vertical Mashing Attemperator a decided improvement upon the original one, being more simple in construction, more effective as a masher and heater; and, from the absence of all corrosion, far more durable. The Caloric Injector is an important and valuable auxiliary in the operation of the mash.

"Crowson and Co."

XXIV.—*From Mr.* Robert Hiscocks, *Birkenhead, Cheshire, May* 5, 1847.

"It gives me much pleasure to state that the Patent Mashing Attemperator has fully realized my most sanguine expectations; and I feel confident that it only requires to be generally known to be adopted to a very great extent in all large Breweries."

Mr. H.'s successors favoured the inventor with additional testimony as follows:—

XXV.—*From Messrs.* E. Cook, Brothers, *Patent Steam Brewery, Birkenhead, January* 8, 1853.

"We are quite satisfied with your Mashing Attemperator, which *we* have now been using upwards of five years, and feel certain it possesses great advantages in obtaining the extract from the malt."

XXVI.—*From Messrs.* Charrington Nicholl *and* Co., *Colchester, Essex, July* 17, 1852.

"We have had your Mashing Attemperator at work in our Brewery for about two years, and have no hesitation in saying that it is of very great service, and answers our purpose remarkably well."

XXVII.—*From Mr.* EDWARD GREEN, *Bury St. Edmund's, Suffolk, February* 20, 1850.

"I have much pleasure in speaking of the merits of the MASHING ATTEMPERATOR. I have now used it for nearly three years, and I consider it of essential service, both as regards extract and soundness."

XXVIII.—*From Messrs.* DAY, PAYNE, *and* CO., *Westerham, Kent, March* 23, 1850.

"We think the best evidence we can give of our good opinion of the MASHING ATTEMPERATOR is to state that, after using one regularly during twelve months at our Porter Brewery, in Bermondsey, London, we have given an order for a similar machine for our Ale Brewery at this place."

☞ The reader will please observe that the superiority of the Pale Ales emanating from the Steam Brewery of the above firm deservedly increased their sales with such rapidity, and to such an extent, that just two years and a half after the above was written, Mr. Tizard received their order to erect another Hot Masher of just double the size, and to be used in conjunction with the former; making *three* Machines used by the same firm, viz., one in their Porter Brewery, and two in their Bitter Ale Brewery.

No written Testimonial from the celebrated house of Day, Payne, and Co., can speak stronger than three such facts as these!

XXIX.—*From Mr.* JOHN SIMONDS (Executor), *Brewery, Basingstoke, Hants, March* 19, 1850.

"Your MASHING ATTEMPERATOR has been in use here upwards of three years to our entire satisfaction; and we consider it to be the greatest modern improvement introduced into the Brewery."

XXX.—*From Messrs.* J. W. *and* G. STEEVENS, *Brewers, Stowmarket, Suffolk, October* 5, 1847.

"We approve as strongly as ever of its principle, because it may be applied with considerable advantage. We doubt not many Brewers would consider it a great boon, inasmuch as they would improve their extracts from 10 to 20 *per cent.*"

XXXI.—*From Messrs.* I. M. *and* B. THORNE, *Nine Elms Brewery, Vauxhall, London.*

"It gives us pleasure to add to our former Testimonial, that we continue to use your MASHING ATTEMPERATOR with great advantage.

"By reducing to certainty the results of temperature, an advantage which every Brewer can appreciate, the effects of a complete conversion and concentration of the extract are most readily obtained, and that without the usual risks attending the old method.

"Increased production is, of course, the best recommendation; and we feel justified in stating that several pounds *per* quarter may be safely calculated upon.

"The Machine, which we have had in use several years, has required very trivial repairs, and, independent of the Attemperator, is a most efficient MASHER."

XXXII.—*From Messrs.* E. H. SOULBY *and* CO., *New Bolingbroke, Lincoln, June* 4, 1849.

"We beg to say, that having used the MASHING ATTEMPERATOR since the 1st of November, 1848, we have confidence in recommending it to any one in the Trade as a most efficient machine. We have by its means been enabled to obtain a considerably increased extract."

Two years afterwards the following notification was forwarded to Mr. Tizard from the same firm:—

"We are happy to say your ATTEMPERATOR continues to give us every satisfaction, and has not cost one penny in repairs during the two years we have had it in work.

"E. H. SOULBY and CO."

March 9, 1853.—A second MASHING ATTEMPERATOR has just been forwarded to the above gentlemen for their Ale Brewery at Coningsby.

XXXIII.—*From Messrs.* THOMAS *and* JOHN HUNT, *Brewers, Banbury, Oxon, January* 20, 1845.

"Having used Mr. TIZARD'S MASHING ATTEMPERATOR for some time, we can confidently recommend it to the brewing public as a much superior Mashing Machine to any we have before met with, as it enables the Brewer to regulate the temperature of the mash to any required degree, without the least danger of setting the malt, or otherwise injuring the mash;

and by this method the whole of the extract may be drawn off into a wort of 32 or 34 lbs. gravity, so that the Brewer is not obliged to make either Table Beer or a Return Wort; and the wort so obtained is more pure, and consequently less prone to acidity; besides which the extract is increased from *seven* to *ten per cent.* These are its advantages, and to the intelligent and practical Brewer we think they need no comment."

September 23, 1846.—" After more than two years' experience in the use of the MASHING ATTEMPERATOR, we entertain the same opinion we formerly expressed."

N.B. A second HOT MASHER has just been supplied to Messrs. Hunt.

XXXIV.—*From Messrs.* THOMAS *and* JAMES NASH, *Brewers, Chesham, Bucks, September* 3, 1846.

" As regards the MASHING ATTEMPERATOR, we have no hesitation in pronouncing it a valuable addition to the Brewery. We have been uniformly successful since it has been in operation the last two summers, in turning out a good article, and at the same time getting an increased extract."

*** Mr. Marsden, Managing Brewer to the Messrs. Nash, in a more recent letter says:— " The ATTEMPERATOR has great merits, as the Ale I have brewed with it has been uniformly good; and in the hands of a skilful operator it will prove a valuable auxiliary to any Brewery."

XXXV.—*From Mr.* W. NICHOLSON, *Maidenhead Brewery, Berkshire, March* 20, 1850.

" I am pleased to add my testimony to the well-known merits of the MASHING ATTEMPERATOR: I have now used it more than two years to my entire satisfaction; and I am aware of no plan capable of producing so large an extract in so condensed a form."

XXXVI.—*From Messrs.* BLADON *and* WOODCOCK, *Star Brewery, Old Brompton, London, February* 23, 1850.

" We have now had the MASHING ATTEMPERATOR in use for two years and a half, and have much pleasure in saying that we have found it most useful, in giving not only a much larger quantity, but, what is better, an extract far superior to the usual method. We may also add, that we have been much astonished to find it keep in such good repair, and at such a trifling expense as it has done, considering the heavy work it has to perform."

XXXVII.—*From Mr.* R. A. LEWIS, *Market Deeping, Lincoln.*

" Since I left the Star Brewery, London, where I used your MASHING ATTEMPERATOR from the day of its erection, I have placed a copper steam pipe on the bottom of my Mash-tun here, as a substitute for the Patent Masher, in order to avoid an outlay; the fixed coil of pipe has, however, totally failed, and experience has shown me that I cannot get so large an extract by at least 10 *per cent.*, neither so pure, so sound, and so brilliant an article by some shillings *per* barrel; you will therefore oblige me by sending one of your last improved Mashing Attemperators of the following dimensions . . . . by train, as soon as possible."

XXXVIII.—*From Mr.* H. N. BYLES, *Patent Steam Brewery, Gosport, Hants, June* 11, 1852.

" I have always approved of your MASHING ATTEMPERATOR, in theory, and am happy to say practice with it does not alter my opinion. The invention does you infinite credit, and I sincerely wish you the encouragement you deserve."

XXXIX.—*From Mr.* JOHN BAKER, *Manager of the Patent Steam Brewery, Starbeck, Harrogate, Yorkshire, June* 11, 1852.

" Numerous have been the means resorted to for accomplishing uniformity of heat during the whole time of steeping the grist. In no one instance have I ever seen this desired object attained, until using your ingenious and valuable MASHING ATTEMPERATOR. It certainly stands pre-eminent to every other mode of applying heat to the contents of a mash! All practical Brewers possessing a knowledge of its mashing and heating, and consequent *converting* powers, will adopt it, and recommend its use. It is just two years I have operated at Starbeck with your Hot Masher and Steam Plant, during which period I have given the whole process a studious examination, and am therefore enabled to record my decided opinion of its merits. The production is great, bright, and sound, and in every sense bears testimony of the existence of a superior kind of extract."

XL.—*From Mr.* ROBERT N. G. BAKER, *Patent Steam Brewery, Heavitree, Exeter, June* 22, 1853.

"I have much pleasure in bearing testimony to the merits of your Patent Steam Plant. The MASHING ATTEMPERATOR produces a much greater extract, and the worts are sounder, especially in the summer, than can be obtained under the old system. I also highly approve of steam boiling: it far surpasses boiling in a copper, both as regards brilliancy and flavour."

XLI.—*From Messrs.* J. A. DEVENISH *and* Co., *Weymouth, Dorset, June* 14, 1852.

"We could have wished a longer trial of your Hot Mashing Machine prior to our testimony being recorded, but up to the present time it has given us great satisfaction."

The following is still more conclusive :—

"*January* 31, 1853.

"After further experience, we feel pleasure in bearing testimony to the efficiency of your MASHING ATTEMPERATOR, more especially in brewing ales of 35 lb. gravity; we also find the store beer to our satisfaction, and we have not made a return wort since we have used your Hot Masher. J. A. DEVENISH and Co."

XLII.—*From Mr.* T. H. HAWKINS, *at the Nine Elms Brewery, London, June* 6, 1843.

