THE

SCOTTISH ALE-BREWER

AND

PRACTICAL MALTSTER,

A COMPREHENSIVE DIGEST OF THE ART OF BREWING ALES

ACCORDING TO THE

SCOTTISH SYSTEM.

CONTAINING

FOUR TABLES OF ORIGINAL GRAVITIES AND ATTENUATIONS, OF THE ALES OF THE VARIOUS SCOTTISH BREWERS, ALSO A TABLE OF THOSE OF THE MOST EMINENT BREWERS OF LONDON, BURTON, EDINBURGH, ETC., AND THE METHOD ADOPTED BY THEM IN THE MAKING AND MANAGING OF

INDIA PALE ALE.

WITH A

SUPPLEMENT

ON THE

RELATIVE VALUE OF MALT AND SUGAR.

SHEWING THE ADVANTAGES AND DISADVANTAGES IN THE USE OF SUGAR IN BREWING DERIVED FROM PRACTICAL EXPERIENCE OF TWELVE YEARS, AS WELL AS THE GRAVITY EACH POUND OF SUGAR WILL IMPART TO ONE GALLON OF WORT OF THIRTY DIFFERENT KINDS OF SUGAR.

BY

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AUTHOR OF "THE BRITISH WINE-MAKER AND DOMESTIC BREWER."

THIRD EDITION.

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PREFACE TO THE THIRD EDITION.

The Author respectfully begs leave to introduce a Third Edition of "the Scottish Ale-Brewer and Practical Maltster," and, at the same time, embraces the opportunity of tendering his acknowledgments to the public, for the gratifying manner in which they have received the work, scarcely seven months having elapsed since the publication of the second edition.

A third edition has now become necessary; but as nothing worthy of particular notice has taken place in the manipulations of the science during that short interval, to render farther enlargement expedient, the present edition is merely a reprint of the former, but with a Supplement on a very important subject, highly interesting to all Brewers at the present moment.

In consequence of Government now allowing the unlimited use of sugar in brewing, it

becomes a matter of great importance to brewers, to obtain all the information possible, with regard to the relative value of malt and sugar, in order that they may be enabled to judge whether it will be advantageous or not, to avail themselves of the privilege granted them.

The Author having derived his knowledge from long and patient practical experience, in quarter brewings for his own family, both as regards the entire and the partial substitution of sugar for malt, as well as the real value of sugar to the wine maker—consequently to the brewer—considering himself fully qualified to communicate the knowledge to others; the more especially is he induced to offer this information, when at present so many contrarieties of opinions prevail, and so much has been written in the public prints, apparently only to serve a particular end, and assuredly calculated to mislead.

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PREFACE TO THE SECOND EDITION.

THE First Edition of the Scottish Ale-Brewer was published in 1837, and I have much pleasure in stating, that the whole of the impression, with the exception of a few copies that were sent to America, was exhausted in the course of the ensuing twelve months. Since then the work has been constantly in demand by practical Brewers, to whom it was especially addressed; but circumstances, over which I had no control, prevented me from completing a new edition to meet those calls until now. I can only, therefore, express my gratification for the manner in which the work was received, and at the same time my regret that I have not sooner been enabled to comply with the wishes of those whose interests and pursuits it is intended to promote.

During this interval I have been uninterruptedly and extensively engaged in prosecuting the practical departments of brewing; and I need hardly say, that in preparing the pre-

sent edition, I have applied the results of my experience to the improvement of its contents. It is, therefore, with increased confidence, that I submit the present volume to the practical Brewer as well as to the public generally.

I have carefully revised the whole of the former work, and introduced throughout a variety of additions, which those who compare the present with the former edition will readily perceive. I have, however, added nothing which I did not believe was most essential to the full and clear explanation of the various processes, in order to ensure certainty and success in the operations of the Brewer.

In addition to these improvements, I have introduced several new features, which I think well-calculated to increase the general utility of the work.

The important branch of trade which has lately so much increased, in the article of pale beer for the Indian market, and pale Indian ale for consumption at home, has induced me to enter upon a series of experiments, with the view of enabling the Brewer to produce this ale in the highest style of perfection, with the most perfect assurance of success.

In following out this object, I have by means of the process of partial evaporation ascertained

the original gravities, with their attenuations, of forty different ales made by the brewers of London, Edinburgh, Leith, Burton, and other English towns most famed for this article. I have thus been enabled to supply exact information as to the process by which the India beer may be produced, and I submit with confidence the details of this process, as an important and valuable addition to the "Scottish Ale-Brewer."

I have also devoted especial attention to the subject of malting, the importance of which has been hitherto somewhat overlooked in works of this kind; convinced that to many the information on this subject will be highly useful, while it extends the practical knowledge of those more particularly engaged in other departments.

In order to convey a more correct idea of the contents of the work, I have added to its original title of the "Scottish Ale Brewer" that of the "Practical Maltster."

LAVEROCK BANK, EDINBURGH,
August 1, 1846.

PREFACE TO THE FIRST EDITION.

In presenting the following work to the public, I may state briefly, that my principal aim, in its composition, has been to simplify and analyse every branch of the subject, in so plain and practical a manner as to render my statements, descriptions, and rules clearly intelligible, and practically available to those who have not previously acquired the knowledge which results from experience, even on the smallest scale. I have not been the less solicitious to illustrate the subject to those who, though partially acquainted with its various details, are devoid of that peculiar and more *manual* knowledge (as I may call it) which is absolutely indispensible to the accurate and assured management of the various processes, especially in the more advanced stages.

It may be remarked, that, from the number of Treatises on the Art of Brewing already in circulation, it will appear to many, that the field upon which I have en-

tered has been fully pre-occupied, and the subject exhausted. I feel called upon, however, conscientiously to state, that none of those publications contain a sufficiently ample and satisfactory description of the several interesting and delicate processes which constitute this useful art. The authors to whom I allude have, likewise, failed to convey the requisite information on many practical points, of the greatest importance. Their statements are frequently confused, vague, or contradictory. These defects may partly be accounted for by the fact, that not a few of the treatises in question are the productions, not of brewers—of persons trained to the actual practice of the art, but of mere scientific men, obviously unacquainted with the professional details of the various processes which they describe. I admit that the theories propounded by some of these writers are extremely beautiful, and that the merit of their works is very considerable;—but, on the other hand, it is reasonable to believe, that as they must have been indebted for much of their information to other parties, not always interested in stating the *whole* truth, and, moreover, as they possessed few proper opportunities of

experimentally testing the facts upon which they proceeded, many essential errors occur in their works, which are, indeed, clearly apparent to the experienced practitioner. Notwithstanding the imperfect and inaccurate character of these works, the young brewer almost invariably proceeds to study and digest them, in the expectation of deriving much practical benefit from their perusal. He receives them with an implicit belief in the knowledge and judgment of their authors, and, without hesitation, he applies the rules and information, which they present, to the operations of brewing, in all its practical departments. The results, however, in such cases, are often very different from those which were anticipated—and, on closer observation, it is speedily ascertained that the instructions, laid down with so much formality and apparent confidence, are founded either in error or in ignorance. Should the operator persevere in following these theorists, he must continue to experience, in the end, nothing but reiterated disappointment.

Another inducement to the publication of the present work arose from the fact, that the Treatises on Brewing, hitherto presented to the public, have, with one exception, ap-

peared in England, and are limited simply to the consideration of the methods of conducting the various processes, as pursued in that country. The exception to which I have referred is the article on Brewing, contained in the Supplement to the Encyclopædia Britannica, which, although necessarily condensed in its statements, and partaking more of the nature of an outline than of a comprehensive treatise, yet affords the most perfect and enlightened view of the subject that I have any where seen. The information which it contains, so far as it goes, may be relied upon with complete confidence, and the young brewer need have no reason to distrust the judgment or sagacity of the writer. Still he has left many branches of the subject untouched—and I may add, that the article resembles the other works to which I have adverted, inasmuch as it is also confined merely to the discussion of the *English* system, and is altogether more theoretical than practical in its details and directions. Such being the character of these publications, it appeared to me that there was ample scope, if not an absolute necessity for a practical treatise, having only one object in view, namely—that of conveying a comprehensive, minute,

and strictly intelligible account of the practice of this art, as it prevails in Scotland—more particularly with reference to the system which obtained in former times, when *Scotch Ale* deservedly held, as it still holds, the first rank amongst fermented-liquors of British manufacture.

The first portion of the work is occupied with a detailed description of the Saccharometer, and an account of the various modifications which it has undergone, from the hydrometer constructed by Mr. Martin, in 1768, to that invented by Dr. Thomson, and made by Alexander Allan, of Edinburgh, which I consider the most simple, accurate, and best adapted to the purposes of the brewer. The great, the inestimable value of this instrument cannot be too strongly impressed upon the practitioner. It affords him a safe and unerring guide through many difficulties, enabling him to distinguish his progress, step by step, until the final completion of his labours.

I next proceed to what may be strictly termed the practical department of the art. Having enumerated and characterised the materials employed—such as water, malt, hops,

&c., I divide the operative processes into seven branches, namely, Grinding or Crushing, Mashing, Sparging, Boiling, Cooling, Fermenting, and Cleansing. I have described the method of conducting these several processes, according to the practice of the Scottish brewers; and I hope, as I have reason to believe, that the reader will be enabled to follow my statements with ease and satisfaction. I have, however, endeavoured to be more than usually explicit in explaining the important process of *sparging;* not only because its real value is little understood or appreciated in the South, but because it possesses many great advantages over the corresponding operation adopted in England—I mean the process of *mashing a second time.* With the view of enabling the English brewer more fully to comprehend the nature of this practice, and the mode of working the machine used for sparging, my description is accompanied by a diagram, or drawing, of a newly invented self-acting sparger. The Scottish brewers have not only found this machine admirably adapted to their purpose, but it has been the means of enabling them to dispense with a considerable amount of

manual labour, which formerly entailed upon them much expense and inconvenience. In respect to fermentation, I have pointed out the difference between the practice of the Scotch and that of the English; the former preferring a low, the latter a much higher temperature, in pitching their tuns. This distinction is of great importance; and, in connection with the practice of sparging, may be considered as constituting the leading peculiarity in the Scottish system of brewing.

I had long been of opinion that it was possible to ascertain the original gravity, as well as the final attenuations, of any worts. This conviction I was led to entertain, in consequence of being made aware of the strict accuracy of the results obtained by means of the process of partial evaporation, as adopted by the Excise for ascertaining the original gravity of the distillers' wash. The worts of the brewer, it is very obvious, may be tested on the same principle—and, accordingly, I applied the method practised by the Excise, which is equally simple and scientific, to the purpose of obtaining similar results regarding the original gravity of worts.

In the body of the work, I have explained

in detail the various means which I adopted to render my experiments as accurate as possible. Amongst other methods of testing their accuracy, a scientific friend afforded me the opportunity of ascertaining the gravities of certain ales, which he had himself previously marked. Upon the completion of my experiments, the results which I had obtained were compared with his notes, and they were both found to correspond so nearly, as to leave scarcely the difference of one degree in three out of the six successive experiments which I performed.

I have thus endeavoured to ascertain the original gravities of eighty different ales, made by the most eminent brewers of Edinburgh. The results of several highly interesting experiments, conducted on the principle to which I have referred, are recorded; and though they may not, in every instance, be accurate to a single degree of gravity, I am certain they approximate very closely to the truth. The original gravities and final attenuations of those ales, with the proportions of proof spirit, *per centum*, contained in each, have been found and carefully noted. The operator may occasionally find it beneficial to

enter upon similar experiments; and to enable him to pursue them with accuracy, I have detailed the mode of conducting them with some minuteness. The entire apparatus employed is described—and a table is inserted, with the view of facilitating his efforts, and simplifying his calculations.

The examples of brewing two different kinds of ale, with which the work concludes, will enable the operator to perceive, in a distinct form, the course and successive intervals of his labours.

In the view of explaining and obviating the difficulties which present themselves to the practitioner, who is unacquainted with the details of the Scottish system, I have inserted a reply to the inquiries of a practical English brewer, who spontaneously applied to me for information on the subject.

LAVEROCK BANK, NEAR EDINBURGH,
June 14, 1837.

BREWING.

In treating of the subject of Brewing, it is not my intention to enter into a lengthened detail of the history of this useful art, from the period when it was first known and practised to the present time. It may suffice to state briefly, that the making of beer appears in the train of domestic arts introduced into this island by the Romans; to whom, accordingly, we are indebted for the exhilarating and most wholesome beverage, now so universally consumed in this country.

Without attempting to explain the process of the ancients, I proceed to mention that, prior to the sixteenth century, beer or ale was made without the addition of the hop; as a substitute for which, various aromatic herbs of a bitter flavour, though less agreeable than that plant, were used, and spices of different kinds were likewise occasionally added.

We learn, however, that, during the reign of Henry the Eighth, the hop was introduced into England

from the Netherlands; and there can be little doubt that its usefulness in preserving the ale, and its value in imparting to it a delightful flavour, were in a short time duly appreciated.*

Of the method of brewing beer previously to the eighteenth century we have little knowledge. Indeed, our information on the subject is so limited, as scarcely to deserve a higher character than that of mere conjecture. During the eighteenth century, however, many valuable discoveries were made, and several treatises written, explaining the nature of these discoveries.

About the year 1760 brewers began to use the Thermometer as a guide to direct them in regulating their heats, both for mashing and for fermentation; but so sceptical were they as to its utility, or practical value, that it was several years before it was brought into general use. Mr. James Baverstock was one of the first professional men who employed this instrument; not, however, without encountering much opposition, and that even on the part of his own father, with whom he had become connected in the management of a brewery at Alton. To use the son's words, "Having met with Combrune's Theory and Practice of Brewing, published in 1762,

* Beer seems to have been considered in former times a drink fit for Courtly Halls; for Hume mentions, that at a splendid entertainment given at Kenilworth Castle by the Earl of Leicester to his Royal Mistress Queen Elizabeth, three hundred and sixty-five hogsheads of beer were consumed.

he purchased a thermometer, which he was forced to conceal and to use by stealth, his father objecting vehemently to such experimental innovations." To him, also, brewers are indebted for untiring perseverance in experimenting upon *worts* with the Hydrometer, (*i. e.* Saccharometer.) In the face of opposition and discouragement, and even of the ridicule of Mr. Martin the inventor of the latter instrument, Mr. Baverstock made many valuable discoveries, till at length his continued success overcame in a great measure, the prejudice entertained against this improvement. Other brewers soon perceived the advantage of adopting his views, and,—following his example,—found that they had not overrated their importance. The successful results of their experiments fully justified the enthusiasm of Mr. Baverstock. For many years, however, general opinion was so unfavourable to the proposed introduction of the Hydrometer in brewing, that when that gentleman spoke of it to Mr. Whitbread, that eminent brewer's advice to the young man was, "to go home, and not to engage in such visionary pursuits." From the scientific Mr. Thrale his proposal met with a very different reception. So convinced was this latter brewer of the value of the Hydrometer, that he entered warmly into his views; and so satisfactory were the results of their experiments, that the celebrated Dr. Samuel Johnson was induced occasionally to be present while they were performed.

It may be remarked, without hyperbole, that

since the introduction of the thermometer and hydrometer, (*i. e.* Saccharometer,) the art of brewing has ceased to be a mere mechanical operation, which may be conducted by any illiterate person, and may be supposed to depend for its success in a great measure, if not entirely, upon chance. It has, in fact, attained in many respects the rank of a science. The improvements in brewing may, indeed, be classed with those in chemistry, and ought to be studied, not only by the common brewer, but by all who are desirous of obtaining a knowledge of those arts and sciences on which domestic economy so largely depends, and which contribute to the comforts of life, or add to its social enjoyments. While to a brewer the knowledge of this art is indispensable—without which, indeed, he must ever work in the dark—to those who are fond of chemistry it will afford a highly instructive and interesting subject of study.

Having mentioned the value of the thermometer and saccharometer in the process of brewing, I shall now present a short description of each of these instruments, and at the same time explain the method of applying them: For although the greater number of those who will peruse this treatise would never attempt to brew without their aid, yet, as this work may fall into the hands of some who have not been enabled to appreciate their merit in a practical point of view, it shall be my endeavour, as it is my earnest desire, to explain their uses. It is unneccessary, how-

ever, to say anything more of the thermometer than merely to assert its value, and to demonstrate the impossibility of brewing with any certainty of success, or any degree of satisfaction, without it.

By means of the thermometer we ascertain the degree of heat which is required to penetrate the malt, and dissolve the farina or bruised kernel, and consequently to extract the saccharum which it contains. Without the application of this instrument, the heat of the liquor necessary for effecting this purpose cannot be regulated; but by employing it, the operation proceeds without the danger of failure. Were the liquor used at too high a temperature, upwards of one-fourth of all the malt that had been wetted would be rendered comparatively useless, as it would form into paste, in consequence of the liquor hardening its surface, and thereby shutting up the pores. There would be, in this case, no possibility of effectually mashing the malt afterwards; for, instead of being consistently mixed, it would present balls, or hard lumps of impervious glutinous paste. The internal parts of each of these being composed of unwetted malt, would remain closed up in this paste, and consequently become unavailable. If, on the other hand, the liquor be used at too low a temperature, the farina will not be dissolved; and, besides the loss which will arise from the deficiency of quantity, as well as of gravity in the extract, the liquor will not be so transparent as it would be had the heat been judiciously regulated.

The evil occasioned by too low a temperature, however, is not so material as that produced by the opposite cause; as the former can, in a great measure, be remedied by using liquor of a higher temperature in the process of sparging.

Besides the indispensable necessity of using the thermometer in this first step of the process, the instrument is found to be of equal importance in the more advanced stages, especially at that stage when it is required to know the degree of heat of the worts necessary for the purposes of fermentation, according to the brewer's own experience. It is impossible that the eye or the finger can afford correct evidence of the amount of heat which may be present. At one time the warmth of the human body may be greater than at another; and, in this case, the worts may appear too cold, when in reality such is not the fact. Again, the accidental warmth of the finger may be less, and then the worts will appear too hot, as is the case in cold weather. The inference which we would thus draw, by judging according to the touch, would be erroneous in both these instances; and, if acted upon, would certainly prevent the production of a consistent fermentation. In short, if so unscientific a mode of proceeding proved successful, the brewer would, to say the least of it, be more favoured by good fortune than by good management. We thus perceive, that in the earlier stages of brewing the thermometer is essentially requisite; and when we attentively carry

out this consideration, it will be found not less valuable in conducting fermentation through each succeeding stage.

Having briefly noticed the value of the thermometer in brewing, I now proceed to give a short description of the Saccharometer, (an instrument equally indispensable to the scientific brewer,) in the belief that the reader will at once acknowledge its utility. By simplifying its application, I hope that the hitherto unskilful or prejudiced brewer will be induced to make himself acquainted with its practical advantages; convinced as I am, that when once he has overcome his prejudices, and experimented with this most valuable instrument, the gratification resulting from his consequent success will only be lessened by the regret which he will feel that he has pursued his business so long independently of its important aid. For I feel assured, that he will, after adopting my suggestions, at once discover, that in his previous brewings, he must have incurred considerable loss, from not employing the Saccharometer, not to speak of the mental excitement occasioned by an operation which experience had proved to be, at the best, very uncertain in its results. With regard to the loss sustained, I am not proceeding upon mere assumption; for, an extensive brewer in one of the Midland Counties of England was so sceptical on this point, that, for several years, nothing could induce him to make trial of this instrument. At length, through the

earnest and repeated entreaties of a scientific friend, he was persuaded to put its utility to the test. His friend lent him a Saccharometer for this purpose, as he would on no account incur any expense in prosecuting what to him appeared a Utopian theory. After a fair trial, however, he candidly acknowledged, that he was so completely convinced of its importance in conducting the processes in brewing, that even although the cost of it were one hundred guineas, he should consider it *cheap;* because in six months the benefit accruing from its use would fully compensate the sum expended in the purchase of it.

THE ORIGIN AND USE OF THE SACCHAROMETER.

This instrument, upon the value of which I need not further enlarge, as it may be justly denominated the brewer's compass, is not of modern invention, the attention of scientific men having, at an early period, been directed to the necessity of having some certain guide, to assist them in determining the value of their worts. At the same time, it must be

acknowledged, that the idea of inventing such an instrument as the Saccharometer did not altogether or immediately spring from the enthusiasm of scientific research; but, like most valuable discoveries, arose partly from incidental causes.

Mr. B. Martin of Fleet Street, having invented an instrument called the Hydrometer, for the use of the distillery, the idea of employing the same, or similar means of ascertaining the strength of beer, ale, wine, and worts, was suggested to his mind. But Mr. Martin remained incredulous as to the possibility of success, in consequence of having injudiciously experimented with fermented liquor, instead of worts which had not undergone fermentation. Having failed in such an attempt, he could not be induced to entertain the belief that, by any improvement of his instrument, the desired result could be effected, and, consequently, he abandoned all intention of prosecuting the idea beyond the point to which he had already carried it.

Mr. Baverstock, a celebrated ale brewer, was not satisfied thus to continue inactive in a matter of such obvious importance, the more especially as he was fully convinced that the unsatisfactory results of Mr. Martin's experiment arose, not from any defect of the instrument itself, but from the want of judgment on the part of Mr. Martin, the experimenter.

Mr. Baverstock, therefore, continued to uphold its usefulness, and, accordingly, persevered in his experiments. He not only appears to have been the

first professional brewer who used this instrument in the brewery, but he did so successfully and satisfactorily.

In the year 1785, he published his Hydrometrical Observations and Experiments in the Brewery, which he dedicated to the Society for the Encouragement of Arts, Manufactures, and Commerce; and it appears he had, for sixteen years previously to that publication, been in the constant practice of employing an instrument for ascertaining the specific gravities of his worts.

In consequence of the success attending the experiments conducted by Mr. Baverstock, Mr. Quin and Mr. Richardson were induced to direct their attention to the subject; and the result was, that each invented an instrument of a corresponding construction. But to Mr. Richardson alone must the palm be awarded for the invention of the instrument which is called the *Saccharometer*, and which was considered in his day, 1784, as peculiarly adapted to the purposes of the brewer. It then began gradually to find its way into general use amongst the intelligent and unprejudiced portion of the trade. It appears, however, from the statement of Mr. Baverstock, that this instrument was not made known for sixteen years after he had begun to use the hydrometer in his brewery. Messrs. Dring and Fage, Dicas, and others, followed Mr. Richardson, each asserting the superiority of his respective instrument. Mr. Dicas' instrument was made to

show the number of pounds of solid extract contained in thirty-six gallons of wort, each pound of which extract occupies the space of ·06 parts of a gallon.

The instruments of Messrs. Dring and Fage, and of Mr. Richardson, show merely the increase of gravity caused by the weight of sugar, or solid extract, put into a full barrel of water, containing thirty-six gallons, and the difference between the weight of the sugar, and the weight of the water thus displaced. For example, suppose a barrel of water, weighing three hundred and sixty-nine pounds, at the rate of 10·25 pounds per gallon, by adding seventy-eight pounds of sugar, it will be increased to four hundred and forty-seven pounds; but by adding the seventy-eight pounds of sugar, a certain quantity of water is displaced by the sugar, or extract; and as it is ascertained, that each pound of sugar, or extract, occupies the space of ·06 parts of a gallon, so, by multiplying the pounds of sugar (seventy-eight) by the space which each pound occupies, (·06 part to each gallon,) it appears that 4·68 gallons of water have been displaced.

Deducting these 4·68 gallons of water, displaced from the original thirty-six gallons, there will only remain 31·32 gallons of water. Multiplying 31·32 gallons by 10·25, the weight of each gallon of water, there will then be three hundred and twenty-one pounds, instead of three hundred and sixty-nine.

By adding the above quantity of sugar, or extract,

(seventy-eight pounds,) the excess of gravity will be only thirty instead of seventy-eight; so that a barrel of wort weighing thirty pounds, by the instruments of Richardson, and of Dring and Fage, weighs actually three hundred and ninety-nine pounds; namely, three hundred and twenty-one pounds of water, and seventy-eight pounds of sugar, or extract.

To prove the accuracy of this statement, Mr. Baverstock informs us, "That he evaporated, to perfect dryness, a quart of raw wort—the extract of malt—indicating by Dicas' Saccharometer seventy-six and a half pounds of solid fermentable matter; and as the extract could not be completely detached from the evaporating vessel, the whole was put into the scale; it weighed 24·25 ounces. The vessel after being perfectly cleansed with hot water, which brought the extract again to the state of wort, weighing 15·75 ounces, thereby showing that the actual quantity of fermentable matter, or solid extract, contained in the quart of wort, was 8·5 ounces, which, multiplied by 144, the number of quarts in a barrel, gives twelve hundred and twenty-four ounces, and this, divide by 16, (to bring the ounces to pounds,) gives 76·5 pounds."

In the years 1805 and 1806, Government selected three distinguished men of science, eminent as chemists, to inquire into the differences in value between the English and Scotch barleys and malts. Professor Thomson, one of these gentlemen, has shown in his report, that the instruments invented

by the parties to whom I have before referred, are, in point of fact, mathematically incorrect. He has himself accordingly, invented one which is completely accurate, and which was constructed from the Professor's instructions, by Alexander Allan of Edinburgh; and the same instrument is now made by his successor, Peter Stevenson.

The instrument invented by Dr. Thomson is so contrived as to show the actual specific gravity of the liquid intended to be valued; and, as in all saccharine liquids, exceeding the sixtieth degree of heat, the gravity will be lessened; whilst on the contrary, if below that degree, the weight will be proportionably increased; a thermometer, and a sliding rule, accompany the instrument, for the purpose of exhibiting the strength of the extract at any required temperature.

This adaptation is very desirable; for it would be extremely tedious, especially in brewing, to be compelled to delay examinations until the extract should be cooled down to 60°, the standard degree of heat.

Dr. Thomson's instrument, called Allan's Saccharometer, was appointed to be used by the Scotch Excise, by act of Parliament, in 1815. But previously to this date, Allan's Saccharometer was used by the Excise, as far back as 1805 (though not by act of Parliament.) This instrument was the only one used by that body, which certainly shows they

found it most accurate in its indications, so as to justify them fully to enforce its use.

I am decidedly of opinion that no one ought to brew without using the Saccharometer. Some few individuals, however, entertain a prejudice against it, from the alleged difficulty of understanding, and the mode of applying it;—and, certainly, many of the treatises on brewing are well calculated to convey this idea, from the complicated arithmetical workings of the examples given to ascertain the average gravity of various worts.