"I have concluded an experimental examination of two equal portions of worts, one of which was brewed by means of your patent machinery, the other according to the usual process. The two specimens were reduced to the same gravity, and produced by evaporation equal weights of solid extract; the two extracts were then examined for sugar, and were found to contain it in very dissimilar quantities: 60 parts of the extract from the wort by your process gave $19\frac{8}{10}$ parts of sugar; the extract from the other wort afforded 10 parts in 60. This surprising increase of saccharine matter must be the result of maintaining the temperature of the mash at the most favourable degree, and for a sufficient length of time for the conversion of the whole of the starch into sugar, which is effected in an admirable manner by your arrangement of the ATTEMPERATOR, which allows of the mash being made with less water, the sugar formation being favoured by the more concentrated condition of the wort whilst in the goods."

XLIII.—*From Mr.* CHAS. WORKMAN, *Patent Steam Brewery, Dursley, June* 29, 1853.

"I have much pleasure in testifying to the high value of your MASHING ATTEMPERATOR, also of your Catharine Refrigerator; the latter enables me to cool my worts direct from the boiling back, consequently the worts are freed from the injurious effects to which they are subjected when obliged to remain in the coolers for several hours. Your little steam engine, as well as used for brewing, drives a Grist Mill and Chaff Machine, and I intend to apply it for other uses also. I have been in the trade twenty-four years, and during all my experience I never used or saw a plant so much to my satisfaction as the one you erected for me twelve months since."

Some of the foregoing Testimonials were published in the third series of the REPERTORY. The following additional ones have since been obtained, chiefly in reply to the mendacious assertion, made by itinerant vendors of a rival machine, that the MASHING ATTEMPERATOR is liable to discolour the worts.

XLIV.—*From Mr.* T. H. PAGDEN, *Hope Brewery, Epsom, October* 29, 1857.

"We have had your MASHING ATTEMPERATOR in constant use for the last seven years, and never have discovered any discoloration of the worts, but highly approve of the Patent Masher, both as regards extracts, and also imparting soundness to Beers."

XLV.—*From Mr.* JOSEPH CLISSOLD, *Patent Brewery, Nailsworth, Gloucestershire, November* 14, 1857.

"Having had Mr. TIZARD'S HOT MASHING APPARATUS in constant use for about six years, we can speak with confidence of its working, and feel much pleasure in speaking of it with unqualified praise. We have never found the slightest tendency to discolour the worts, but, on the contrary, have always brewed the very palest Ales with entire success."

XLVI.—*From Messrs.* W. B. EDWARDS *and* SON, *Patent Brewery, Stamford, Lincoln, October* 29, 1857.

"I have much pleasure in again bearing testimony to the great value of your Treatise on

Brewing, and also to that of your invention, the MASHING ATTEMPERATOR, which I have used several years. I have extracted worts by its agency as pale as any Burton Ale I ever saw.

"WM. EDWARDS."

XLVII.—*From Mr.* R. N. G. BAKER, *The Heavitree Brewery, Exeter, October* 27, 1857.

"Having worked your MASHING ATTEMPERATOR for four years, I have much pleasure in informing you that it does its work admirably, the worts being, in my opinion, much sounder, of a beautiful colour, and very brilliant, yielding also a much greater extract than I could obtain previous to using your valuable machine."

XLVIII.—*From Mr.* W. T. BELL, *Patent Steam Brewery, Cross-street, Oakham, November* 4, 1857.

"I have great pleasure in bearing testimony to the efficiency of your MASHING ATTEMPERATOR. As the most uniform circulator of heat. and most easily attempered, I consider it stands unrivalled, and from some years' experience I think it next to impossible it can impart any additional colour. If it has enemies, which useful inventions generally patent with themselves, I can only say I have always been fully satisfied, and you are quite at liberty to use my name as a reference to any party on the subject."

XLIX.—*From Messrs.* HUGHES *and* BISHOP, *Liverpool, November* 3, 1857.

"In reply to your inquiry respecting the MASHING ATTEMPERATOR, we beg to say that after six years' experience our opinion of its merits is such that we strongly recommend it to all our brethren in the trade. Our extracts for the whole time we have operated with it have been uniformly better in quality, and much larger in quantity, than they were previous to its adoption; the colour has never been injured in the least, and we do not hesitate to say that all who assert the contrary, must have some interest in other inventions, or a desire to injure you."

L.—*From Messrs.* QUICK *and* NORMAN, *Wheatsheaf Brewery, Southampton, November* 2, 1857.

"After using your MASHING ATTEMPERATOR constantly between two and three years, we have invariably found it, with proper management, and a knowledge of the business, a most desirable machine, and we feel ourselves highly satisfied with it. We cannot fancy any one discarding it after using it for a short time only; that must necessarily arise only from want of knowledge, or carelessness in the use of it. We have never found the worts the least discoloured from its use, and think the parties who fancy they have observed it must have mistaken the *desirable* clarifying effect it most certainly has on the mash for discoloration of it."

LI.—*From Mr.* DAVID PAINE, *Navigation Brewery, Derby, October* 27, 1857.

"With respect to the MASHING ATTEMPERATOR, the machine mashes beautifully, and such a thing as setting the goods, or balling, I never saw. In fact I have tried mashing liquor at 188°, with malt and liquor running at the same time, and even at that have had not the slightest appearance of 'balling.' I believe it is *possible* to add colour to the worts by the Attemperator if the steam is allowed to pass through the machine at *too great* a pressure, and with all its force; but with ordinary care this can be avoided, and the worts drawn off as pale and much brighter than where steam is not used. The same thing is to be said of the steam-coil for boiling the worts. If the steam is allowed to pass through the coil with full power, and when the boiler is at 30 or 40 lbs. pressure, it will raise the colour considerably; but if it is turned on very gently at first, and till about two-thirds of the whole is drawn, then this will not take place. The old 'finger thermometer' brewer has his prejudices against all new things, and is not fit to be trusted with a steam Brewery (nor any other, in fact). But it is a vast saving of labour. For instance, with my plant (8 qrs.) I will engage to crush the malt, heat the liquor, mash, boil the worts, turn over 28 barrels of common ale at 24 lbs., and 8 barrels of small beer at 6 lbs., and without the assistance of a *single* individual,—no, not even to stoke the fire. Just the cleaning down of backs, coolers, &c., is all the help I should require. Now, can you find me a master brewer who can do this with the old plant from 4 A.M. to 10 P.M?"

LII.—*From Mr.* WM. OKELL, *Patent Steam Brewery, Douglas, Isle of Man, November* 10, 1857.

"For five years I have been regularly using your MASHING ATTEMPERATOR, and I have come to the conclusion that no other discovery has ever conferred so great a benefit upon the practical man. From first to last it has been unerring in its action, doing quite as much, if not more, than you ever led any one to expect. Moreover, it has never yet required the slightest repairs."

LIII.—*From Mr.* JOHN BAKER, *Hall Street Brewery, Dudley, November* 2, 1857.

"After thirty years' practice, seven of them spent over your plant, in two different counties, I think I am entitled to give an opinion as to its merits or demerits. First, the arrangements of buildings are economical, useful, and ornamental; secondly, the fixed utensils are well arranged, combining comfort and convenience with business-like operations. I must not forget the MASHING ATTEMPERATOR, whose merits cannot be spoken too highly of. It is of the greatest possible utility, enabling the experienced operator to draw a greater length, with an improvement of colour and quality of the various ales, as letters addressed to me from London, Liverpool, Leicester, Leeds, York, Hexham, Newcastle-on-Tyne, and many other places sufficiently testify. I have always found the ales produced by means of the Attemperator considered of superior quality to any others ever presented to the public."

LIV.—*From Messrs.* JOHN *and* JAMES ARDEN, *Penketh Brewery, near Warrington, November* 17, 1857.

"After five years' constant use of your Patent MASHING ATTEMPERATOR, we have much pleasure in saying that it has given entire satisfaction. It preserves the colour of the worts, while it yields an abundant extract; and our trade being principally in Pale Ales, we have much pleasure in bearing testimony to its usefulness."

LV.—*From Mr.* CHARLES SHEPPARD, *Operative Brewer, Liverpool, November* 16, 1857.

"DEAR SIR,—Understanding that you are about to issue a new edition of the 'Brewers' Repertory,' and that several in this town have forwarded testimonials to be inserted therein, I cannot resist the temptation, although only an 'operative brewer,' of submitting to you my opinions of your several inventions. After twelve years' practice in the old blundering style, I commenced operations with your improved machinery in May, 1850, and have continued to work with it ever since. The HOT MASHER is a valuable invention, and ought to be in every Brewery in the kingdom. By its means from 5 to 15 *per cent.* more extract can be obtained than by any other known means, while the quality is far superior, and *the colour as pale as amber.* Its powers of concentration are such that if it is used properly, neither Table Beer nor return worts *can* be made, as nothing but water remains in the goods after drawing off the last worts.—The steam-boiling back you fitted up for us answered admirably. It is by far the most cleanly and economical method, and I cannot imagine how any brewer can continue to put up with the dirt and annoyance, besides wear and tear, of a common furnace, after having once seen one of your steam plants at work.

LVI.—*From Mr.* HENRY N. BYLES, *Gosport.*

"I most willingly bear testimony of my experience of your HOT MASHER, which performs its duties nobly as a masher, and in the use of which I have never detected any increase in the colour of the worts, though I have detected a very considerable increase in the amount of gravity *per* quarter over the old system."

LVII.—*From Mr.* CHARLES WORKMAN, *Patent Steam Brewery, Dursley, November* 3, 1857.

"After five years' experience with your Patent Steam Plant, I believe it to be the most efficacious yet invented, both as regards extract, and as regards ease. The MASHING ATTEMPERATOR will not colour the wort in the slightest degree. My Bitter Ales (with Pale Malt and Hops) are almost as pale as water. M. Wicking, Esq., of the Southwark Brewery, has tasted my Pale Ales, and, if you ask him, will give you his opinion respecting them."

LVIII. *From Mr.* HENRY COX, *Maiden Newton, December* 3, 1857.

"It is now nearly six years since you erected your Steam Brewing Plant for me. The MASHING ATTEMPERATOR has fully answered my expectations. It has not required any repairs, and imparts no colour to the worts, which leave the Mash-tun, both pale and brilliant."

LIX.—*From Messrs.* COLING, HIPWELL, *and* COLING, *Olney, Bucks, October* 28, 1857.