Allan's Saccharometer indicates the specific gravity of the cubic foot of all liquids heavier than water, which is taken at one thousand ounces; and although this estimate is not, strictly speaking, correct, (water weighing from nine hundred and ninety-five to nine hundred and ninety-seven ounces per cubic foot,) yet it is sufficient approximation for all practical purposes.

A different method is adopted with the common Hydrometer, namely, that of Richardson, Dring and Fage, and others. Instead of taking the cubic foot as their standard, the weight of a barrel of water is assumed, containing exactly thirty-six gallons, weighing three hundred and sixty pounds, at 60° of heat, that is, ten pounds per gallon; and as by the addition of solid extract, or sugar, this liquid becomes heavier, the instrument shows how many pounds it exceeds the three hundred and sixty pounds;

thereby indicating not the greater specific gravity, but the additional weight per barrel caused by the sugar, or extract. It is affirmed that a gallon of pure sugar, dry and without vacuities, weighs about sixteen pounds; accordingly, supposing the sugar not to displace its equal bulk of water, the barrel of liquid would, with the above addition, weigh three hundred and seventy-six pounds, and the stem would in this case be cut by the surface at sixteen; but this gallon of sugar, or extract, which has been put into the barrel, must have displaced a gallon of water weighing ten pounds, therefore the weight of the gallon of this displaced water, namely, ten pounds, falls to be subtracted from the three hundred and seventy-six pounds, reducing it to three hundred and sixty-six pounds; and, when tried by Richardson's, or Dring and Fage's Saccharometer, the stem will be cut at six, water thirty-five gallons, at ten pounds per gall. = 350 lbs. sugar, 1 gall. 16 lbs. + to 350 = 366, excess of weight, 6.

Mr. David Booth, in his Treatise on Brewing, remarks, "If we wish to reduce the Saccharometer indications ('Richardson's, or Dring and Fage's) to the proportion of one thousand, we have only to multiply them by $2\frac{7}{9}$, because 1000 is $2\frac{7}{9}$ times 360." "Thus a wort which shows 9 lbs. by the Saccharometers alluded to, is equal to 25 parts of 1000, and in the tables of gravities would be written 1025;" and of course, Allan's Saccharometer would indicate 25° But the 1000 which is the as-

sumed weight of water is never taken into account by the brewer, when he speaks of his gravities; and this is the reason why Allan's instrument has marked on it 10· 20· 30·, &c., instead of 1010· 1020· 1030·, &c. Mr. Booth, on these *data*, has ingeniously compiled a table for reducing pounds and tenths of pounds of additional gravity per barrel, into parts of 1000. Although the factor given by Mr. Booth, $2\frac{7}{9}$, for this purpose, is apparently correct, yet Drs. Hope and Coventry, in their report of experiments made, by order of the Commissioners of Excise for Scotland, in 1806, say, "By trial we find to transfer the indications by this instrument (Dring and Fage's) into the language of specific gravity, it may be done, with sufficient accuracy, by multiplying the degrees under twelve by 3, and those above twelve by 2·75."

Since Mr. Booth compiled his second table, he has made several experiments, and has found the *data* upon which he proceeded to be incorrect, and this he acknowledges in the third part of his Treatise on the Art of Brewing. As his experiments are interesting, I am induced to quote one of the most successful of them.

"A brewing was made of three quarters of malt, which weighed when ground 925·5 pounds. From this there was extracted, on the Scotch system, 7·6 barrels of ale wort of 30 lbs. gravity, lbs.

amounting to 228

5 barrels of return wort of 2.5 lb. gravity = 12·5

Hops (if not pressed) retain the worts in which they were last boiled, to the extent of a barrel in 60 or 70 lbs. according to their quality. In this case there were 13½ lbs. which could not conveniently be boiled with the return, and consequently contained about ⅕ of the gravity of a barrel of the ale wort, .	6
so that the whole gravity extracted was	246·5

or about 82 lbs. per quarter; that is, 80 lbs. independent of what was left among the hops."

"In order to ascertain the weight of kernel from which this gravity was obtained, the grains were taken from the mash-tun and dried at a low heat, to prevent their being charred, until they appeared to be of the same dryness as the malt was when ground. In this state they weighed 308 lbs. which, deducted from 925·5, the original weight of the malt, leaves 617·5, being the weight extracted. Dividing this by 246·5, the amount of gravity communicated by the worts, we have 2·505, the proportion of dry malt required to form a pound of specific gravity. This proportion differs nearly 1 per cent. from the average table given in the first part of the Art of Brewing; but from the foregoing and other similar experiments, made since that table was constructed, we are convinced that 2·5 is very nearly the truth; and, consequently, the brewer may be satisfied that

2½ times is the specific gravity,* as indicated by the brewer's Saccharometer, (the instrument with which those experiments were made,) will show the real weight of extract which he has drawn from his malt. The calculations from this proportion are so easy, that a table is unnecessary." After reviewing the experiment, and showing that 100 lbs. of malt give out 66·7 lbs. of extract, and quoting some remarks of Dr. Thomson, on the article of barley, he proceeds:—

"Calculating from the preceding data, without adverting to the possible concentration, this specific gravity of the dry extract would appear to be 1·665, water being unity, which rather exceeds that of pure sugar, as determined by Fahrenheit; for in that case

35 gallons of water at 10 lbs. per gall. = 350·
and 1 gall. of malt extract @ 16·65 lbs.
per. gall. - - - - = 16·65

would produce a barrel of liquid weighing - - - - = 366·65

or 6·65 lbs. more than a barrel of pure water.

"The gravity of 6·65, which would be indicated by the instrument, would, when multiplied by 2·505, the proportion found by experiment, give 16·65, the weight of dry extract introduced into the barrel."

* Mr. Booth here errs in the term made use of. For "*specific gravity*," read "*pounds per barrel*."

I have dwelt much longer upon the merits of the Saccharometer than will, perhaps, be acceptable to the general reader; but as this work is calculated chiefly, if not altogether, for the common Brewer and the victualler, I have been induced to do so, under the conviction that to many, even of them, its inestimable value is unknown.

In this place it is proper to state, that the present treatise is intended to point out to the English brewer the system adopted by the Scotch brewers for producing their different ales. The apparent difficulty in the application of the Saccharometer disappears, in a great measure, when that system is simply explained.

In general, the method employed by the English brewer is, to mash three times,—each wort being different both in quantity and quality. In most cases, the two first worts are mixed to form the ale wort, and the last forms the table beer wort. Occasionally, however, the third wort is added to the two former, to form the ale wort, and a fourth is obtained by mashing again, for an inferior beer, or a return wort. These three different quantities frequently occasion a difficulty in ascertaining the mean gravity of the whole when mixed; especially if decimal parts must be taken to represent each, as, in this case, the arithmetical working becomes rather complicated.

The practice of the Scotch brewer is not so intricate; for, as his ale wort consists only of one mash-

ing, he does not require to ascertain the mean gravity of two or more different worts, unless it be to satisfy himself, when both the ale and beer worts are in the coolers, in order to ascertain the total gravity of the malt which he has mashed.

Having, in the previous portion of this work, illustrated briefly, but I hope, intelligibly, the history of the art of brewing, and detailed the various stages of improvement which it has undergone, as well as described the nature and uses of the instruments which have proved so indispensably necessary to the brewer, namely, the Thermometer and Saccharometer, fortifying my statements with practical examples and the results of experiments, I shall now proceed to the leading department of the subject, with the view of supplying the class for whom this treatise is chiefly designed—the practical Brewer—with the detailed information necessary to the efficient and successful practice of his profession, in all its stages, from the outset to the close of his operations. I shall, at the same time, explain the nature, quality, and properties of the various materials employed in the different processes, to which the brewer of ale and table beer must have recourse; founding my statements and suggestions upon the experience which I myself possess, as well as upon the information and writings of my intelligent predecessors in the same walk.

WATERS.

To procure water suitable for brewing, is an object of the greatest importance to the operator, both with respect to the flavour of his ale, and to the quantity of extract to be obtained from the malt. Hard water will not have such free access to the malt as soft; the farina, therefore, will not be so effectually dissolved, and much of the saccharum, as well as of the flavour, will be left in the grains.

Besides, experience has shown that fermentation proceeds much more equably with soft than with hard water; although it has been asserted by some brewers, that by using hard water the ale is prevented from fretting, and it is, at the same time, preserved. Notwithstanding this opinion, I would recommend the softest water to be used, as best adapted in every respect for the brewer's purpose. River-waters are, generally speaking, the softest and best for use, provided they run over a bed of gravel or sand, and do not receive, in their course, any tributary streams from marshy ground, impregnating them with noxious qualities, or peculiar flavours; for, whatever is unpleasant in the taste of the water, will be communicated to the ale.

Well-waters are, in general, hard; but this is not always the case, many of them are as soft as the softest river-water. Water, however, ought to be entirely free from all putrid matter; for whatever difference of opinion may exist with regard to the use of either hard or soft water in brewing, there can be no question respecting the detrimental effects of putrid water, or water containing any putrescent vegetable, or animal substances.

The slightest impregnation of this kind, although imperceptible to the taste, might, in the latter stage of fermentation, prove fatal to the brewer's expectations. As it is not the *present* but the *old* system of Scotch brewing which I inculcate, it may be necessary here to state that, in former times, the brewers had, in their premises, wells from which their breweries were supplied; and, even, at the present day, these wells continue to be an object of importance, except in several of the brew-houses recently established. In the vicinity of Holyroodhouse in Edinburgh, some eminent brewers are to be found, who assert, that the excellence of their ale depends upon the water found within their premises; and further, that the water at a higher elevation is not capable of producing ale of equal quality. To show that this opinion is not viewed as merely theoretical, it may be mentioned as a curious fact, that nine-tenths of the brewers in Edinburgh have their works erected on the lower ridge of the Canongate. Those parties in Edinburgh who have not wells purposely dug

within their premises, are supplied by a spring called the Crawley-water, which is conveyed in iron-pipes of large bore from the Pentland Hills, in the immediate vicinity of the city, for the use of the inhabitants. This, though spring-water, is soft, and of a fine flavour, and the supply most abundant. But, indeed, the whole of the Edinburgh water is considered to be very good, and well adapted for the brewer's purpose. In particular, there is a well in the Castle-yard, the water of which has, for centuries, been esteemed as fine as any in Britain; and what enhances its value is, that, however dry the season, it has never failed.

The agent next to be considered in the process of brewing is malt, of which there are various kinds, differing from each other in quality, from 16 to 25 per cent., and some kinds exhibit a still greater diversity. From a bushel of the best malt weighing forty pounds, twenty-six—nay even thirty—pounds of fermentable matter, or saccharum, may be extracted; while, from the same quantity of a different

kind, twenty pounds are the most that can be obtained. Some brewers assert that they have repeatedly extracted a far larger amount of fermentable matter from a bushel of malt than thirty pounds. I quote the following statement contained in a letter from a brewer in Somersetshire to one in Lancashire who wrote to me for my opinion on this subject. "I am glad to inform you that the malt of this season (1841) is vastly superior to last. Our extract since Michaelmas is 96 lbs. per quarter. I have in some instances obtained as much as 98, 100, 106, and one case on a sample of fine Chevalier barley weighing previously to malting 56 lbs. per bushel, 110 lbs. per quarter. The malt weighed 362 lbs. per quarter." This last enormous extract is equal by Allan to 302 lbs. per quarter, or 37·75 lbs. per bushel. The Lancashire brewer states that in one or two occasions he has obtained from malt made from fine Chevalier barley weighing 43 lbs. imperial bushel, 253 lbs. per quarter, but as for 3 and 2 lbs. it appears incredible. Amidst such varieties, the only method of forming an accurate judgment of the value of any given malt, is to ascertain the gravity of the worts by means of the saccharometer; and it is by this mode of procedure alone, that the information necessary to direct the operator in his farther progress can be obtained. Were he to suppose the malt deficient in saccharine matter, while the fact is otherwise, and, in consequence, draw off a smaller portion, he would then waste the malt which would

have produced a great deal more. To know before mashing the quantity of extract which can be obtained from each quarter of malt, is a matter of impossibility even to the most experienced; but a tolerably correct judgment, to a certain extent, may be formed, by infusing a small quantity—a quarter of a peck, for instance—and then trying the wort by the instrument. From the knowledge obtained by this means, the waste of the malt will be prevented. Unquestionably, the best malt ought invariably to be used, and that which has been dried at the *lowest* instead of the *highest* temperature ought to be preferred; as, in the former case, it contains much more saccharum than in the latter. The ale made from it will be of a paler and more delicate hue, and this peculiar colour, accompanied by a transparent clearness, has ever been considered an indispensable beauty. By strict attention to the rules prescribed, in regard to the quality of malt, the Scotch ales have justly acquired celebrity for their delicacy of colour.