"As regards your MASHING ATTEMPERATOR, we can truly say that it gives us every satisfaction. We obtain large extracts, and full, fine-flavoured worts, which are always of a uniform colour, and quite bright."

LX.—*From Mr.* James Farren, *Salford Brewery, Manchester, November* 1, 1857.

"I have great satisfaction in testifying that I have used your Hot Masher for ten years, and have never found it to discolour the worts."

The inventor of the apparatus to which the above testimonials mainly refer has the gratification of adding extracts from two recent works edited by eminent scientific men.

Chemistry, as applied to the Arts and Manufactures, by Dr. Sheridan Muspratt, F.R.S.E., M.R.I.A. P. 253. 256 :—

"The usual method of mashing, by letting the water into the tun at an elevated temperature, and then the malt, or both simultaneously, so that by their admixture a medium temperature may be attained, does not answer all the requirements which are wanted, since the application and distribution of the heat is at the first glance partial and unequal; besides, it readily passes off by radiation and conduction, leaving the mash at such a temperature as cannot exert the desirable influence upon the conversion of starch into sugar. The only contrivance worthy of notice, which has been introduced for the purpose of obviating this disadvantage, is that patented by Mr. Tizard of London, and known as the Mashing Attemperator. This apparatus serves the double purpose of masher and attemperator at the same time, and there is no doubt that it is productive of the good effects which it professes to accomplish, since it can be so managed to preserve the heat at any temperature which may be deemed most suitable, and for an indefinite time, should it be required. The heating medium is completely under the control of the operator, and therefore he can urge or restrain it within certain limits, even to nicety.

"The influence of the attemperator, in communicating a temperature of 160° to 165° Fahr. to the goods during the mashing, is highly beneficial, inasmuch as the whole of the starch is saccharified, and most probably a portion of the mucilage which is formed during the malting. Hence its great advantage at once appears palpable; and, consequently, deserving of the Brewer's attention.

"Before leaving this subject, it may be stated as certain, that the change of the gum into saccharum is much less active than that of the starch, and hence it requires the proximity of the saccharifying agent in the malt, and the intervention of a continued heat at the proper pitch, before it is completed. From this circumstance arises the great value of Mr. Tizard's apparatus, as it maintains the contents of the mash-tun at the most efficient degree of heat throughout the mashing."

From the Encyclopædia Britannica, by Dr. Thomas Stewart Traill, F.R.S.E. P. 325—327. Eighth Edition :—

"Mr. Tizard has lately endeavoured to introduce a new plan of mashing, which seems to possess considerable advantages over that in common use. He mashes the malt in water at the temperature of 160°, no matter what the temperature of the malt may be, thoroughly stirring and mixing it; the water being in the proportion of 1¾ to 1⅞ barrel per quarter of malt. The tun is then covered for an hour and a half, to allow full time for every grain to be fully saturated. After this period, in order to raise the mash to that temperature which the researches of Payen and Persoz showed was best fitted for extracting the soluble matters, and allowing the diastase its full action in the conversion of the starch and dextrine into sugar, he heats the mash by means of steam to the temperature of from 160° to 170°. This he effects through the agency of what he calls his Mashing Attemperator, which he has patented. This machine is merely the fixed rakes and oars made of hollow tubing, which he sets in circular motion by means of the steam-engine, and throws steam into them. The heat thus communicated to the mash, through the hollow rakes and oars, raises the temperature from 130° or 140° to 160° or 170° in about twenty minutes, at which temperature he maintains the mash for four or six hours, according to the colour and quality of the malt, and the discretion of the brewer. Mr. Tizard holds that this plan possesses several advantages over that usually followed. It converts more effectually the whole starch and dextrine into sugar, allowing the diastase to exert its full chemical power. It extracts a larger proportion of saccharine matter from the malt. And by requiring a lesser quantity of water to exhaust the malt, saves waste in the subsequent processes by requiring no boiling. Viewed in a purely chemical light, we should say that Mr. Tizard's plan seems best adapted to attain the end in view.

"By Mr. Tizard's plan the diastase is left in contact with the starch and dextrine so long as to convert the whole into sugar; whereas if the diastase be drawn off with the first mash before it has had time to effect this change, the chemical powers of what is left in the mash are greatly weakened in the second mash by the running in of water at a temperature of 200°, which is known to destroy its chemical action."

"That Mr. Tizard's plan is the most scientific, and promises to yield the best results, can scarcely be questioned."

PART III.

DESCRIPTIVE LIST OF INVENTIONS AND DISCOVERIES IN THE MODERN MALTHOUSE, BREWERY, AND DISTILLERY, &c. &c., WITH SCALES OF CHARGES.

By W. L. TIZARD.

Offices, 12, Mark Lane, City.

[Designs, plans, estimates, drawings, and specifications, furnished free of charge, if followed by an adequate order.]

Mr. Tizard is the inventor and manufacturer of the Patent Economic Steam Brewery, an imperfect * model of which, containing his Patent Mashing Attemperator, was shown in Class 6 of the Exhibition of the Works of Industry of All Nations in Hyde Park, 1851, for which a prize medal was awarded by the Jury and associates of that class, amongst whom were—

General J. V. Poucelet, *Chairman*, France; Member of Institute, late Director of Polytechnic School, &c.
Luigi De Christophoris, Austria; Vice-President of Chamber of Commerce, Milan; Member of the Scientific Institute of Bologna.
Benjamin Fothergill, Manchester; Mechanical Engineer.
Guilherme Kopke, Portugal; Mechanical Engineer.
John Penn, Greenwich; Mechanical Engineer.
George Rennie, F.R.S., Whitehall Place; Mechanical Engineer.
Samuel Webber, United States; Civil Engineer.
A. Barclay, Brewery, Park Street, Southwark; Brewer.
Robert Davison, 33, Mark Lane; Civil Engineer.
A. Payen, France; Member of the Institute.
Dr. Varentrapp, Zollverein; Professor of Chemistry.

Mr. T. also constructs and supplies the following articles: —

I. Steam Engines of superb workmanship, and of the very best materials. Prices from 10*l.* to 25*l.* *per* horse power.

☞ Tizard's improved Steam Engine occupies less room, is lighter and more portable, and, in proportion to the capacity of its cylinder, is more powerful,—simpler, and consequently *cheaper*, than any other Engine ever introduced. It is entirely disencumbered of the appendages which incommode, more or less, the Table, Beam, Horizontal, and other Engines; viz. Connecting Rods, Side Rods, Gabs, and other Levers, Guides, Columns, Entablature; Cross, Transverse, and Spring Beams; Counterbalance, Air Pump, Cold Well, Condenser, with its complex Valves, Injection Cocks, and other apparatus; Parallel Motion, with its Radius Bars, Links, &c. &c., Cross Heads and Tails, Masonry; or the like of any of them. Consequently this Engine requires less lubrication; and not being so complicated as others, is more easily managed; demands less thought and knowledge on the part of the engine-driver or stoker; and can never be subject to side strains and shocks; while the friction being less, the wear and repair are very much diminished accordingly.

II. Steam Boilers, Furnace-work, Smoke-consumers, Safety-valves, Mercurial and other Steam-Pressure Gauges, Water Gauges, Floats for Steam Boilers, cylindrical or tubular iron and copper Piping of all dimensions; Bends, Flanges, &c.

III. Self-acting Alarum Steam Whistle. Verdicts on Coroners' Inquests have long shown, and scientific men now prove, that explosions of Steam Boilers, and the catastrophic events thence arising, are commonly caused through inattention on the part of the stoker or engine-driver, as regards a deficiency or excess of water, and, consequently, the undue and often unexpected accumulation of steam on the one hand, or, on the other, the burning and cracking of the bottoms and sides of boilers. From these and similar causes accidents continue to arise that may be prevented by the use of this Alarum, which may be placed out of the stoker's control, and can be set to whistle in any given key or intensity of shrillness, loud enough to be heard at a distance of some hundreds of yards, the moment the boiler needs a supply of water, or has an over-sufficiency of it. Price, from 5*l.* to 10*l.*

IV. Patent (Tizard's) Malting Apparatus, whereby, besides making the most perfect

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* Arising from limitation of space and time for erection.

article, and drying the malt from the palest possible shade to any colour, and economizing labour and room at least 500 per cent., the whole of the processes, including steeping, turning, sprinkling, drying, and sweating the grain, are conducted and completed in one close vessel, which may be locked up by the officers of Inland Revenue * immediately after the introduction of the barley, and not opened again until the operation is complete! when self-acting machinery empties the cylinders, sweeps them out, screens the malt, if desired, and conveys it away to the stores.

The mechanical operations of turning, sprinkling, conveying, and sweeping can be applied to the floors of ordinary malt-houses: economizing labour, and doing that perfectly, which has hitherto been a desideratum only, viz. turning without bruising the corn, and so applying the sprinkling water, that each individual grain shall get neither more nor less than its share.

The Patent Malting Apparatus is thus described by Dr. Sheridan Muspratt, p. 241, 242, in his new work on Chemistry, as relating to the Arts and Manufactures, thus:—

"In concluding the account of Malting, the Editor cannot refrain from making a comparison between the present system and the ingenious and excellent one lately patented by Mr. W. L. Tizard, the eminent mechanical and consulting engineer of London.