Although it is impossible to ascertain before mashing the precise quantity of fermentable matter which may be obtained from the malt, yet it is by no means difficult to prove whether the malt is good. Barley, when properly malted from good grain, has a full round body, easily broken, and, when broken, it presents a beautiful, soft, sweet, white flour. The pickles, when put into the mouth, break freely, and have a sweet, mellow taste, and the skins of them are very thin. On the contrary, if the malt is bad,

on crushing it with the teeth, it is hard and flinty. It is much heavier than good malt, as may be proved by putting a portion of it into a tumbler of water. The greater part of the bad malt falls to the bottom of the glass, in the same manner as barley itself does before it undergoes the process of malting; whereas, if it were well malted, it would float on the surface. This last mentioned method of discovering whether barley has been well malted, is so highly esteemed by some brewers, that they will never venture to purchase a quantity of malt without previously taking a handful from the sample, and counting out, indiscriminately, a hundred grains, which they throw into a tumbler of water, for the purpose of observing how many fall to the bottom, how many float in the middle of the water, and how many remain on the surface. The grains which sink are the unmalted barley, those which float about the middle the partially or imperfectly malted, and those which float on the surface the well malted. The brewers consider, that if not more than a twentieth part of it sink the malt is good. Malt, however, which stands this test is seldom to be met with. In the very best malt, some few pickles will be found in the middle of the water, and a few at the bottom; but these will be very few indeed, compared with those which will be found on the surface. The reason of this is obvious; for although malt of itself is specifically heavier than water, yet the air lodged between the skin and the kernel, and which enters

into it during the process of malting, by decreasing that weight, increases the volume, thereby causing it to float. When, on the contrary, by imperfect malting germination has not taken place, the specific gravity is not decreased by the increase of volume, in consequence of the introduction of a lighter substance than water—air; therefore the pickles sink. This increase of volume is quite apparent; for, good barley well malted, while it loses considerably in weight, in like manner increases a good deal in bulk.

Brewers in Scotland malt their own barley, a practice which gives them the advantage of not only choosing a good material to work upon, but of converting that material under their own inspection into such malt as they judge suitable for their purposes.

HOPS.

The agent employed in brewing which remains to be considered are hops; and as, in regard to this article, there are many different tastes and opinions—some brewers preferring hops from one county, and

some from another—it is a point of some difficulty to decide which kind is really the most desirable. The majority of the brewers give the preference to the Kent hops, which, generally speaking, bring a higher price in the market than those grown in any other county. The diversity of opinion on this subject has existed many years, as will appear by the following extract from Richardson's Treatise on Brewing:—"It is astonishing that the preservative, or antiseptic quality of the hop, should, as a simple bitter, be productive of such variety of flavour in malt-liquor, as is found to be the case; and this generally arises from essential difference, readily cognizable by the palate, though sometimes, it must be confessed, it is the child of caprice. Of the latter is that prevailing predilection in favour of Farnham hops, which, though of acknowledged excellence, certainly claim a preference, in the minds of some people, of a most ridiculous nature; in so much that, I am told, the hops which grow on one side of the hedge, because, *bona fide*, in the township of Farnham, are deemed very superior in quality to those which grow on the other side, which happens to be in another parish. The difference of soil has certainly a considerable influence in producing the real difference in flavour observable in hops.

"Those which grow on the stiff clays of Nottinghamshire, and are thence termed *North-Clay Hops*, have the pre-eminence in *rankness* and, accordingly, with a certain description of buyers, bear a higher

price than Kent, though that is not so high as the general price of Farnham hops. To those who are not accustomed to the flavour of North-Clay hops, they are undoubtedly rank, bordering on the nauseous, particularly whilst the beer brewed from them is new; and, indeed, that rankness generally remains a very considerable time, if not concealed by an abundant extract of malt. Hence, they appear better adapted for strong, keeping-beers, than to any other kind of malt-liquor.

"Farnham hops, however deserving the reputation they bear, are by no means worth the difference in price given for them, to a brewer, except the vicinity of his residence may, in some measure, lessen that difference; and it is not the intention of these pages to appreciate their value to the private consumer, with whom, perhaps, the idea of their incalculable excellence may have originated.

"The county of Kent, though justly claiming pre-eminent distinction in the produce of its hops, considered as uniting flavour with strength, is far from being uniform in its general priority, in this respect; for different parts produce different qualities, varying with the soil, or some other local circumstance, and all yielding the palm of superiority to those which grow in the neighbourhood of Canterbury.

"If, however, the rank austerity of the North-Clay hops excites a nausea on the palate accustomed to the milder flavour of the Kentish; these, again, are as little relished by people who are in the habit of

drinking ale, in which Worcester hops only have been used. The flavour of these has a grateful mildness in it, not to be met with in any other hops. Hence, the finest growths of Kent, in Lancashire, Cheshire, and some other counties, where the use of Worcester hops prevails, would be rejected as unsaleable; and so great is the objection of some of the inhabitants of those counties to the flavour of Kent hops, that I have heard them distinguish ale bittered with the latter by the name of *porter-ale*. Indeed, the distinction has propriety in it, so far as the strength of a large portion of these may convey to some palates the idea of *porter*, and that the mildness of the former can hardly be applicable to any liquor but *ale*."

My immediate object, however, is to exhibit the general opinion of the brewers in Scotland, with respect to the kind of hops which are esteemed by them to be the best. A correct judgment on this point may, to some extent, be formed from the fact that, in Edinburgh, which has been long famed for ale, nine-tenths of the hops which are used in brewing are grown in the county of Kent. Hops of whatever kind, whether Farnham, Kent, Sussex, Surrey, Essex, Worcester, &c. &c., deteriorate by age to such an extent, that at the expiry of one year they become less valuable by twenty-five to thirty per cent., and in the market are termed yearling hops, and sometimes sold at even a greater loss than that now stated. However carefully they may be preserved, this effect will

ensue, and, indeed, they will have lost so much of their aroma, as to be unfit to be used for the finer kinds of ales. It is almost unnecessary to notice here the method by which the value of the hops is ascertained, as every practical brewer is aware of it; but as these pages may fall into the hands of such as have not previously directed their attention to the subject, I may mention, that the method alluded to is effected by rubbing a few of the pods in the palms of the hands, and observing, whether by this friction a small yellow dust is produced; while a clammy, resinous substance, exhaling a most fragrant odour, is perceptible; and, at the same time, whether the hops are of a fine, bright, yellowish, olive-green colour. Mr. Baverstock recommends the using of the Hydrometer to ascertain the value of the hops, but this can only apply to the unctuous or preservative parts, and not to the aroma.

Having now fully described the various materials employed by the brewer, in the production of malt-liquor, more particularly Scotch ale, I proceed to follow out the subject in the order which it naturally suggests. I shall, therefore, direct the attention of the reader to that portion of the art which requires to be next considered—I mean the details connected with the several processes to which the materials already explained are respectively subjected. For the purposes of clearness and practical utility, it will be necessary to arrange my

information under separate heads, in that succession which these important processes bear in relation to each other. System is essential in every walk of art, or science,—but in none more than the art of brewing;—and I trust, that, by strictly adapting my explanation of facts to the nature of the subject, the brewer will be enabled to proceed regularly and systematically in the delicate and difficult operations which it is his business to direct and control.

The various processes, which I now proceed to explain, must be performed in the following order:

1. Grinding or crushing.
2. Mashing and infusing.
3. Sparging.
4. Boiling.
5. Cooling.
6. Fermenting.
7. Cleansing.

When these subjects shall have been exhausted, I shall furnish two examples of Scotch brewings, explaining the various processes incidental to these operations from the first to the concluding stages.

GRINDING OR CRUSHING.

In England, there has long existed a difference of opinion, whether *grinding* or *crushing* is the more beneficial for the brewer; that is to say, whether he will obtain a better and a finer extract from malt ground by the mill-stones, or from malt bruised by rollers. My opinion is decidedly in favour of the latter system, providing the malt is good, and that the wort is for ale; and it appears to me a matter of surprise, that among so many intelligent and scientific men, there should exist such difference of opinion. Certainly if the malt is bad, the rollers will not crush it sufficiently; for, in this case, the barley has not been well malted, and consequently the pickles are tough, and at the same time flinty, instead of being short and meally.

There is another method employed for grinding malt, and that is by steel mills, constructed similarly to those used for the grinding of coffee. A machine of this kind, twelve or fourteen inches in diameter, and performing about one hundred and forty, or one hundred and fifty revolutions in a minute, will grind from six to seven quarters of malt per hour. This mill does not act upon the malt in the same way as

the mill-stones, or even the rollers. The malt passes through the mill so very rapidly, that both the husks and the kernels are cut; the latter not being reduced so to powder as by the mill-stones, nor crushed as by the rollers. This last mentioned method is simple and convenient, and can be performed at any time with the greatest facility.

Upon a cursory view, the ancient way of grinding by the mill-stones may appear the best; as we are apt to consider the more finely the malt is ground, the more readily will the liquor penetrate, and consequently we shall obtain a better extract; but in this there are two very great disadvantages. Brewers endeavour to set their mills so, that the stones may act uniformly upon the malt; but notwithstanding all their care, some of the smaller grains will only be partially ground, whilst the larger ones will not only be reduced to powder, but the husks will be so cut, or rather minced, as to impart a coarse, raw, meally flavour to the worts, in the infusing; and such flavour will be especially prominent in the finer kinds of ales.

Secondly, When the kernel is reduced to powder, it is very susceptible of *setting*, if we use liquor at a high temperature. It is not meant here by *setting*, that the whole of the goods will be shut up; this can only happen where the liquor used is upwards of 196° to 200°—and such a heat would never be contemplated by any brewer possessing a thermometer;—but they will be *partially* shut up, and the

extract will be sadly deficient. The paler the malt is, the more susceptible will it be of doing so. A third evil may here also be noticed. If the grist is very fine, the worts will not separate themselves so freely from the goods, in consequence of the holes in the false bottom being plugged up with the husks.

The brewer's main object is, to have his malt ground in such a manner, as to allow the liquor free access to every particle of the bruised kernel, in order to extract the good it contains. The husks, in that case, being merely crushed, and partially separated from the kernel, act as a filter, at the same time giving out only what is valuable in them. To obtain this object, the rollers seem better adapted than either of the other methods which have been noticed.

Whether the malt has been ground or crushed, it is of the greatest consequence to the after processes that it should not be used immediately after this first operation. Care should be taken that it be ground at least twenty-four hours before it is wetted, in order to allow the heat generated by the grinding, to escape. By this time the temperature will be sufficiently reduced, and the malt *mellowed*, except where the bulk is great. In this case, it will, of course, take a longer time before being ripe for use.

The malt will, by this means, imbibe the *liquor* more readily and effectually. It will give out a better extract than if it were used immediately after being

ground; a visible alteration will be found in the different stages of fermentation; and the ale will arrive much sooner at perfection.

Perhaps it may not be unacceptable to the reader to conclude this process by a quotation from Professor Donovan's Treatise on Brewing.

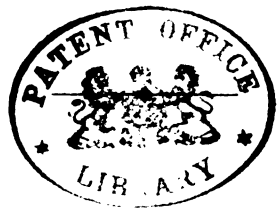
"If the malt be ground to a very fine powder, it will *set* with water at a less elevated temperature than if it be more coarsely ground; it will part with the water, so as to form a transparent solution with more difficulty; and the whole of the valuable portion of the malt will not be extracted. When the malt is merely bruised, or broken into moderately small parts, the water penetrates the substance of each, acts upon its interior, and afterwards is drained out of it, being in a manner strained by percolation through its interstices. It is certain, however, that but for the reasons just assigned, the more minutely the malt is divided in grinding, the more readily would its saccharine part be dissolved away; and it will be still a good method to grind tolerably fine, provided that due agitation be used. But if considerable agitation be not used, the fineness of the powder, by forming a paste permeable with difficulty by water, will rather obstruct than assist the solution; and a weak extract will be obtained. Length of time in mashing will compensate coarse grinding. If the malt be coarsely ground, allowing the hot water to act on it for a greater length of time, will at length dissolve every thing soluble from the grain.

But delays are particularly dangerous in brewing; and often to them may be attributed the commencement of sourness, which has ultimately destroyed the produce. In all cases, the husk of the malt must be completely detached from the grain; for so refractory does it prove to the permeating influence of water, that an unbruised grain of malt will remain long submerged without giving out its saccharine principle. But although the husk should be detached, it should by no means be broken down into powder; on the contrary, its hardness, size, and substance, have the effect of keeping the farina open and porous; the water is thus the better allowed to permeate, and there is less risk of setting.

"The principles which ought to direct us in the grinding of malt seem, therefore, to be as follow:—

"We should, if possible, totally detach the husk. We should break down the cohesion of the interior of the grain in such a manner, as that no part of its natural hardness should remain unsubdued. But the perfection of the process would be, if, having succeeded in subduing the cohesion of the grain, its parts were still to remain cohering, with just as much force as would prevent their falling into flour, yet would permit the complete entrance of the water amongst all the disintegrated particles. The nature of this would be best expressed by the word *crushing*. Were it possible to effect all this, the advantages would be, that it then becomes not only allowable, but highly beneficial, to use water of a higher

temperature in mashing than should otherwise be used, such as will with more effect produce the solution or evolution of the saccharine matter, (whichever the truth may be,) or, in technical language, produce a rich extract. This would be accomplished without danger of setting, or enveloping, instead of evolving, the sweet principle; and after the mashing, there would be found no difficulty in drawing fine transparent worts, without holding entangled any insoluble parts of the malt."



MASHING AND INFUSING.

The next process in brewing, which comes naturally under our notice, is mashing or infusing. In treating of this part of our subject, it may be necessary to divide it into two parts, namely, *taking the liquor* and *mashing*.

TAKING THE LIQUOR.