"It is well known that an ordinary malting establishment consists of an extensive range of buildings, containing a cistern, a couch, extensive floors, and the kiln. Mr. Tizard's newly-invented malting apparatus consists of a vertical cylinder, containing a series of wire trays, provided with sprinkling and turning apparatus and steam pipes, vacuum and plunge pumps, vacuum and pressure gauges, thermometer, *et cetera*, and worked throughout the whole year with 75 per cent. less labour and 50 per cent. less fuel than the old one. Experienced men admit, that of late the harvests have been so unpropitious, that the farmer is unable to secure his barley crop sufficiently dry for the purpose of the maltster, and the latter asserts that it is necessary to dry or sweat the grain artificially on a kiln, previous to its saturation with water in the cistern. The process of sweating is, however, neglected, on account of the great trouble it gives, or from there not being an extra kiln provided for the purpose. Hence the malting is commenced in a slovenly and imperfect manner. The temperature of the steeping liquor, and the number of hours allowed for the saturation of the grain, are also disregarded as matters of routine, notwithstanding that they are points of very great importance as affecting its manufacture into malt. With the new apparatus, the process is commenced and finished in one vessel, which is a cylinder, occupying but one-twentieth the area of a malt-house. The barley gravitates from the stores above into each tray; after which the door is screwed up, and the cylinder made air-tight. The conversion of the grain into malt commences thus:—A current of steam is passed through a series of tubes lying under the bottom of each tray, which imparts its caloric to the grain, by which all superfluous moisture and atmospheric air escape from each corn in the form of vapour. When the contents of the cylinder are heated to the temperature of about 100° Fahr., the vacuum pumps are put in motion, by which such vapour is extracted, and a partial vacuum created. The atmospheric pressure being thus removed, and the dilatation of the grain effected, a vacuity necessarily exists in the pores and interstices of each corn. In this favourable condition it imbibes steeping liquor at a temperature of 53°. Thus the steeping is accelerated, and a perfect saturation produced. The grain is now allowed to germinate; but throughout this interesting process, the laws of nature are subject to the controlling hand of science, which has here brought to its aid all the mechanical means necessary to achieve the great object of the maltster, namely, that of thoroughly exposing and making available the whole farina of the corn, without which the article would be imperfect. This is effected and kept within the range of proper temperatures by a steady sprinkling and evaporation of cold water, accompanied by the constantly evolving carbonic acid, which are together removed by the vacuum pumps. On the other hand, its temperature might be increased, and the process accelerated, by occasionally applying the plunge pumps, which subjects the manufacture to atmospheric pressure. The great revenue arising from the malt duty will, to a moral certainty, render this invention as acceptable to Her Majesty's Commissioners of Excise, and the Chancellor of the Exchequer, as to the honest maltster; inasmuch as it admits of being locked up, like a rectifier's still, as soon as the barley is introduced, and need not be opened till the manufacture is complete, and the malt ready to be removed to the stores; so that the whole process is proof against fraud, and the daily supervision of the officers of Excise could be dispensed with.

"Space will not admit of a disquisition on the comparative merits of the old and new processes of couching, flooring, sprinkling, germinating, turning, heaping, and withering, but a brief description of the curing or finishing process, termed *drying*, cannot be dispensed with. This can be accomplished without the painful experience of having destroyed the vitality of the grain by the barbarous shovel, or the soles of the feet; by excessive light; cold or hot currents, or other incidental causes. Presuming, then, that the new apparatus has supplied the necessary moisture and atmospheric air, and abstracted all superfluous caloric, and the carbonic acid gas generated by the germination of the grain, which it cannot fail to do to perfection, the drying is performed as follows:—Steam is passed through the pipes, speedily

* It is presumed that the practice of government officials at present existing in distilleries will not be objected to by the maltster, inasmuch as facilities are afforded for withdrawal and examination of samples during any part of the process, which can be accelerated, retarded, and controlled at the will of the operator through the various means provided.

raising the temperature of the contents of the cylinder to 90° or 100°. The vacuum pumps are also put in requisition, which immediately extract the steam as it flows out of the grain, preserving a partial vacuum on its exterior, during the withdrawal of the whole of the moisture. The malt is thus thoroughly dried in a distended form, and its original plumpness is preserved. It is acknowledged that the palest malt produces the largest amount of extract, and that it cannot be too pale if properly desiccated. The apparatus thus briefly alluded to has been designed by a practical maltster and brewer, with the view of advancing one of the most important of our national manufactures, and one which is most susceptible of improvement, the common malting processes being rude and unsatisfactory in the extreme. Here is a complete set of apparatus to enable an intelligent operator to control the various processes of sweating, steeping, and converting the farina of his corn into sugar, and of desiccating it to perfection, without imparting the least possible colour or contraction of the grain. Indeed, malting is now reduced to a science, and cannot fail to meet with the support of the Government, and the most intelligent of the malting and brewing communities. For the pale ale brewer, this invention ought certainly to be invaluable, and the Editor would strongly recommend the leading firms at Burton and elsewhere to introduce the apparatus into their establishments."

Mr. Tizard begs to tender his warmest thanks to Dr. Muspratt, and takes this opportunity of informing Maltsters and Brewers that as the most valuable part of the above invention, viz., that of drying in partial *vacuo*, is applicable to existing malt-houses, he intends (at present) only to supersede the old drying *kiln*, by introducing the patent vacuum cylinder, and by which he will guarantee that the grain shall be expeditiously and thoroughly dried without contraction or acquisition of colour, and the malt very considerably improved in flavour and productiveness.

For estimates, &c. &c., address Mr. Tizard, at his Engineering Offices, 12, Mark Lane, City.

V. Patent (Tizard's) Vertical and Conical Thrashing Machine, with or without Beaters in the Drum Cover.

The principles of this novel invention are briefly as follows:—The upper end of the conical drum being but one-half the diameter of its base, it follows that the periphery of the lower travels at double the speed of the upper portion, while the revolving beaters or thrashers maintain a speed fluctuating between the two; for example:—taking the cone at 2 feet one end and 4 feet the other, if the drum-shaft revolves 1000 times per minute, which it should, the small end of the drum will travel about 6000 feet per minute, its other end 12,000 feet, and its middle 9000 feet.

Thus, the velocity and scutching power of the drum gradually increases with the emptiness of the ears of corn, and the difficulty of dislodging the whole of the grain; while the receding and whipping action of the beaters maintains their efficiency, although never offering a rigid resistance to the grain.

The immediate consequences are rapidity of production, economy of power, clean threshing, and no cut, bruised, split or otherwise broken corns; all of them points of the greatest importance to the farmer, the maltster, and the brewer, particularly the latter *.

VI. Revolving Barley Screens, of the merits of which the following testimonial from a large Maltster and Brewer bears witness:—

"*Baldock*, *January* 10, 1851.

"I am perfectly satisfied with the machine, and consider there ought to be one used in *every* malting in the United Kingdom. I am, &c.,

"John Steed.

"Mr. W. L. Tizard."

VII. Improvements in Distillation (Tizard's Patent). The pressure is reduced on the surface of the wash, low wines, or spirits, to be distilled or rectified, by suitable means; so that a lower temperature suffices for vapourizing the alcohol, whereby ensues a purer spirit with fewer rectifications, and economy of time, fuel, labour, and condensing liquor.

VIII. Improvements in Vinegar-making (Tizard's Patent). These consist of the introduction, under pressure, of thin films or streams of heated atmospheric air or oxygen into the body of the wort or wash in an acidifying vessel or vat, so that the whole of the fluid is being continually brought into contact with fresh particles of the decomposing gases, considerably expediting the process, which being carried on in a close vessel no loss of the strongest and most volatile portion of the acid occurs, and the usual waste of from 15 to 20 per cent. is avoided.

IX. Mitre, Bevel, Spur, and Screw Wheels and Pinions, Strap Pulleys, Turned Shafting, Plumber Blocks, Clutches, and Levers, and every other description of Machinery, all of the best materials and workmanship, and at moderate prices.

X. Shafting and general Gear, with Self-lubricating Bearings, &c.

XI. Improved Catharine Refrigerators for Cooling Worts. Price, from *30l.* upwards.

Necessary Qualities of a Refrigerator.

1. The material of which it is made must be durable and a good conductor of heat.

2. It should be composed of as few and as tasteless metals as possible, every part being tinned on all sides to prevent contagion.

* See ch. iii. of "Theory and Practice of Brewing Illustrated."

3. It should be so constructed as to facilitate the radiation and absorption of caloric, by exposing the greatest possible surface of wort to the cooling medium, in the smallest compass.

4. Its wort and water channels should permit none but an equable and uniform circulation of the passing fluids.

5. Easy access to the wort and water chambers, for the purposes of examination and cleansing, are most desirable.

Notwithstanding the above obvious requisites, no machine has heretofore appeared in the market really possessing them, especially the fourth and fifth, in any degree approaching to perfection. Mr. Tizard has paid very considerable attention to this difficult subject, and has had the experience of working almost every species of Refrigerator in existence, none of which have been constructed *with either a due regard to the laws that regulate the motions of fluids, or sufficient facilities for cleansing all their parts.* Most of them may be kept tolerably clean exteriorly, and the wort passages in some may be cleaned without much labour, yet the water compartments are invariably soldered up, or so closed in some way as to require considerable expense and delay in their necessary purification, independently of the rapid destruction of the instrument which ensues on the accumulation of petrific particles in the interior, gradually encrusting the joints till their removal cannot be effected without violence and consequent injury to the metal of the instrument; whereas, if the channels could be kept open and duly washed, as in the case of the Improved Catharine Refrigerator now introduced, the damage would be avoided, and the expense of the coppersmith averted.

Mr. T. has enlarged upon this subject in his Brewing Treatise, and on the absurdity of decreasing the efficiency of the apparatus by suffering the allodgments of filth to counteract the cooling powers, by stopping up such of the cavities as thereby, or through corrosion, are successively rendered useless.

His new invention is inwardly composed of a series of separated or portable corrugated plates, with open channels, alternately placed in each of its two doors or covers. Its peculiarity in construction and chief merit consist in the wort and water passages being both open, and so contrived, that cold cannot produce stagnancy by gravitation, nor a hotter stratum exist to travel at an undue speed. No pipes, flat or erect channels, deposits of sediment, or stagnant fluids, exist to intercept or retard any portion of either the wort or water currents, which move with equal and undeviating rapidity throughout their whole course, and this peculiar facility of gradation of temperature ensures that the heat of the egress wort shall not, if required, exceed that of the ingress water. The area which it occupies is remarkably small, the quantity of water required less than in any other Refrigerator, and its power is so considerable, even when the operation is commenced at 210°, that the usual cooler room may safely be reduced one-half, so that besides the great saving in the outlay for these backs, the waste of wort adhering to them is proportionately diminished, and the great injury done to the fluid by long exposure to the atmosphere, in cooling down to a proper fermenting temperature, is avoided. Add to this the convenience with which every inch of its interior may be cleaned or inspected as often as desired, so that any appearance of dirt or crust may be removed before it can trespass to any formidable extent, which is an important consideration. It may be placed between the coolers and fermenting vessels, or occupy any convenient position *beneath either.* The corrugated plates are not fixed, but merely placed one over the other, and can all be taken out to clean, if desired, and may be replaced by a child; or they may be cleaned on both sides, without being taken out of the case in which they are fitted. The Improved Catharine Refrigerator is thus the simplest and most powerful cooler yet invented. Neither pipes, nor crooked or closed channels exist in it; consequently, soldered, riveted, or screwed joints are wholly dispensed with.