In the first place, to be properly directed in the choice of the heat of the liquor employed, is of the first importance. Much of our future success, both

in quantity and quality of extraction, depends upon the judicious management of the heat of the liquor for the first mash, as well as our attaining an early and spontaneous fineness in the barrel. Changes in the state of the atmosphere, &c. at this time, require a corresponding change in this respect. The great aim of all brewers is, that the wort, when it flows from the mash-tun, shall range from 147° to 152°, and if they succeed in this, and at the same time the worts part freely from the goods, flowing transparently, and carrying a fine white pearly head, they rest satisfied that the heats employed were judicious.

The very great mystery which many brewers make with regard to the heats they employ in mashing, can only impose upon the ignorant. Any one acquainted with the following circumstances, will at once see that no stated heats can be used as a standard, but that they must vary according to these circumstances.

In the first place there may be a variation in the atmosphere of 30°; and if so, both the grist in the mash-tun or elsewhere, and the liquor running from the copper, will be affected by this variation: they will, of course, cool much sooner when the temperature is low than when it is high; and the brewer ought to use his liquor several degrees higher in consequence. The heat of the atmosphere acting upon the grist also must materially affect it, causing it at one time to lose from twenty-five to thirty degrees, and at an-

other time from forty-five to fifty. This grist, were it tried in the bulk by a thermometer immediately after being ground, would vary from 80° to 90°; but, during the time it remains mellowing, the heat is gradually decreasing, according to the temperature of the atmosphere, while at the same time it absorbs moisture more readily than would be the case if the malt were unground. As this absorption is in fact equivalent to so much cold water, it will consequently require the liquor used in the mashing process to be of a higher temperature, especially if it has been ground for some days.

If the grist shall lose at one time 25° to 30°, and at another time 40° to 50°, it will make a material difference in the temperature of worts when running from the mash; and this being taken into consideration, there must necessarily be a corresponding alteration in the heat of the liquor. In many places the bulk of the grist is equal to that of the liquor employed; and some brewers make this their standard for the quantity of liquor for the first mash.

Suppose the bulk of the grist and of the liquor the same, and the heat of the grist at one time 60°, and at another time only 40°, by using one uniform heat for every first mash, the brewer will have a difference (as in the two supposed cases) of 20° in his wort, when flowing from the mash; and this will be the case, without taking into consideration the mean temperature of the air in the brew-house, as well as of its effects in cooling the liquor in the mash-tun,

during the operation of shooting in the grist. The next consideration is, whether the malt about to be used has been dried at a high or at a low temperature; because, as high-dried malt contains a smaller portion of starch than pale malt, the higher the malt is dried, the less danger there will be of setting, by using the liquor at a high temperature. We ought also to consider whether the malt has been ground finely or coarsely; because, when the malt is ground small, it will not allow of the liquor being used at so high a temperature as when it is coarse.

We must likewise be guided in regulating the heats of the liquor, by taking into account whether the ale is intended for immediate use or not. To determine this was formerly of great consequence to the common brewers in England, as the ale was then stored in vats, and kept there for some time before being brought into the market; but now it is of no importance, as large vats in England are almost universally done away with, and the brewers there now follow the plan in use with the Scotch brewers, in so far as they cleanse their ales in barrels, &c., for the purpose of getting them spontaneously transparent, as soon as possible, in order to obtain a quick return.

The regulation of the heats in mashing, being of so much importance to the brewer, it is my desire to give him every information in my power; and I shall for this purpose, in addition to my own experience, bring forward the opinions of others who

have written on the subject. The first quotation is from "The Philosophical Principles on the Science of Brewing, by John Richardson."—"In this preliminary part of the process, the skill of the brewer is very much to be exerted, as various malts require various degrees of heat, for the more advantageous extraction of their valuable parts, and the greater perfection of the product; to determine on which will materially rest in the judgment of the operator. Here it is to be observed, too, that the *first* liquor inevitably stamps a characteristical impression on the whole *gyle*, and as the complexion of the future product must receive a powerful tincture from the leading principle, so an error once committed in its application will ever leave traces of its influence, in spite of the efforts of the most judicious operator. Whence it is evident how much the *use of the thermometer* ought to be studied by the brewer, in order to insure him that certainty of success which he can by no dissimilar means obtain. Without this instrument, it is impossible he can accommodate his practice to the different qualities of his malts, so as to secure to himself every obtainable advantage. The discrimination of the senses is limited and irregular. Beyond the temperature of the body, our judgment of heat cannot reach, and within that degree it is very incompetent. In this business, the variation of a very few degrees, which the instrument only can determine, produces effects not less extraordinary in themselves, than important to the interest of

the brewer. It is here the foundation is laid of that desirable quality, *transparency*, which, by proper regulation of heat, according to the quality of the malt, may be procured in a few days, or postponed to as many weeks or months, agreeably to the convenience of the brewer, or the taste of the consumer.

" From these considerations may be inferred the vexatious consequences which often result from wrong practice herein; and it is a demonstrable truth, that many disgraceful properties of beers have here their origin, which being attributed to other causes, the operator is induced to persist in errors which ever lead to disappointment and loss." In a subsequent part of his work, entering more minutely into the subject, he proceeds thus: " From the nature of the constituent principles of malt, it is easy to conceive that the former, or saccharine or mucilaginous parts, yield most readily to the impression of water, and that of so low a degree of heat as would have no visible effect upon the latter. If, therefore, we are to have a certain proportion of every part, it is a rational inference, that the means of obtaining it rests in a judicious variation of the extracting heat, according to the several proportions required.

" A low degree of heat, acting principally upon the saccharum, produces a wort replete with a rich, soft sweet, fully impregnated with its attendant mucilage, and in quantity much exceeding that obtainable from increased heat; which, by its more power-

ful insinuation into the body of the malt, acting upon all the parts together, extracts a considerable portion of the oleaginous and earthy principles, but falls short in softness, fulness, sweetness, and quantity. This is occasioned by the coagulating property of the mucilage, which, partaking of the nature of flour, has a tendency to run into paste, in proportion to the increase of heat applied, by which means it not only locks up a considerable part of the saccharum contained therein, but retains with it a proportionate quantity of the extracting liquor, which would otherwise have drawn out the imprisoned sweet, thence lessening both the quantity and quality of the wort; and this has sometimes been known to have had so powerful an effect as to have occasioned the *setting of the goods*, or the uniting the whole into a pasty mass; for though heat increases the solvent powers of water in most instances, there are some in which it totally destroys them. Such is the presence of flour, which it converts into paste, besides those of blood, eggs, and some other animal substances, which it invariably tends to harden.

"From a knowledge of these effects, we form our first ideas of the variations necessary in the heat of the extracting liquor, which are of more extensive utility than has yet been intimated, though exceedingly limited in their extent, from one extreme to the other.

"The most common effects of too low a heat, besides sometimes producing immediate acidity, are

an insipidity in the flavour of the beer, from a deficiency of those characteristical qualities before mentioned; and a want of early transparency, from the superabundance of mucilaginous matter, extracted by such heats, which, after the utmost efforts of fermentation, will leave the beer turbid, with such a cloud of its lighter feculencies as will require the separation and precipitation of many months to disperse.

"The contrary application of too much heat, at the same time that it lessens the mucilage, has, as we have before seen, the effect of diminishing the saccharum also; whence that lean, thin quality observable in some beers; and by extracting an overproportion of the oleaginous and earthy principles, renders the business of fermentation difficult and precarious, and impresses an austerity on the flavour of the liquor, which will not easily be effaced.

"Yet the true medium heat for each extract cannot be universally ascertained. An attention not only to the quality of the malt, but to the quantity wetted, is absolutely necessary to the obtaining every due advantage; nor must the period at which the beer is intended for use be omitted in the account. The quality of the water, also, claims a share in the consideration, in order to supply the want of solvent force in hard, and to allow for the natural lightness and fermentative quality of soft; a particular to which London, in a great measure, owes the peculiar mucilaginous and nutritious qua-

lity of its malt liquors; though it is not an improbable conjecture, that the water of the *Seine*, and of some other large rivers on the Continent, would produce similar qualities by similar application.

"Although the variations above alluded to are indispensable, it is easy to conceive, from the small extent of the utmost variety, that they cannot be far distant; if, therefore, we know that a certain degree extracts the first principles in a certain proportion, we need not much consideration to fix upon another degree that shall produce the required proportion of the remaining qualities, and effect that equal distribution of parts in the extract, which it is the business of fermentation to form into a consistent whole."

From these quotations it is manifest, that the operator must be guided in the regulation of his heats by the circumstances in which he is placed; but yet Mr. Richardson is not sufficiently clear in giving practical rules for this purpose; and the same mystery already noticed, which has been thrown around the subject by many brewers, when the heats of their liquors have been inquired into, is apparent here. It was not, however, the intention of Mr. Richardson to put the public in possession of all he knew, at the time when he published his Treatise, but only to make them so far acquainted with the subject as to create in them a desire to be farther instructed. The more valuable part of his informa-

tion, accordingly, he communicated to such only as became his pupils, and were willing to advance a sum of money for that purpose. About the same time, also, he sold a manuscript for one hundred and fifty guineas, containing all the "mysteries" of the art, on condition that it should not be made public for twenty years. That his principal inducement for publishing this Treatise was to recommend his Saccharometer, and by this means bring it into general use, can scarcely admit of a doubt; and, by doing so, he certainly conferred a benefit upon the public.

The next quotation is from Mr. Booth, who, in his "*Art of Brewing*," copies the instructions contained in the manuscript alluded to.

FOR MILD ALE IN GENERAL—HEAT OF THE LIQUOR.

"This being an ale which requires early purity, the first heat of the liquor must therefore scarcely ever, be under, and is not seldom above, 180°, to which 5° are to be added for the second mash, and 5° more for the third where three mashes are made for strong ale; but where there are two only, the addition may be 10°; that is, 180° and 190°. If however, you find by experience that a lower heat of the liquor will produce purity, this will be a preferable practice, as producing a more mucilaginous wort, and it is better calculated for making small beer

after it. It is therefore advisable that you begin with the heat of the liquor just mentioned, and then try 175° for the first mash, varying 5° at a time in different brewings for the sake of practice and experience. Sometimes, indeed, when I take my first heat at 180°, or higher, I only increase 5° for my second, though I have but two mashes for strong ale, in order to avoid that thinness on the palate which too high a heat is sometimes apt to produce."

The third quotation is extracted from a work recently published in London, under the title of "A Practical Treatise on Brewing," by W. Black.—"The next subject we shall discuss is the heat and quantity of liquor to be turned over the first mash. This is a point of very great importance, as I may say the whole after success of the brewing depends upon it.

"In my judgment, the whole of the extract should be made in the first mash, all that is required afterwards being merely to wash out what remains in the goods: those who go farther may do more harm than good, as they only obtain mucilage, which, instead of enriching, impoverishes the beer. That the extract is obtained in the first mash is distinctly shown in regularly mashing with the same quantity of liquor, when, by comparing the gravities of the different taps, it will be seen that you go on in regular gradation, washing out the extract until you get all that you can. Many people make a very great mystery of their heats for mashing all through. I

hold the heats after the first mash to be a point of very little importance, if you get your extract properly in the first instance. Others say that high or low temperatures in your mashing, make very great differences in your fermentations. All that I can state is, that I never found it so. I do not say so, however, with regard to the first mash; because, unless you take a proper temperature for that, you will not make a good extract, but, on the contrary, perhaps, produce an unsound one, which may materially injure your fermentation. After the first mash, however, I will allow any—the first brewer in England—to dictate my heats from 180° to 204°, and I will undertake that both my extract and fermentation shall be quite as good as his, and either slow or fast, as he may choose.

"I shall now proceed to give such certain rules as to the temperature of the first mash and the quantity of liquor to be turned over, as I think no one can mistake. I believe it is an admitted point, that if your first taps, when half run down, show by the thermometer a temperature between 138° and 152°, you cannot be far wrong; I shall take 145° as the medium. For pale beers, therefore, your taps should be from 145° to 152°; allowing a range of 7°. For brown beers your taps should be from 138° to 145°. All we have to do, therefore, is to regulate the heat of the liquor so as to produce this effect.

"To accomplish this, you must first ascertain by the thermometer the heat of the grist in the mash-tun, which may range from a temperature of 32° to

80°, according to circumstances and the season of the year.* I shall take again a medium, say 58°, for the heat of the grist, a temperature, then, of 175° for pale beer will generally make your taps spend within the given range, and 160° to 165° for brown beer will do the same. We never, however, require a difference in the temperature of the mashing liquor of more than from 10° to 15°, let the temperature of the malt be what it may."

The last quotation I propose to make on this part of the process, is from a very useful work on Brewing and Malting by Mr. G. A. Wigney, who certainly appears anxious to give every information, and to withhold nothing from interested views. As the rule he has laid down for choosing the heat of the first mash is, on the whole, very judicious, without any further comment, I proceed simply to quote :—

" Having endeavoured to point out clearly the necessity of correctly taking a right first mashing heat, and such being done, then properly mixing the malt and mashing liquors, and with as much speed as possible, I will next endeavour to point out the means by which may be ascertained, what should be the correct mashing heat, of the liquor, so as that the

* Mr. Black's range of heats from 32° to 80° must be erroneous, as it is impossible for the grist ever to be reduced so low as the freezing point, or to continue so high as 80°, if it is allowed to remain from twenty to forty hours, which is the usual time, covered up in the mash-tun, or elsewhere, after grinding. I have never found the temperature of the grist under 42°, nor above 68°, and seldom, indeed, have I experienced such extremes.

mean temperature of the goods when mashed, may be at from a 144 to 150 degrees of heat, or thereabouts.