The Refrigerator may be had *on trial.* Great numbers are already ordered.

XII. Jacob Ladders, Creepers, or Archimedian Screws, and Hoisting Tackle, for raising and conveying Grain; also Hose and Driving Belts of Leather, India Rubber, and Gutta Percha, &c., or a compound of the two latter. Cranes, and all kinds of Millwrights' work.

XIII. Plunge, Force, Rotary, and Lifting Pumps, for hot or cold Liquor, giving facility of access to the Valves; made to work by Steam or by Hand, alternately or otherwise. Sold singly or in sets.

XIV. Perforated and Slotted Hop and Mashtun Bottoms, either of Copper or of enamelled, galvanized, or adamant Iron, woven Wire, &c.

XV. Safety Friction Malt Rolls, with Springs or Toggle Levers. These crush Malt evenly, and permit one of the Rolls to recede upon the intrusion of pebbles, nails, and other casual hard substances which would otherwise either indent or break the mill or roll, or cause damage to the driving gear. Price, from 16*l.*

XVI. Revolving and Self-acting, or Stationary Spargers, from 5*l.* upwards.

XVII. Grain Traps, which admit of the removal of the exhausted contents from the Mash-tun with one-fourth of the usual manual labour, and in a fourth of the time, and which obviate the necessity of throwing out the grains over the side of the tun. Grains will never sour a Mash-tun fitted up with a simple trap and duly used. Price, about 4*l.* They are also applicable to elevated Malting Cisterns.

XVIII. Copper Worms and Coils, for boiling worts and liquor in wooden and other vessels by means of Steam. Price, from 6*l.* upwards.

XIX. Copper Pans with Iron Steam-jackets, also for boiling worts, &c.

XX. Blowing-off Apparatus, for purifying Casks with Steam and Water, from 20*s.* to 30*s.* each.

XXI. Tinned Copper Attemperators, portable or not, for regulating the heat of the Gyle in Fermenting Vessels. Price, from 3*l.* upwards. Made also to float or sink like fish, at the will of the person using them.

XXII. Patented Slate Fermenting Squares, which are non-absorbents, good conductors of heat, never perish or leak, or impart bad flavour, and are easily cleaned with cold water. Price, from 15*s.* to 20*s.* *per* barrel.

XXIII. Self-acting Barm-skimmers, which admit of being adjusted and fixed by a screw, according to the depth of the fermenting wort, take off all superfluous yeast by day and night, without manual labour, and the yeast so abstracted contains much less beer than by any other mode of skimming yet discovered. Price, from 3*l.* to 5*l.*

XXIV. Double or Attemperating Barm-skimmers are now made by their inventor with regulating screws. This is a novel and invaluable instrument, answering the purposes of the ordinary Attemperator or Single Barm-skimmer. Hundreds are sold yearly. Price, from 10*l.* 10*s.*

XXV. Hot and Cold Liquor Backs, Mash-tuns, Boiling Backs, Coolers, Squares, Rounds, Vats, Stillions, and Casks, of various materials, of the best kinds, supplied at reasonable charges without delay.

XXVI. Manhole Doors for Vats, perfectly air-tight, constructed to prevent the danger arising from an accumulation of carbonic acid gas. Price, from 2*l.* to 5*l.*

XXVII. Improved Patent Cocks, in which the old leaky plug is discarded, and a screw valve of a new construction is substituted, that never leaks, sets, or goes out of order. Prices, about the same as gun-metal cocks.

XXVIII. Floating Rackers, by which the finest beer is drained off Settling Backs without disturbing the bottom. The same object is also accomplished in deep Vats by a series of tinned copper rings, invented and made solely by Mr. T., and sold in sets varying from 15*s.* to 2*l.*

XXIX. Correct Thermometers. Price, from 10*s.* to 20*s.* each. Also, improved Mashtun, Malthouse, and other Thermometers.

XXX. Pontoons, Parachutes, Syphons, and various self acting Filling Apparatus.

XXXI. Pocket Saccharometers, capable of correctly proving the density of any glass of drawn malt-liquor, 2*l.* to 3*l.* Also extra strong and large Saccharometers, for weighing hot worts, and other practical purposes. Price 3*l.* 3*s.* each. Hygrometers 16*s.* each.

XXXII. Dipping Rods and Floats, Ullage and other Rules, Self-acting Vent-plugs, &c.

XXXIII. Engineering, Architectural, Surveying, Levelling, and Valuing Apparatus of the most modern and improved constructions, with directions for their application.

XXXIV. Field's Patent Alcoholmeters, for showing the amount of Alcohol generated in worts by attenuation, as well as their gravity prior to fermentation, thereby testing the value of a malt beverage according to its contents. This instrument also proves the condition and worth of stock in stores, and compares sugar-brewed beers with those that are extracted purely from malt. It is supplied with a glass saccharometer, a slide rule, and a testing glass, with full instructions for use. To the Alcoholmeter is appended an Acetometer, for testing the amount of acid (however small) in old or stale beer, and all fermented liquids, by which means the quantity of spirit and consequent saccharine lost by the acetous fermentation is ascertained.

XXXV. Slate Rounds, and Circular Vats of Slate, of any dimensions, from ten to two thousand Barrels.

XXXVI. Malt Kilns, constructed so as to dry pale and properly, of wire and other material that will not choke up or cut the Shovel. Floors of Asphalt and Portland Cement. Drawings, Material, and Workmen sent to any part of the world.

XXXVII. Attemperators, for Store Vats, Pontoons, &c.

XXXVIII. Fans, for cooling worts where the supply of cold water is limited, or the temperature not sufficiently low, and which may at the same time be made to ventilate stores and cellars.

XXXIX. Brewer's Journal, on the most Approved Plan. Each Volume contains headings for three hundred Brewings, enabling the practical man to record in a lucid and perspicuous manner the various processes, from heating the Mashing Liquor to storing the Beer. Price 10*s.* 6*d.*

XL. Mr. Tizard also supplies, and is sole agent for, SHEPPARD'S CHEMICAL CLEANSING LIQUID, for effectually decolourizing, and rendering fit for immediato use, brewers', distillers', and other Casks, whether old or new. By means of this Liquid, a Wine, Rum, or Brandy Cask can be so completely cured in *less than one hour*, that it may be immediately filled with Gin, Whisky, or other liquid, without the slightest fear of taint or colour being acquired, even if kept for years. The cost of cleansing does not exceed one penny per cask. The Liquid is supplied, at 5*s*. per gallon, in jars, of two or more gallons each; or the recipe for manufacturing the Liquid will be communicated for a moderate sum. The following are a few testimonials from persons who have used the Cleansing Liquid:—

"*Liverpool, November* 24, 1857.

"DEAR SIR,—Your Cleansing Fluid saves both time, trouble, and expense, and is truly valuable. I have much pleasure in recording my opinion of its merits, and wish you every success. No matter what colour a Rum or Wine cask may be, half an hour is sufficient to render it fit for Gin or Whisky, and, although kept in for months, it is perfectly free from taint or colour.—Yours, &c.,

"JOHN BISHOP, Wine and Spirit Merchant."

"*Llangollen, November* 24, 1857.

"DEAR SIR,—In reply to your inquiry I beg to say that I find your Cleansing Fluid of great value; during the last summer I tried it on hundreds of new Ale barrels with complete success. It is equally efficacious in curing and decolourizing Wine and Spirit casks, one hour or less being quite sufficient time to render a Rum or Wine cask fit for Gin or Whisky.

"With many thanks for your valuable recipe, I am, yours, &c.,

"WALTER BOOTH, Brewer and Spirit Merchant."

"*Shelton, November* 24, 1857.

"DEAR SIR,—I have used your Cleansing Fluid on several occasions with great success, both on Rum and Wine casks, and, although immediately filled with Gin, Whisky, and other Spirits, I have not detected the least taint of colour or flavour; I havo also tried it in my Brewery on new Ale barrels, and with the same result.—I am, yours, &c.,

"ARTHUR PETERS, Brewer and Spirit Merchant."

"*Dudley, November* 24, 1857.

"DEAR SIR,—I have every confidence in recommending your Cleansing Fluid to the large body of tradesmen to whom it will prove useful, viz., Brewers, Coopers, Spirit Merchants, &c. &c. I have tried it on many occasions, and can vouch for the correctness of your representations as to its value: I have tried it on both new and old casks without a single failure.—I am, yours, &c.,

"WILLIAM SHEPPARD, Wine and Spirit Merchant."

"*North John Street, Liverpool, November* 14, 1857.

"DEAR SIR,—I tried your solution on some small spirit casks during an alteration last summer, and can fully bear out the truth of your assertion as to its capabilities of neutralizing any colour, and entirely purifying any cask it may come in contact with, and that in a few minutes. I shall have great pleasure in recommending it to all my friends.—Yours, &c.,

"W. PARSONAGE, Spirit Merchant."

"*Llangollen, November* 24, 1857.

"MY DEAR SIR.—The receipt you gave me many years ago, for seasoning casks, I have tried in all parts of the country with astonishing results, and it has often surprised me that you did not bring it before the public.

"I wish you the success your meritorious discovery deserves.—Yours truly,

"F. PETERS."

"114, *Warwick Street, Liverpool, November* 24, 1857.

"MY DEAR SIR,—You ask me for my opinion, 'in writing,' of the merits or demerits of the receipt I purchased from you many years ago for seasoning casks. During all my experience both in the Brewing and Wine and Spirit trades I candidly admit I have never met with any thing like it; its operation is almost magical, and the trouble and expense is comparatively nothing. No matter whether it be a Rum, Brandy, or Wine cask, in a few minutes all traces of taste and colour completely vanish, and it may *immediately* be filled with any other kind of liquid without the slightest fear. With new casks it is equally valuable. During the seven years I was in Messrs. Hughes and Bishop's employ, I have repeatedly tried it on new Ale barrels, and should there be a green sappy stave, the liquid goes *completely through it*, and renders it sweet and fit for use. I can recommend it with perfect confidence to all who use casks, and shall be glad to answer any inquiry, either personally or by letter.

"Wishing you every success in bringing it before the public, I am, yours truly,

"JNO. MARSHALL."

This CLEANSING LIQUID has an important property additional to the one to which it owes its name. It renders timber both *fire* and *water* proof. Nothing can ever afterwards penetrate a barrel which has been operated upon by it, and it is thus capable of rendering Quebec or white American timber as valuable for the brewer's use as Dantzic, the saving thereby effected being enormous. A barrel to which the Liquid has been applied both outside and inside will set the rot at defiance.

XLI. ROBERTS'S PATENT CASKS, with staves and ends of uniform thickness. Mr. Tizard is sole agent for these casks, which are the invention of Mr. T. H. Roberts, of Plymouth. The invention had its origin in his experience, during many years' practice in a brewery, of the inconvenience and delay attending the use of casks manufactured by the usual method, in consequence of the wood, during the ordinary process of firing, becoming either smoky, blistered, or burnt. Mr. Roberts has directed his attention to the cure of these evils, and flatters himself that he has successfully overcome them. He causes his casks, in the process of manufacture, to be uniformly heated, without coming in contact with either smoke or flame, and they are thus made fit for immediate use. Moreover, the head of his patent cask is made of the full thickness throughout, and is fitted into the staves by a circular dovetail, instead of a groove, as in the ordinary method, thus supporting the chimes of the cask, and preventing it from splitting, breaking, or leakage. The head also being perfectly fair or flush on the inside, the Gauging Rod gives the *exact* measurement of the cask, in every case. Prices are: per barrel, 1*l.*; per kilderkin, 13*s.*; per firkin, 7*s.* 6*d.* Mr. Tizard is also sole agent for—

XLII. ROBERTS'S MACHINE FOR CLEANING THE INSIDES AND THE OUTSIDES OF CASKS. By means of this machine, from 18 to 20 puncheons per hour can be readily and efficiently cleaned, without the trouble and expense of unheading the casks. The machine is durable and very simple in its construction. It will take any cask, from a butt to a firkin, without requiring any alteration, causing the cask to revolve rapidly, either on its bilge, or end-over-end, and thus cleaning every part. Price, without fixing or driving belts, from 25*l.* to 30*l.*

XLIII. Unsightly and unpleasant Beer generally arises from one or more of the undermentioned causes:—

1st. Indifferently matured, or otherwise inferior or badly proportioned materials.
2nd. Improper mashing heats and wrong processes in the mash-tun.
3rd. Overboiling.
4th. Ungenial fermentations.
5th. Ill-managed cleansing.
6th. Bad stores, or mistreatment in better.

Thus cloudy, sour, grey, or ropy beer is produced, any of which defects are remedied by Mr. T., who provides means to prevent the occurrence or repetition of them, entailing as they do the loss of capital, character, and business, upon any Trader who is unfortunate enough to be subject to their unpleasantness, and not sufficiently alert to adopt prompt and efficacious measures to ward off their insidiousness and its consequences.

XLIV. The natural element most important to the brewer is water. It is also the one whose quality, owing to combination with foreign matters, is subject to most variety. For instance, water which runs off moors, besides containing vast quantities of other matter, both organic and inorganic, highly injurious to the brewer's materials, and to the strength and wholesomeness of his beer, is so saturated with the tannin of peat as to entirely neutralize the essential oils both of malt and hops; while water obtained from wells contains less organic matter, but is apt to be surcharged with salts and oxides eminently prejudicial to the successful exercise of the brewer's art. Mr. Tizard begs to announce that he is prepared to analyse every description of impure water, and to supply instructions for the application of the proper correctives.

XLV. PALE ALE. This much-admired beverage might be brewed by most brewers. Mr. Tizard gives practical instructions for the production of an article superior to any thing of the kind extant, at from 10 to 15 per cent. more than the ordinary profits. His fee is moderate, and is not required to be paid (expenses excepted) until after a month's trial, and full approbation, of the ales brewed under his instructions.

XLVI. Mr. Tizard also supplies instructions for the CONVERSION OF ORDINARY BARM INTO GERMAN YEAST. The fee is one guinea.

PART IV.

TESTIMONIALS

Of practical men respecting the character of Mr. Tizard's Publications, especially the larger, alphabetically arranged.

I. ANDOVER, Hants.—" I have very great pleasure in enclosing a Post-office order for 25*s.*, the amount of your valuable Treatise, which I have read with much interest and delight. It is full of useful information, and I most sincerely hope all your plans may be fully accomplished. JOHN POORE."

II. ARDWICK, Manchester.—" Enclosed you will find a Post-office order for the amount of your valuable Treatise on Brewing, &c., which I have read with great satisfaction, and I hope all your plans may succeed. JAMES YOUIL."

III. ASHFORD, Kent.—" I have been much pleased with the perusal of your work, the ' Theory and Practice of Brewing,' and think it well worth the attention of all that have to do with Brewing. THOMAS ELLIOTT."

IV. ASTON CLINTON, Herts.—" I have no hesitation in saying that your Treatise on Brewing is decidedly the best written work on the subject that I ever had the good fortune to peruse.

" So convinced am I of its merits as an Instructor, that I have not one friend in the trade to whom I have not recommended it. JOHN SHEERMAN."

V. AUCKLAND (WEST), Durham.—" My opinion with respect to your publication is, that it is a very useful book, and treats of subjects that would not have been known in this part of the country. HENRY HENDERSON."

VI. BATH. (Batheaston Brewery.)—" I approve of your Treatise on Brewing very much, and I only wish I had the local means to adopt *the whole* of your improvements, and particularly the MASHING ATTEMPERATOR. J. NEATE."

VII. BIRMINGHAM, Warwick. (Ashted Brewery.)—" I have finished perusing your valuable Treatise on Brewing, which I have read with much pleasure; and, Sir, I am happy to acknowledge that I consider it a very accomplished work, and one from which I have gleaned some very useful information. I wish you every success, which I am sure your Treatise merits.

" JOHN R. MARRIAN."

VIII. BRISTOL.—" I consider yours an excellent work on the *Theory and Practice* of Brewing, and am of opinion that those who adopt your system will be much benefited by it.

" R. FLEAY."

IX. CAIN'S CROSS, Gloucester.—" I regard your work on 'The Theory and Practice of Brewing Illustrated,' as the best publication of the kind that has ever come under my notice. It is a book that will furnish many useful hints to the advanced practitioner in the Art of Brewing, while to the more inexperienced it will be found a valuable assistant.

" EDW. CARPENTER."

X. CANTERBURY, Kent. (St. Augustine's Brewery.)—" I can but say, that, without exception, it is in my opinion the most useful and scientific I have ever met with.

" GEORGE BEER."

XI. CANTERBURY. (Northgate Brewery.)—" After carefully perusing your first edition, we feel bound to say it is the very best work on Brewing we have ever seen. We have enclosed a Post-office order for 1*l.* 10*s.*, and will be obliged by your forwarding the second edition, and also your Essay, ' A Voice from the Mash-tun.' WALL & SAKER."

XII. CANTERBURY. (Rigden and Delman's Brewery.)—"I purchased your Treatise on Brewing when it first came out, and I have recently obtained the last edition of it, and also the 'Voice from the Mash-tun.' I am so greatly pleased with the science and skill displayed in these works that I should like to try your 'Brewer's Journal,' and herewith send Post-office order for its price. EDWARD COWELL."

XIII. CHATHAM, Kent.—"I consider your work to be based upon just principles, and will go far to clear away the mist which has obscured the art. It has thrown open a field for investigation, which, if judiciously followed, will lead to most important results. The chemical facts with which the Treatise abounds, will make it a standard work of reference, and doubtlessly it will be in the possession of every practical Brewer who would wish to keep pace with the improvements of the day. Your MASHING ATTEMPERATOR, as well as your other brewing apparatus, hold out benefits which cannot well be dispensed with in any well-regulated Brewery. H. T. COULTER."

XIV. CHELTENHAM BREWERY, and now of Norwich.—"Your Treatise on Malting and Brewing I have read through, and consider it a work of great research, and from which every Brewer may obtain very useful information. Should any thing new be added in your next edition, I shall be happy to take a copy. JOHN BULL."

XV. CHESTER.—"I consider your Treatise on Brewing should be read by every one following the business of a Brewer, as they by so doing must derive a great deal of very valuable information as well as pleasure. W. J. SELLER."

XVI. COLCHESTER, Essex. (North-Hill Brewery.)—"I have perused your work and applied such parts of it as my utensils will permit, and consider it a great improvement in the science, which no doubt would be further realized if carried out to its full extent.

"WILLIAM BOWLER."

XVII. CREWKERNE. (Merriott Brewery.)—"I have much pleasure in bearing testimony to the great value of your work, 'The Theory and Practice of Brewing Illustrated.' When I commenced business in conjunction with Mr. Bidgood, I took your book as my standard, and to it I attribute the very excellent quality of my article, and, consequently, the great satisfaction it gives. I would advise every young Brewer, as well as every experienced one, to master your work. W. W. WEBBER."

XVIII. DARTFORD BREWERY, Kent.—"I have read your Treatise on Brewing, and can with confidence recommend it generally, as containing a vast quantity of useful information. Your arrangements, were they to be fully carried out, would, I have no doubt, prove highly advantageous. W. PITTOCK."

XIX. DARTFORD, Kent.—"We were much pleased with your work, and derived some valuable information from it. WM. MISKIN & CO."