" But before I attempt to inform the reader of the method, I must inform him that I by no means consider it a perfect one, but as probably the best which may be attainable.

" The principle of the method is to ascertain the heat and weight of the malt, then to find out the weight of the liquor intended to mash with; and taking the mean temperature of the goods after mashing, at any point from 144 to 150 degrees; then to deduce therefrom, at what temperature the mashing liquor should be, so that the admixture may be of the required heat.

" Example.—A Brewer is required to mash 20 quarters of malt, weighing 40 lbs. per bushel, and at a temperature of 50 degrees, with 40 barrels of water, weighing 360 lbs. per barrel, and it is required that the heat of such malt and water when mixed, should be at 144 degrees. Query! What should be the heat of the 40 barrels of water?

Weight of malt, per bushel, - -	40 lbs.
Bushels per quarter, - - -	8
Weight of one quarter malt, -	320
Quarters of malt to mash, - -	20
Weight of 20 quarters of malt, -	6400
Heat of the malt, - - -	50
Heat and weight of 20 qrs. of malt,	320000

Weight of an imp. bar. (36gs.) water, 360 lbs.
No. of bars. of water for mash, - 40

Weight of 40 barrels of water, 14400
Weight of 20 quarters malt, - 6400

Weight of 40bls. water & 20qrs. malt, 20800
Required heat of water and malt, when mixed, 144 degrees,

83200
83200
20800

Total heat and weight of goods, 2995200 when mashed.
Substract heat and weight of 20 qr. of malt. 320000 degrees.

Divide by the weight of 14400lbs. 40 barrels of water, -)2675200(185¾° of heat of mashing water.
14400

123520
115200

83200
72000

11200
4

14400)44800(3
43200

1600

" To a reflecting person, the imperfections of this rule, will doubtless be apparent. The liability of a difference in the temperature of the malt, in different parts of the same heap; the difference between

the weight of a single bushel of malt, weighed for the occasion, and the proportionate weight probably of the whole grist; the difference between the weight of a barrel of cold and hot water; the difference between the weight of a barrel of water and return wort; the loss of heat during the process of mashing; the increase in active heat, arising from the conversion of latent into active heat; the consequence of decomposition by solution; and a few other points may be urged against the method.

"But it should be observed that all these objections, and others in addition, may, with as much and more propriety, be made to any fixed and arbitrary standard of heat, which is adopted upon any other principle, and it does not follow, that because we cannot attain to perfection, that we should not approach as near to it as we can, consistent with the convenience of common practice, based on careful and industrious principles. And to judge fairly of the merits and value of a system, we should weigh the products against the cost, the labour, and the inconvenience of carrying it into effect."

I come now to notice the heats generally employed by brewers in Scotland, which are considerably higher than those of the English brewers. Those heats range from 178° to 188°, and even to 190°. But it may not be out of place here to observe, before proceeding further, that the practice in Scot-

land differs materially from that in England. In Scotland, instead of introducing their grist into the mash-tun first, and afterwards running the liquor under the false bottom, the liquor is previously run into the mash-tun, and when the heat is reduced to the desired temperature, the grist is allowed to fall into it from a receiver, in the shape of a hopper, where it has been conveyed for the purpose, and which is conveniently placed above the mash-tun. Some brewers, however, have no such vessel; but having ground the malt into sacks, they empty the grist from them directly into the mash-tun. In either case much of the farina of the malt escapes, even although a screen is employed, which is sometimes done to prevent it. It is not likely that the English brewer will adopt either of those modes in preference to his own; his mash-tun into which his malt is ground, being provided with a cover, which prevents the dissipation of those particles which form the most valuable parts of the malt.

When the temperature of the atmosphere is about 45°, they generally employ their liquors for the first mash at a heat of about 180° to 182°. Some, however, prefer 185°; and it is well known that 190° have been frequently used. These heats, of course, vary according to the temperature of the atmosphere at the time of mashing, and other casualties already noticed. It may, however, be remarked, that it was the universal practice of the brewers in Scotland

to use only the palest malt for their finer ales—a practice which has been creeping out gradually of late years.

After the experience of several years, I have found the average temperature of the atmosphere in Scotland, at the brewing seasons, to be about 42°. The heat that I take for the first mash, in those circumstances, is 180° turning on for the first running, four-fifths of the whole of the liquor I intend to use. After mashing about twenty-five minutes, I then turn on the remaining fifth on the goods, at an increase of 5° of heat, to make up for the loss of temperature which necessarily takes place during that time, and continue the mashing until it is finished. This has not been the practice of the Scotch brewer, although of such obvious importance.

The next point which comes to be considered is, the quantity of liquor used in Scotland in proportion to the malt; and when the reader is informed that the Scotch ales vary in price from L.3 to L.8 per hogshead, he will see how impossible it is to give any correct idea of this proportion, unless we fix upon one of these qualities. Suppose we take L.5 ale as an example. At this price, the proportion in bulk is nearly equal, and generally about one and a half barrel of liquor are used to each boll of malt.* My own practice for this class of ale has been, to

* A boll contains six imperial bushels, and consequently is one-fourth less than a quarter.

use about one and a half barrel in the first mash to each quarter of malt; four-fifths being turned on at first, and the remaining fifth at the middle of the mashing, as before described.

The process of mashing in Scotland, by means of oars, so much in use formerly, is the same as in England. It is performed with the greatest care, until every ball or lump is broken, and the whole uniformly mashed. When this process is completed, about a bushel of grist is equally strewed upon the surface of the mash, which, by forming a temporary paste, retains the heat, and keeps up the temperature. The time generally employed in mashing is from forty to fifty minutes. The mash-tun is then covered up, and allowed to remain in that state from two to three hours, according to the heat of the air. This being done, the tap is then set, and the wort allowed to run into the under-back, or, according to the practice of one or two breweries, into the wort-copper.

It may be proper here to state, that the brewers are provided with two or three coppers, one of a small size for liquor required for various purposes in the brewery, the second for the mashing liquor, and the third for worts alone. In one or two breweries the wort-copper is placed lower than the mash-tun, in order to allow the wort to run direct into it, instead of into the under-back; thereby avoiding the necessity of using the pump.

Of late years the mashing-machine has been

adopted instead of oars, in almost every brew-house of note in Edinburgh. This machine is certainly valuable, inasmuch as it obviates the necessity of manual labour; and in distilleries and porter breweries it is further valuable, because it is the means of producing a better extract; but as the object of the brewer is to obtain for his ale only the richer and less mucilaginous part of his wort, this very powerful and searching process operating upon the goods or mash is not advantageous to him, as his first wort must necessarily contain much of the grosser portions, which should be left for the second or last extraction. It is an acknowledged fact, that the liquor first drawn from the mash, even should it be of less gravity than the wort from a second mash, is yet much more valuable, because it contains more of the *saccharum*, and less of the *mucilage*.

When the wort commences running from the mash tun, the greatest care is taken that the taps shall only be partially set. This is necessary in order to regulate the volume of the wort, for otherwise the pressure would be so great that a portion of the sediment would be drawn out along with the wort, and would, of course, render the whole thick and muddy. After running for a short time, and when it appears transparent, the volume is gradually increased. I may here allude to a practice which formerly prevailed and still is in use, in order to insure the transparency of the worts, that is, when the tap is set, a pailful is drawn off and immediately returned into the

mash-tun. If before the pail is quite full the wort appears to be transparent, it is allowed to run into the under-back; if not transparent, a little more is drawn off. By means of this partial setting of the tap, another evil—and that a very serious one to those who brew upon the Scotch system—is avoided, namely, the cracking of the bed of the grains in the mash-tun in consequence of the great pressure. Indeed, so careful are brewers to obviate the possibility of this injurious effect, that they have now two or more taps of a smaller diameter to equalize the pressure.

If this evil has occurred, the liquor, when put on in the third process, namely, that of sparging, instead of remaining equally diffused through the bed of grains, and by gradual percolation obtaining a good extract, would be immediately diverted into the channel which has been formed by that pressure, and consequently the extract would be deficient. These remarks, however, are only calculated for those who draw off a considerable portion of the wort before they proceed to the operation of sparging.

The brewer now naturally watches with anxiety the appearance of his wort in the under-back or wort-copper. If the heat of the liquor has been judiciously applied, the wort will not only be transparent, but will exhibit a fine light pearly head of considerable height. If, on the contrary, the colour be deeper than that of the malt employed, and if the froth be of a reddish, fiery appearance, and deficient

in height, although it be transparent, there is every reason to fear that the mashing heat has been too high. Again, if the wort while flowing from the mash assumes a turbid, dead appearance, it may be justly concluded that the liquor used has been of too low a temperature.

It is assumed that every practical brewer is aware of the capacity of his vessels, and can at any time tell by his gauge the number of barrels or gallons they contain; for without the most accurate knowledge in this respect, he will not be able to judge of the quantity of liquor which will be necessary, after mashing, to turn on for Sparging—the process which now falls to be considered.

SPARGING.

This process is adopted by the Scottish brewer in lieu of a second mashing; on the other hand, the English brewer draws off the whole of his wort before he mashes a second time. The practice of the Scottish brewer is to commence sparging very soon after the taps are set, or, as it is termed, *slacked;* others commence to sparge immediately upon the taps being

set, and, indeed, some commence before they *slack*, and continue this operation without intermission until the desired quantity of extract has been obtained; the taps are allowed to run meanwhile, in order that the wort may run off in nearly the same proportion with the liquor which is sparged on. Others, again, before they begin this process, allow a fifth or more of the wort to run off, but this practice varies, some allowing more to remain, others less. Be this as it may, it is absolutely necessary to ascertain the exact quantity remaining, and the brewer can only judge of this by knowing the quantity of liquor which the malt will absorb or retain. A quarter of pale malt will absorb about a half hogshead, or twenty-seven gallons of liquor, unless the quantity wetted be very great; a greater quantity will absorb less.

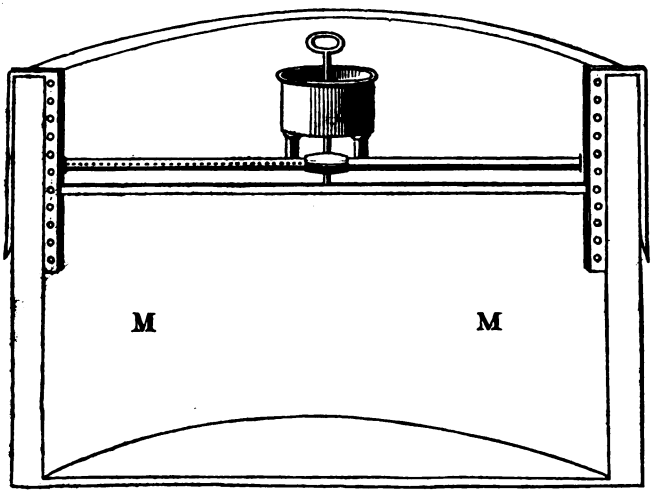
From what Professor Donovan states in his article on brewing, in his work entitled "Domestic Economy," p. 203, it appears that the opinion of that writer as to the quantity of liquor imbibed or absorbed by malt is very different from what has just been stated. His calculations produce almost double the quantity. He says, that, "in calculating the quantity of water necessary to produce a given quantity of a first mash, it will be of use to know that an imperial bushel of ground malt absorbs and retains about 6¾ imperial gallons of water." From my own experience, which is in accordance with all the authorities I have consulted, it appears to me

that Mr. Donovan has greatly over-estimated the quantity of water which is absobed by the malt. In no case have I found it to exceed three gallons and a half; and when larger quantities of liquor are employed, it is generally much less.

On this subject I have considered the question, whether Professor Donovan was led into this erroneous calculation by making his experiment on a small scale, when the result might have been very different from what it would have been if made on a large, or even a moderate scale; for, in the latter instances, I was satisfied that he is mistaken. Having a very small mash-tun, capable of mashing half a peck, and having obtained a quarter of a peck of the very best malt, which, before being ground, weighed two pounds and a half, and, after being ground, measured about five English pints, I run upon it six English pints of liquor, at a temperature of 182°, and, after mixing it thoroughly, I allowed it to remain undisturbed for the space of two hours and a half. I then set the tap running, and obtained about four pints and a quarter of wort, leaving with the mash one pint and three quarters. Now, as there are only sixteen quarters of a peck in a bushel, and as each quarter of a peck has been found to absorb only one pint and three quarters, those sixteen quarters will absorb twenty-eight pints, that is, three and a half instead of six gallons and four-fifths, as Professor Donovan asserts.

I now proceed to observe, that sparging may be

defined as the process of equally sprinkling or trickling hot liquor over the surface of the goods by a continual and uniform shower. This operation is performed by running the liquor into a vessel called a sparging machine, a figure of which the reader will find at the end of this article. The mashing machine is so contrived as to allow the sparger to work on it. Where a mashing machine is not used, an iron bar is thrown across the tun, supported at each end by a loop of grooved iron, with several holes bored to admit pins. This bar is made to fit into the groove, and can be raised or lowered by shifting the pins, which are placed in the holes for the purpose of supporting the bar. When the operation is concluded, and the sparger taken off, the temporary iron bar with its support is removed. The engraving subjoined renders any more minute description of this machine unnecessary here, as it is accompanied by a technical explanation in a subsequent page.