XX. DARTMOUTH, Devon.—"We have derived much information from the perusal of your Treatise. The principles laid down we believe to be correct. In a word, we highly approve of the work and strongly recommend it. BAKER, BROTHERS, & CO."

XXI. DERBY. (Navigation Brewery.)—"Your work upon Brewing that I have is the third edition. I have several works of other authors, but in my opinion there is not one yet published that can compete with yours. Its price, too, is extraordinarily low, compared with its contents. DAVID PAINE."

XXII. DETROIT, MICHIGAN, United States of North America.—"I received the second edition of your very interesting work on Malting and Brewing a few days ago, and am perusing it with pleasure and profit. Up to the time I left England I procured and read, very attentively, every work that had been written on Malting and Brewing, but I have derived more important information from *your* work than from all the other works I ever read.

"THOMAS HAWLEY."

XXIII. DOUGLAS, Isle of Man.—"Your work has interested me greatly, and I shall always peruse it with pleasure and profit, as I attribute my extraordinary success entirely to having carefully digested your book. WM. OKELL."

XXIV. DUDLEY, Worcester. (Hall-Street Brewery.)—"The chief *demerit* which we perceive in your 'Theory and Practice of Brewing Illustrated' appears to us to be that, if followed, it will produce a great many good Brewers at a small expense.

"GEO. ENGLAND & SON."

XXV. DUDLEY. (Hall-Street Brewery.)—"Your Treatise on Brewing contains many useful hints, with accurate calculations, and true statements of facts. JOHN BAKER."

XXVI. DURHAM. (Gilligate Brewery.)—"I have read your 'Theory and Practice of Brewing Illustrated' with much pleasure and benefit. WILLIAM PEACOCK."

XXVII. EPSOM, Surrey.—"The perusal of your truly valuable Treatise on Brewing has afforded me great satisfaction; and it is with feelings of a more than ordinary degree of pleasure that I contribute my conscientious opinion of its merits. It may be said to contain *a mine* of information; treating copiously, as it does, on every subject connected with the trade, and alike interesting to the public and the private Brewer. Of the patented apparatus described in the work I have seen the MASHING ATTEMPERATOR, and consider it to be unquestionably the greatest modern improvement introduced into the Brewery. Its adoption will, I have no doubt, become universal when the advantages arising from its use are more fully made known.

"G. K. KING."

XXVIII. GOSPORT, Hants.—"With regard to your Treatise on the Art of Brewing, I am of opinion that it is a most valuable work, and cannot be too highly appreciated; in fact, every Brewer and Maltster ought to possess a copy. I hope it will gain an extensive circulation, and in some measure recompense you for the talent evinced. I hear your work highly spoken of by all who have perused it. F. GOODEVE."

XXIX. GUILDFORD, Surrey. (St. Nicholas Brewery.)—"I have perused your work, and have found it abound with practical and theoretical information, especially on that great end where the Brewer reaps his 'golden harvest!'—I mean fermentation. G. M. CROOK."

XXX. HARROGATE, Yorkshire.—"Your Treatise on Brewing contains many useful theoretical hints and practical rules. Its principles clearly appear to have reference to a scientific knowledge, deserving the attention of Brewers. I have seen the working of the MASH-TUN ATTEMPERATOR, and am sure that when known it will be generally used. I am convinced the operator is enabled to produce an additional extract, of finer quality and flavour, by its valuable assistance. JOHN BAKER."

XXXI. HORNDEAN, Hants. "I have perused your valuable Treatise on Malting and Brewing with very great pleasure, and think it a useful and valuable work, and shall feel a pleasure in recommending it to any friend in the trade. WM. WISE."

XXXII. HORSHAM, Sussex. (Horsham Brewery.)—"Having carefully perused your Treatise on the Art of Brewing, I feel confident the more generally your process is brought into practice, the more it will be appreciated by the trade. As far as regards the operation of your MASHING ATTEMPERATOR, it must be obvious to every Brewer, that as certain heats are necessary for mashing, it is quite expedient to keep up those heats for the complete saccharification of the goods. In fact, the whole Treatise is a complete masterpiece, and supersedes all other publications on Brewing, and should be in the hands of every practical man; because the different processes are founded on the knowledge of the chemical operation, without which no person can expect to have his ales of an uniform quality. DREW HONEYWOOD."

XXXIII. KETTLEBURGH. (Deben Brewery.)—"Such a work as yours has been long desired by Brewers; for mere practical details, as usually given in works on Brewing, have not been found to answer the purpose, succeeding in one locality, or even one house, and signally failing in another. In your book the Brewer is presented with a vast array of facts laboriously collected from other departments of science, carefully applied to illustrate and improve his own. Every Brewer, from the chemical information contained in the work, will be able to modify his present system on unerring principles. J. B. GRANT."

XXXIV. KIDDERMINSTER.—"Nearly twelve months since I wrote to you for a copy of your 'Brewers' Repertory,' on reading which I was induced to purchase your work on Brewing. I must say it is the best work of the kind I ever read. It contains a great deal of information to both brewers and maltsters, to which latter class I belong. JOSEPH FLIND."

XXXV. LEEDS, Yorkshire.—"I think the book would have been cheap enough at $5l.$ The question is, Would you not have sold nearly as many at that as at the present price?

"WM. SPONG."

XXXVI. LEWES CLIFF, Sussex.—"I have every reason to think the work will prove useful to society, and reflects great credit on the author. It is very useful to me in economy, as regards both expense and time. EDMUND HILLMAN."

XXXVII. LITTLEPORT.—"With respect to your Treatise on Brewing, I consider it to be a valuable publication, and one which ought to be in the hands of every person in the trade.

"WM. CUTLACK."

XXXVIII. LIVERPOOL.—"With respect to your Treatise on Brewing, we have studied it with advantage, and, notwithstanding we have retired from the brewery trade, shall feel obliged if you will forward us a copy of your new and improved edition, for which we enclose Post-office order, value 25*s.* HUGHES BISHOP."

XXXIX. LONDON. (Barclay, Perkins, and Co.'s Establishment, Southwark.)—"I have no hesitation to state, that in my estimation your Treatise on Brewing is a work of considerable merit.

"I shall not only be pleased with giving it room in my library, but shall place it there among those works I most esteem on account of their merit.

"I have written to a friend, and strongly recommended your plans. W. A. BROWN."

XL. LONDON. (Vauxhall Brewery, now patent.)—"I have read your Treatise on Brewing with an infinite deal of pleasure and advantage; and after mature deliberation am so fully convinced of the correctness of the principles there laid down, that I have come to the conclusion of adopting your machines and plans in the Brewery I am now erecting, as far as the locality of the ground will admit; and I have no hesitation in saying that the time is not far distant ere such principles will be generally adopted. HENRY LOVIBOND."

XLI. LONDON. (Dolphin Brewery, Ratcliff.)—"We have perused your book with much pleasure and satisfaction, and though many of your bold and original schemes may startle the staid practical Brewer, yet no Brewer can read the work with attention without gleaning much novel information calculated to improve his practice. MASTERMAN & CO."

XLII. LONDON. (Cambrian Brewery, Hoxton Old Town.)—"I have attentively read your Treatise on Brewing. It is full of practical information, and well deserves the attention of the trade generally; and in my opinion it will go far, very far, to advance the Science of Brewing to maturity. The MASHING ATTEMPERATOR no Brewer ought to be without. G. F. SMEE."

XLIII. LONDON. (Bow Brewery.)—Abbot and Co.'s, after complimenting Mr. Tizard in terms precisely similar to those above, in respect to the Treatise, concludes by saying—"I doubt not your MASH-TUN ATTEMPERATOR, when better known, will be generally used.

"T. T. TYRREL."

XLIV. LOUTH, Lincolnshire. (Phœnix Brewery.)—"It is with infinite pleasure I give my conscientious opinion, which I have had no occasion to alter. I consider yours to be the first Treatise on Brewing which has really placed the art on its proper pedestal, and appropriated to it a niche in the Temple of Science.

"I believe a day will come when the theories you have propounded shall be received as established truths: they have their origin in unerring principles; and to overthrow the superstructure you have raised, the settled basis of such men as Liebig, Berzelius, Saussure, our own Turner, and a host of others, must be annihilated. Had Newton given his sublime discoveries to none but ordinary minds, he would have unfolded 'All Nature's Laws' to no purpose beyond his own gratification. ST. JOHN WELLS LUCAS."

XLV. MAIDSTONE, Kent.—"From your book on the system of Brewing, I can safely say I have learned more than from all the other books I ever read on the subject put together; and if I were commencing the building of a Brewery, I should certainly adopt most of your improvements. I believe that what you have written will cause the science to advance with rapid strides. W. FISH."

XLVI. Maidstone, Kent. (Medway Brewery.)—" I have carefully perused your work on Brewing, and I do consider that your system therein illustrated, both practical and theoretical, is the best, and based upon the soundest and most philosophical principles of any work I have ever met with. H. Godden, Jun."

XLVII. Maiden Newton.—" I consider your Treatise on Brewing a most valuable work on the subject, and should say no Brewer's library would be complete without it.

" Henry Cox."

XLVIII. Malling, Kent.—" I have read your works with much pleasure, and beg to state they are the most useful to a Maltster and Brewer I ever had an opportunity of seeing, and shall be happy to make a subscriber to your next edition. H. Dickenson."

XLIX. Manchester. (Salford Brewery.)—" The more I look into your 'Theory and Practice of Brewing Illustrated,' the more I am convinced it does you immense credit, and is a work invaluable to the Brewer. I consider it the most interesting and edifying practical scientific work I ever read. James Farren."

L. Milbourn St. Andrew's, Dorset. (Milton Brewery.)—" I have perused your Treatise with much interest, and am so far satisfied with the soundness of your practical experience and depth of scientific research, that I have recommended it to many of my friends. The extended sale which you must have will, I am of opinion, convince you that the Brewing World, as a body, are neither slow in appreciating merit, nor backward in adopting improvements. C. Warne."

LI. Newhaven, Sussex.—" Of your Treatise on Brewing I may conscientiously speak in the highest encomiums. It illustrates *old and new* practice in such an exquisite and explanatory manner as to render it of great utility to the Brewer. It reflects much credit on the author, and well merits the approbation of the whole community. C. W. Fowner."