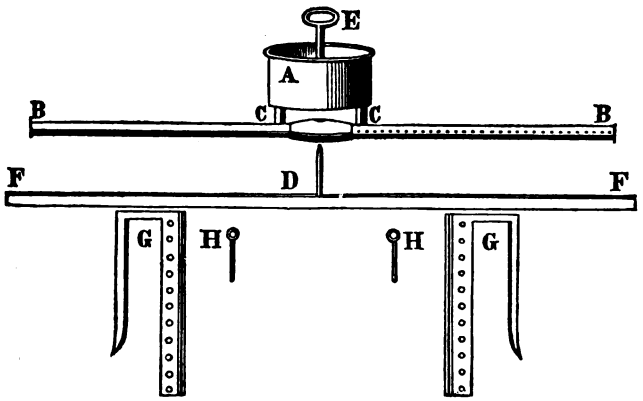


The Sparger is a copper tube of about one and a half to two inches in diameter, divided into two equal parts or arms, closed at each end, (having a line of small holes perforated on their reverse sides,) and a cup or receivér, also of copper, of about twelve or fourteen inches in diameter, and from eight to ten inches deep, having a hollow tube up the centre, terminated by a handle, and a conduit on each side of the tube at the bottom. In the centre of the bar which is placed across the mash-tun a pin is fixed, which, when the sparger is lowered, runs up through the centre of the cup to the handle, and works on a pivot there. This cup receives the hot liquor, which is thence conveyed by the conduits into each arm of

the machine, turning it round, and flowing out at opposite sides in a regular and constant shower upon the goods below.

I now proceed to the method of using the sparger. The heat of the liquor employed for sparging is generally from 8 to 12 degrees higher in temperature than that used for the first mash; but, here it must be observed, that the heat is taken from the copper instead of from the mash-tun. The liquor is run by a shute from the copper into the receiver, or cup of the sparger, and falls into the cylindrical tube, called the wings or arms, setting it immediately into motion; and, at the same time, flowing through the small holes in a light shower over the mash. From ten to twelve barrels of liquor hourly can be sparged in this way.

As the description already given, and the first engraving of the sparger fixed in the mash-tun, may not have conveyed to the reader's mind a distinct idea of its detached parts, I have considered it necessary to insert a second engraving, described in detail, and figured.



A. cup or receiver, BB arms, CC. conduits for supplying the arms, D. pin in the centre of the bar, which runs up the cylinder through the cup to the pivot, (a piece of steel placed just below the handle E,) E. handle of sparger, F. bar which is thrown across the mash-tun, GG. grooved iron loops to support the bar, HH. pins which support the bar when in the loops.*

This process of sparging is, in my opinion, decidedly preferable to a second mash for ale worts, and has ever been considered in this light by the whole of the Scottish brewers. Indeed, of late years, the great proportion of the more scientific and experienced brewers in England have adopted it, and have,

* This machine is made by a coppersmith in Leith, and varies in price from four to six guineas.

I believe, found it the more advantageous method. There may still be some apt to remain prejudiced against this process; and I am led to this conclusion by the fact, that the scientific Mr. Richardson entirely condemned and ridiculed the practice, as will appear by his own words, which I now quote from his "Treatise on Brewing:"—

"By the use of the Saccharometer, also, we are enabled to detect that absurdity in the practice of many country brewers, which the notable dames of yore agreed to call *leaking on*, a term which means nothing more than the continued sprinkling of water upon the malt, after the tap is nearly spent, till the quantity of wort is produced which the brewer thinks will yield the required length, or quantity of beer, without any regard to the quality of the malt, or that of the wort so produced.

"The least reflection, without the aid of this instrument, will point out the absurdity, though reflection alone will not inform us how much is lost; for what power, or what time, has a fluid to extract, which is sprinkled over the surface of the materials, and immediately trickles out below, without being allowed a stationary moment for infusion?" Such are Mr. Richardson's views of sparging; and assuredly, he has been led to form so unfavourable an opinion by the want of due consideration; or, being prejudiced against it, he has not put it to the test of experiment.

Our practice, with regard to the method of sparging, is to draw off a small portion of the wort; and, just before the surface of the bed of the mash is uncovered, to commence and continue, without intermission, the taps being kept open, until the number of barrels of liquor we intend to use for this purpose is run from the copper. It is of consequence that the surface of the mash should not be exposed to the atmosphere, as the goods are very apt, especially in warm weather, to acetify from the imbibing of oxygen. I am of opinion, that acetification has often taken place through want of this precaution; and am inclined to think, were brewers more generally to take this into consideration, and act accordingly, they would not run the risk of incurring so much loss as they now do, by the frequent return of sour or hard ale; at the same time I would not be understood to affirm, that this is the sole cause of the souring of ale, nor even, in every case, the assisting one, for worts, perfectly sound in the under-back, may yet be acidified by other means, either during the processes of cooling or fermentation, or afterwards when in the casks. It must be allowed by all who have studied the subject, that the extraction is complete after the first mashing, provided the heat of the liquor has been judiciously applied, the process of mashing so well conducted as to secure a thorough equality in the mixing of the mash, and a sufficient time has been allowed for the infusing. I have already noticed that the brewer, when he has

determined on the gravity of his wort, will judge of the quantity of liquor necessary to be used for mashing and sparging; and he will find by the gauge in the under-back or wort-copper, whether this quantity has been sufficient, and also the strength or gravity by applying the Saccharometer.

But were I to stop here, and not to take into consideration the loss he will sustain by evaporation and consequent contraction in the cooling of the wort, and, at the same time, the increase of gravity occasioned through the same cause, I should be guilty of an omission which might lead the operator to form a very erroneous judgment, and, consequently his results would be most unsatisfactory.

Before entering into the details of expansion and contraction, I may briefly remark, that the increase of gravity through condensation will be readily ascertained, by using the Saccharometer with the Thermometer and sliding-rule, as noticed under the article "Saccharometer." Indeed, the loss of quantity may be ascertained by the same means, for the increase of gravity will take place by the extract becoming more dense through the evaporation of the watery parts. When the whole of the ale wort is run off into the wort-copper, or is pumped from the under-back into it, and the quantity and gravity ascertained by means of the gauge and Saccharometer, the operator proceeds immediately with the process of boiling. In the meantime more liquor has been heated in the liquor-copper, for the purpose of again sparging to

exhaust the mash of its remaining extract, in order to obtain an inferior ale, or table-beer, or, in lieu of these, a return wort. The Scottish brewers very seldom sparge or mash for a return wort, and for this they have several reasons. In the first place, the great proportion of mucilage to that of saccharum which still hangs about the goods in the mash-tun, after the first mashing and sparging, would cause this wort materially to deteriorate that of the succeeding brewing, by imparting to it a coarse, meally flavour. Secondly, as the surface of the mash must necessarily have been long exposed to the air, through protracted sparging, there is a great probability that the wort taken from it would prove unsound, especially should the weather be warm. The most ruinous consequences in that case must necessarily ensue to the succeeding brewing, as this return wort would impart to it the brewer's greatest enemy—acidity. And, thirdly, there is so great a consumption of table and small beer in Scotland, that it is more advantageous for the brewer to sparge for them, than to run the risk of the probable evils accruing from a *raw* or *return* wort.

With regard to small beer, not only is it drank at the tables of all the respectable classes in this country, but it is in general use even among the lower orders.

Some few years ago it was very general with the Edinburgh table-beer brewers to evade the greater part of the duty on table-beer in a most ingenious

manner, and this they did generally with impunity, after the Excise officer had left the brewery for the night. I shall make a short quotation from the Supplement to the Encyclopædia Britannica on this subject.

"About twelve years ago, it was customary with some of the small beer brewers in Edinburgh to make the small beer of considerable strength, and after the Exciseman had determined its quantity, and the duty to be paid on it, they diluted it largely with water, just when they were sending it out of the house. This fraud was easily put in practice, because the small beer is usually disposed of the moment it is mixed with the yeast, and before it has undergone any fermentation whatever. It ferments sufficiently in small casks, in which it is sent to the consumers. In Edinburgh it is customary to bottle this small beer, which makes it clear and very brisk, and, consequently, very agreeable to the palate."

If we may believe a tradition current in Scotland, this method of rendering table-beer brisk by the addition of cold water, arose from accident. A brewer's drayman going his usual round one day, accidentally spilt a considerable quantity of the beer contained in one of the casks. To prevent his master becoming acquainted with his carelessness, he filled up the cask with water, at the first stream he passed, on the road to Musselburgh, and left it at the nearest public-house, which was kept by an old woman, a regular customer, and a person whom he thought was less

likely than others to discover the inferiority of the beer. Going some time afterwards to Musselburgh, he called for the old woman, expecting a severe rebuke for leaving her such sour, weak trash, and dreading its being returned. He was as much pleased as astonished to be informed, that it was the best beer she ever had, and that she hoped his master would always brew such, as her customers were much pleased with it—in fact, she never had had beer that took the bottle so soon, and was so fine, sharp, and brisk. Upon his return home, the drayman told his master all the particulars of the accident and its consequences, who improved upon the hint for his future advantage. From this story, small beer, when it is very brisk, is often designated by the vulgar "Musselburgh Broke." This small beer is very weak, which may be easily believed when we are informed that, when it is bottled and corked, it is sold for ninepence to one shilling a dozen.

BOILING.

The process of Boiling is conducted in Scotland in the same way as in England; and various opinions are entertained in both countries with regard to the length of time necessary for the purpose. In general, it may be safely asserted that the brewers in this country boil their worts for a shorter period than those in England. The time of boiling for ale wort ranges in Scotland from one hour to one hour and a half. For my own part, I am no advocate for long boiling. The boiling of this wort for a longer time than one hour extracts the coarse flavour of the hop, while the fine aroma, being more evanescent flies off with the vapour, which may be sensibly felt at this time on our approach to a brewery. In this stage of the operation, the great object of the operator ought to be to preserve the delicate aroma of the hop, as well as to prevent the other evils consequent on too long boiling. The fine flavour of the ale very much depends upon a careful attention to these particulars. It may be necessary, however, to caution the operator against the other extreme. A

sufficient time for boiling is necessary, not only to extract the aromatic flavour and the preservative principle of the hop, but to coagulate the superabundant gluten of the first wort. This coagulation, or, as the brewers term it, "the breaking of the wort," can be effected only by boiling. In that process the gluten is separated from the worts; part adheres to the hops, and falls to the bottom with them, while the remainder, by increasing in bulk, floats in large flakes, leaving the wort quite transparent; and which may be ascertained by the usual method of taking out a sample from the copper for inspection. The samples are taken out several times during the process of boiling, the wort at each inspection becoming more and more transparent, and the flakes larger. When the period arrives when it should be turned out, the hops with the flakes will be seen to fall immediately to the bottom of the sample vessel.

With regard to the *quantity* of hops which the brewers in Scotland use for each quarter of malt, it is impossible to fix any certain data, as it varies from four to eight pounds, according to the quality of the ale, and the season of the year. In winter-brewings, six pounds of hops for the best ale, and four for the inferior kinds, may be considered a fair estimate.

Our practice in brewing, from January to March, was, to allow ten pounds of hops per quarter of malt, when the wort was from 95 to 100 of specific gra-

vity. Four pounds of the hops were put into the copper when the wort was about 200° of heat, and boiled briskly for the space of twenty minutes; the remaining six pounds were then added, and allowed to boil thirty or forty minutes, according to circumstances. If the gravity of the wort was from 85 to 90, we only made use of eight instead of ten pounds of hops per quarter, boiling four pounds for fifteen minutes, and the remaining four pounds from forty to fifty minutes, as mentioned above. But if the gravity of the wort was only from 70 to 80, seven pounds a quarter only were employed. Two pounds of these were boiled for twenty minutes, and the remaining five pounds put in and boiled for forty or fifty minutes, as before.

These three examples, it must be understood, were first worts, and for high priced ales. When, as in the first example, the whole of the strong ale wort of 95 of gravity is in the copper, and, instead of table beer, an inferior ale is to be produced from the after running, some brewers in Scotland, instead of reboiling the hops, which have had their finer flavour and unctuous principle already drawn off for the strong ale wort, employ fresh hops, which they boil from one hour and a half to one hour and three quarters.

To obtain, however, the remaining properties, as well as the malt extract that the former hops still retain, they either infuse them in hot liquor, which infusion they add to the second ale wort in the cop-

per, or they allow the hops to remain in the hop-back, and run the second ale wort over them from the copper when boiled.

This practice is not so expensive as at first sight it may appear, because not only has the malt extract absorbed by the hops been obtained, but, as much of the remaining valuable parts of the hops have also been extracted, a smaller portion of these is necessary for the second boiling.

When the wort for the first ale, as in the second example, was 85 to 90, and when, instead of converting the last running of the worts into an inferior ale, it was employed for table beer, the same hops were again boiled with it for two hours.

When, as in the third example, the ale wort was only 70 to 80 gravity, the last running was used for small beer instead of table beer; and, in like manner, the same hops were boiled with it for about three hours.

It will be observed, that the quantity of hops we made use of exceeds the proportion generally allowed by Scottish brewers, and that, in the three examples given, no portion of the hops was put into the copper until the wort was within a few degrees of the boiling point; and until this portion had boiled for twenty minutes, the remainder was not added. The result was, that we obtained for the finer ales the more delicate flavour of the hops, while much of the unctuous quality was still left to be imparted to the inferior ales or beers. Neither

this, nor reboiling the hops, is the general practice; for many brewers put in the whole of the hops at the time when the wort is pumped into the copper.