LII. Newport, Isle of Wight.—" Having carefully read and greatly profited by your instructions in the various departments of the Brewery, I should deem myself most ungrateful not to acknowledge how greatly I am indebted to you for your elaborate and highly useful publication. Since I have attended to your instructions, I have been able to obtain a much better extract from my goods than I ever did before, unless it was occasionally and by accident; but now I proceed with certainty and success. Accept, therefore, my sincere thanks.

" Barnabas Exton."

LIII. Newton Bushell, Devon. (Mill-Lane Brewery.)—" We do most cordially approve of your Treatise on Brewing, and have met with other Brewers who have been very much pleased with the work, and we wish you success. Palk & Pinsent."

LIV. New York, U.S.—" In respect to your work on Brewing, although I do not agree as to the non-boiling system, yet I believe it to be the most scientific and perfect Treatise on the production and management of malt liquors that I have ever become acquainted with.

" M. P. Reade."

LV. Nottingham.—" With respect to your book, I consider it a very scientific and able Treatise, containing many new and useful suggestions calculated to throw a certainty into a science hitherto so imperfectly understood. George Dann."

LVI. Nottingham. (Carrington Brewery.)—" We have perused your work on Brewing, and have much pleasure in stating our gratification with its contents.

" We are bound to say, that all the important points are justly and elaborately treated upon in a scientific and practical manner, and, in our opinion, it conveys information upon the subject more directly than any other work we have yet met with.

" Beasley & Champion."

LVII. Olney, Bucks.—" We have read your Treatise on Brewing, and have derived much valuable information from its perusal. We are convinced that both theory and practice are sound, and consequently recommend it to all our brewing friends.

" Coling, Hipwell, & Coling."

LVIII. PENZANCE, Cornwall.—" I beg to state that I have acted on the principles laid down in your work on Brewing to my great satisfaction. J. B. PENTREATH."

LIX. PORTSMOUTH, Hants.—" I can have no other feeling than that of pleasure in conveying to you my unqualified approval of the deep research your work evinces throughout, and that such a book has long been wanted in the trade. This approval may perhaps be of more value when I inform you that I have been above twenty years a Brewer, and am brother to J. C. Wood of Westminster, where I had the whole brewing management for very many years, and left only from ill health. FREDERICK WOOD."

LX. ST. ALBAN'S BREWERY, Herts.—" I have seen sufficient to convince me, as a Brewer of some experience, that yours is the most practical and scientific work on the Art of Brewing that has yet been published; and the discovery of the ATTEMPERATOR is the most useful and beneficial that has been made in the Brewery for many years.

" DAVID HEELSON."

LXI. SEVENOAKS, Kent.—" We consider your publication, entitled the 'Theory and Practice of Brewing Illustrated,' a work of sterling merit, containing a vast fund of scientific and useful knowledge, evidently the result of profound research. We have no hesitation in stating that we have derived more beneficial information from the perusal of it than from all other works we ever read on the subject. JAS. & HY. SMITH."

LXII. SLEAFORD, Lincoln. (Albion Brewery.)—" I beg to say that I have perused your volume, and am delighted with it. I do believe it to be *decidedly* the *best* publication on Brewing I have ever seen; and if my opinion, which is that of a person who has been upwards of fourteen years engaged in the Brewing department, both practically and experimentally, can afford you any gratification, I feel bound, as an honest man, to say that I consider it a very valuable work, affording instruction to young beginners, and information to experienced men. C. HEPPENSTALL."

LXIII. SOUTHEND, Essex.—" I feel great pleasure in offering my humble tribute of praise to your incomparable Treatise on Brewing. I have read other treatises, but none to compare with yours. No Brewer ought to be without a copy; and I may say, now that I have read it, that I should by no means have considered the money ill bestowed if the price had been Five Guineas. JOHN HUDSON."

LXIV. SOUTHOVER, Lewes, Sussex.—" I have an opinion, which I unhesitatingly give. Many Brewers of the old school, and even those of the present day who are following their rules and dogmata, will be startled at so many new schemes, but not until they prove by experiment and reason that you are wrong, ought they to express their dissent. Your work contains a vast deal of practical knowledge on Brewing, and I have no doubt all into whose hands it may come will agree with me that we have much to learn. I strongly recommend those who may consult it not to be satisfied with merely 'skimming' its contents, but to give it their best attention, and the results will be a good 'extract' of information.

" GEORGE NORMAN."

LXV. STOCKPORT. (Waterloo Brewery.)—" I have your admirable work, 'Theory and Practice of Brewing Illustrated,' and I have read and studied it with a great deal of interest, and am so fully aware of the great truths which force themselves on me almost involuntarily, that I admit to you that if I had a career to *commence*, instead of to follow, I should adopt all your improvements *in extenso*. HENRY SMITH."

LXVI. READING (Caversham), Berks.—" My opinion of your work on Brewing, as a practical Brewer, although no longer connected with the Brewery at Reading, is candidly this: I consider it by far the best work upon the subject that I have ever met with; and if your ATTEMPERATOR realizes the extracts quoted by you in the 'Voice from the Mash-tun,' which I have no reason to doubt, it certainly is one of the most important discoveries in the Theory and Practice of Brewing. C. C. BICKHAM."

LXVII. SOUTHSEA, Hants. (Brunswick Brewery.)—" I have perused your valuable book of information on the subject of Brewing, and consider it to be the very best I have read or seen, and think no Brewer should be without it, as it contains a great mass of useful and interesting matter. THOMAS LUKE."

LXVIII. STALBRIDGE, Dorset.—" We are happy to say we are fully satisfied with your Treatise on Brewing, and consider it a valuable work, highly deserving the patronage of all who wish to advance in the art of Brewing. H. & T. TAYLOR."

LXIX. STAUGHTON (GREAT), Hants.—"I found great pleasure in reading your Treatise on Malting and Brewing, and should recommend it to all parties engaged in the above trades. I have found it particularly useful. THOMAS H. MURFIN."

LXX. STROUD, Gloucestershire.—"I have derived much pleasure from the perusal of the Second Edition of your Treatise on Brewing, the various subjects of which I consider to be handled in a most scientific and instructive manner. I must say that I have never read any work that has given me so much satisfaction, and should strongly recommend every Brewer to procure a copy. STEWART CATON WYLLIE."

LXXI. TAVISTOCK, Devon.—"As far as I have been enabled to carry out the principles of the Treatise, my most sanguine expectations have been realized; and I am persuaded, were they generally adopted, our national beverage would be universally drunk and admired.
"JOHN WHITE."

LXXII. TENTERDEN, Kent.—"I have perused your valuable Treatise on Brewing with both pleasure and profit; and abounding as it does with very useful information to every Brewer, its principles cannot but be universally adopted. Should there be any thing new in your next forthcoming edition, I shall feel great pleasure by my name being placed as a subscriber.
"THOMAS LANGDON."

LXXIII. TOPSHAM.—"I have read your work, entitled 'The Theory and Practice of Brewing Illustrated,' and beg to express my satisfaction of the correctness of its doctrine, so far as I have been enabled to test the same. J. P. HARRISON."

LXXIV. WARRINGTON. (Penketh Brewery.)—"Your Treatise on Brewing is replete with valuable practical information, and cannot fail to recommend itself to all who study its pages.
"JOHN & JAMES ARDERN."

LXXV. WEYMOUTH.—"I have much pleasure in enclosing a Post-office order for 25*s*., being the amount due for your very excellent Treatise on Brewing, from which I have gained much useful information, and I sincerely hope it will meet the extensive patronage it so well deserves. JNO. GROVES."

LXXVI. WHITBY, Yorkshire.—"I have great pleasure in recommending your publication, 'The Theory and Practice of Brewing Illustrated,' which I think every Brewer would do well to have in his possession, as it is indeed a useful production, and must have cost you a great deal of time and pains to accomplish. APPLETON STEPHENSON."

LXXVII. WHITCHURCH, Hants.—"I have perused your Treatise on Brewing, and consider it the most valuable work of the kind I have ever seen. No young Brewer, and I may say old one either, should be without it, being full of information which could not have been obtained without great practice, deep research, and learning. I have heard your work spoken of by my friends in the trade in a highly flattering manner, and the cost of it is not to be mentioned in comparison with the pay attached to the carrying out its conclusions.
"ROBERT FOWLER."

LXXVIII. WHITCHURCH, again.—"My opinion of your book on Brewing is such, that if I had fifty sons, I should give each a copy. G. VINCENT."

The above Testimonials are not more than one-tenth of the number Mr. TIZARD has received.

A VOICE FROM THE MASH-TUN.

This Work, in 12mo, which is bound in the same elegant style as the foregoing, contains all the principles of the Fifth Chapter, with Notes and additional arguments, an examination of Baverstock and his critical opponents and adherents; and in Part II. a Caution to the Public respecting a certain empiric, with Remarks on Richardson's Statical Estimates. Price 5*s*., sent postage-free to all parts of the United Kingdom.

Mr. Tizard can recommend to Brewers desirous of producing VERY SUPERIOR PALE ALES, or otherwise requiring the services of an indefatigable, steady, and experienced operative, an operative brewer, possessing sufficient energy and tractability, who occupied his last situation many years, and can brew *to perfection*, and *with unusual economy*, the delicious beverage known as PALE ALE. Only a moderate salary required, and may be upon the progressive principle, if agreeable. Address XXX., care of Mr. Tizard, 12, Mark Lane, London, E.C.

Mr. TIZARD would esteem himself favoured if gentlemen who receive the REPERTORY would devote a few leisure moments to writing and forwarding to him a list of their friends and neighbours in the brewing business, both principals and operatives, to enable Mr. TIZARD to supply them with the Repertory.

N.B. To prevent disappointment, Country Correspondents are informed that, in consequence of his numerous engagements, four days' notice is necessary to ensure an interview with Mr. Tizard in London. Address:—Mr. W. L. TIZARD, Brewers' Architect and Engineer, 12, Mark Lane, London.