In brewing from October to December for the winter and spring consumption, we were in the habit of using the same proportion of hops to malt as Edinburgh brewers, namely, from four to six pounds per quarter; but still managing the process in the same manner as in the three examples above given. The hops we preferred were the East Kent, and Worcestershire; and these were what were used in the preceding examples.

Before the wort is turned out of the copper, it is customary to take a sample for examination by the saccharometer, to ascertain whether it is of the gravity it was intended to be before fermentation. At this time a considerable increase of gravity will be shewn, not only by its becoming more dense through the evaporation of the aqueous parts, but by what it has now gained from the hop; while, at the same time, it has lost considerably in bulk, which will be found by the gauge. This method of judging by the gauge will be erroneous, in consequence of the hops retaining and absorbing a considerable portion of the wort, and this portion in the first worts, if of high gravities, will be upwards of one-half gallon to each pound of hops. The less the density of the wort, the smaller, of course, will be the portion absorbed or retained.

It must be born in mind, that although the first wort is more dense at this period than it was, yet, as the quantity is much less, the brewer has absolutely lost considerably in this wort. The amount of this may be easily found, by multiplying the number of barrels he now has into their gravities; and, taking for granted, that he found the total amount of extract in the copper, before the hops were added, he has only to subtract the amount of the boiled wort from the raw. By this loss of gravity in the first, he will be a gainer in the second boiling, which will gain in gravity exactly what the former has lost; as the hops will part with the rich wort they imbibed, and this wort mingling itself with the second, will enrich it accordingly, as has just been stated.

The scientific Mr. Richardson was one of the first to experiment upon worts during this process, and has compiled a table shewing the quantity of wort retained by different quantities of hops, in which he states, that sixty pounds will absorb thirty-six gallons.

By those who are not in possession of this table, the insertion of it here will be considered valuable.

Hops used.	Wort imbibed.	Hops used.	Wort imbibed.	Hops used.	Wort imbibed.	Hops used.	Wort imbibed.
1	0.01	11	0.17	30	0.50	400	6.66
2	0.03	12	0.19	40	0.66	500	8.33
3	0.05	13	0.21	50	0.83	600	10.00
4	0.06	14	0.22	60 Bar.	1.00	700	11.66
5	0.08	15	0.24	70	1.16	800	13.32
6	0.10	16	0.26	80	1.33	900	15.00
7	0.11	17	0.27	90	1.50	1000	16.66
8	0.13	18	0.29	100	1.66	2000	33.30
9	0.15	19	0.31	200	3.33	3000	50.00
10	0.16	20	0.33	300	5.00	4000	66.66

The experiments and the statements of other scientific brewers who followed Mr. Richardson, prove the accuracy of the above table. As the method he adopted to obtain his end for this purpose was very ingenious, I shall give the following extract from his treatise.

"OF THE EFFECTS PRODUCED IN THE DENSITY OF WORTS BY BOILING, AND BY THE ADDITION OF HOPS.

"Having boiled the first wort above mentioned, (31·47 barrels, 28·5 lbs. per barrel,) its usual time, I found, that of the 31·47 barrels, there remained only 21·5 when properly cooled; and on applying the instrument to discover its specific gravity, I perceived that it had increased to 34·25, lbs. per barrel. Multiplying, therefore, 21·5 by 34·25, the product

of which was only 736·375 lbs., and deducting that sum from 889, the sum of the fermentable matter originally extracted, I discovered a deficiency or apparent loss of 152·625 lbs. of that fermentable matter.

"Being well aware that this deficiency could not arise from evaporation, which, as has before been explained, can only carry off the aqueous particles, I was convinced that the absorption of the hops used was the true cause of the loss, which induced me to commence an immediate inquiry on that subject."

After experimenting on the hops to ascertain the amount of gravity imparted to the wort by them, which, he states, is about one pound density for every ten pounds of hops, he proceeds:—

"I inclosed a half pound of good hops in a tin case, perforated with small holes, and sufficiently large for the purpose, suspending it by a string in the middle of a copper of first wort, which was suffered to boil one hour and a half. It was then hung up to drain, till the inclosed hops were in the same state with those in the hop-back, from which the whole wort had drained. I next weighed a pint of the wort, when at a standard temperature, and found it to weigh 9862 grains nett. The original weight of the hops (calculated at 440 grains per ounce, from the necessity of making use of weights so proportioned) was 3520 grains, which, by the addition of the imbibed wort, was increased to 25080. The

dissoluble parts of these hops, which must have been extracted, amounted to 352 grains, according to the proportion above stated, which, being deducted from 3520, their first weight, there remained 3168 grains, being the then nett weight of the hops, independent of the worts actually imbibed. I had now to deduct the said 3168 grains, nett weight, from 25080, the gross weight of the whole, and the difference, 21912, was the true weight of the wort imbibed by the hops; which, being divided by 9862, the nett weight of one pint, the quotient, 2·22 pints, shewed the exact amount of the quantity imbibed by half a pound of hops. According to this calculation, somewhat less than 65 pounds of hops will imbibe one barrel of wort, when well drained; but as the expedition required in practice will not admit of a scrupulous observance of every nicety, I find, from long experience, that the average may be estimated at sixty pounds of hops, as generally imbibing a barrel of wort, which estimate, also, from different experiments, where measure instead of weight has directed my calculations, is sufficiently corroborated and confirmed."

Mr. Richardson having ascertained what loss he sustained in his first wort through the absorption of the hops, proceeded to investigate what benefit might accrue to him by employing them for his second.

"My second wort, (29·4 at 17·6,) having boiled its allotted time, with the hops from the first, I perceived that the 29·4 barrels at 17·6 were evapo-

rated to 22, and its specific gravity was increased to 25·5 lbs. per barrel. Multiplying these together, the product (561 lbs.) shewed that there was an addition made to the fermentable matter of the simple extract, amounting to 43·6 lbs. To discover how this could happen, I considered, that to the 517·4 lbs. first extracted, the hops carried with them, from the first wort, 171·25 lbs., which I found they had imbibed, making in the whole 688·65 lbs.; but as they still retained five barrels, the amount of the quantity first imbibed, I considered that the five barrels then imbibed, having displaced the former five, were only to be estimated at the rate of the specific gravity of the displacing wort, which being only 25·5 lbs. per barrel, by multiplying that sum by 5, I discovered the amount of the fermentable matter then remaining in the hops to be 127·5 lbs., which, deducted from the gross aggregate, 688·65, shewed that the sum of the fermentable matter at that time in the wort should have been 561·15 lbs.; and as the actual quantity appeared 561, the accuracy of this calculation is confirmed to a degree of nicety hardly to be expected on so practical an occasion."

Mr. Richardson proceeds farther in his experiments upon the second and third worts, which led him to similar results; the hops still retaining the same quantity, but decreasing in gravity with the worts. When the process of boiling is complete, the wort is run from the copper into the hop-back,

or jack. In England, the hop-back is a square vessel of wood or iron, of a capacity sufficient to hold more than the contents of the wort copper, with a false bottom perforated with small holes to retain the hops, when the wort is drawn off into the coolers. The hop-back is similarly constructed to the mash-tun, having a tap placed between the real and the false bottom. The wort, with the whole of the hops, is run into the hop-back; and while running, it is agitated in the copper, either by a man, or by a machine called a *rouser*, to prevent the hops remaining at the bottom. In England the wort is allowed to remain in the hop-back for a short time before it is run off into the cooler; by this means the hops subside at the bottom; and the wort, when drawn off, filters through them, leaving its impurities behind it.

In Scotland, the brewers seldom have a fixed hop-back, but, as a substitute, use a square or oblong wooden box with a temporary bottom made of hair-cloth. In consequence of employing this hair-cloth bottom, instead of a regular hop-back, as described, the wort immediately disengages itself from the hops, carrying along with it most of its impurities.

There are many different ways of getting the worts into the coolers. Some brewers run them immediately from the copper into this jack over the cooler; others run them through the jack over a

vessel, and then pump them into this cooler; others again pump them at once into the jack over the cooler, leaving the hops in the copper.

From what has been stated, it will be obvious, that there must be a difference in the state of the worts of the English and Scottish brewers when they enter the cooler; the former being more transparent than the latter.

In the Scotch practice, in most cases, a considerable portion of the dreg of the hop must be incorporated with the wort; and whether this dreg is advantageous or not, is a matter of dispute. Those in favour of the hair-cloth maintain, that although it does not admit of the hop subsiding at the bottom, and by this means retaining the impurities, yet, as none of the grosser particles can run through, it will only allow a small portion of the *fecula* of the hop to escape; and that this *fecula* is highly beneficial, both as a preservative in the coolers, and afterwards as an agent in inducing a vigorous fermentation. Notwithstanding the transparency of the worts when they enter the coolers, they will deposit a great portion of grey slimy sediment while there. In the English worts, this sediment will be composed of a small portion of mucilage and gluten; while in the Scotch worts there will be a larger proportion of mucilage in union with the *fecula* of the hop.

COOLING.

These fixtures called coolers, formerly used in Scotland, were, as in England, wooden floors of large dimensions, having sides, not exceeding six to eight inches in height, and completely water-tight. The number of these coolers in a brew-house was from three to six. They were so situated, with respect to their different heights, as to admit of the wort being run from one into the other, and from the last into the fermenting tuns. The wort was first run into the uppermost cooler, when it was gauged; and samples being taken for inspection, it was then run off, and spread through the other coolers, at a depth not exceeding one inch, or one inch and a half. The coolers were placed in the most exposed situation of the brew-house, in order that the worts might have the benefit of a free current of air passing continually over their surface.

In cold weather, this method of cooling the worts was sufficiently safe, the time not exceeding from six to eight hours; and there can arise no danger to worts from their exposure to the atmosphere for so short a period. But in hot, and especially in

muggy weather, this method is so excessively tedious, as frequently to incur a danger of the most ruinous consequences. The worts are very prone to ferment spontaneously in the coolers, the consequence of which is, that acetification takes place even before they enter the fermenting tun. The result of this spontaneous fermentation is, in the language of brewers, called *foxed worts;* a disease which is known by the worts producing on their surface mouldy spots of a reddish colour, and by their emitting a disagreeable odour. This disease continues to increase during all the after processes; and exists even in the ale in a drinkable state, imparting to it an unpleasant flavour, and preventing it from becoming transparent.

When this evil has happened, the greatest care and attention are indispensable to cleanse with lime and water, all the vessels and utensils which have been used. If this be not done, they will innoculate the next worts with the same disease.

The *fox* was scarcely known in Scotland till lately; because the strong ale brewers confined their operations to the colder months of the year; their coppers being silent from May to October. Some of the brewers of the inferior ales and beers ventured, however, to carry on these operations during the summer months, and ran the hazard of this disease, which occasionally made its appearance in the worts. Of late years means have been resorted to, for the purpose of enabling the brewers to expedite

the cooling of their worts, and, in consequence, they can now brew during the summer months with a better chance of success than formerly, though still not without considerable risk. For this purpose, the modern coolers, instead of being of wood as formerly, are of cast iron, and some of zinc, these metals being better conductors of heat; and fanners have been invented to supply, by artificial means, a constant current of air over the whole surface of the worts. The agitation thus produced rapidly carries off the air as it becomes saturated with the rising steam from the surface of the worts, supplying more fresh and dry air, by which the evaporation proceeds without interruption, and the worts are in proportion rapidly cooled.

There is another artificial method employed by some brewers, who have the command of water, to expedite the cooling of their worts. This is by means of a spiral pipe which traverses a large body of cold water. To this pipe the worts are conveyed from the hop-back at about 180°, and in their passage are generally cooled down to the requisite heat for fermentation, and pass immediately into the fermenting tun.

Before proceeding further, it may be as well to present a cursory view of those modern improvements, the object of which is to expedite the process of cooling the worts. In my opinion, strong ale worts should not remain in the coolers for more than nine hours, nor less than four. Were it possible at

all seasons of the year to cool the worts in six or eight hours, by merely introducing a constant current of air, which should pass over them while settled, such a plan would be greatly preferable to the application of artificial means; for when worts enter the coolers, however transparent they may appear, they hold in solution a considerable portion of mucilage, and contain, besides, many incidental impurities. According to the system formerly practised, those impurities were allowed to deposit themselves at the bottom of the coolers, so that, when the worts were run off, they were found to cover the entire bottom of the coolers with a body of greyish mucilaginous slime, instead of remaining in solution, to the injury of the worts incorporated with them, as in the case when the fanners are employed, so as to keep them in a state of continual agitation. Again, the method adopted by using the refrigerator is objectionable on the same grounds, in as much as the worts which, passing rapidly through it, must necessarily carry along with them whatever impurities may exist in them, besides those which may arise in passing through the spiral pipe, forming the refrigerator, when it happens not to be perfectly clean, a circumstance which must often occur in consequence of the extreme difficulty of thoroughly cleansing a conductor with so many turnings, and of such small bore, and which has been traversed by a fluid of so glutinous a nature. The very great care which is absolutely necessary to the effectual cleans-

ing of vessels and utensils used in brewing, when the operations are brought to a close, must be acknowledged by all who have given the slightest attention to the subject. If so much pains be required to keep even such vessels as coolers free from secretion, to every part of which there is easy access, a much greater portion of care and attention, as well as ingenuity, is requisite in regard to the refrigerator, which is a close pipe, extremely difficult of access, and liable, from the very circumstance of the rapid cooling of the worts, to have incrustations formed in its interior.

Metal is decidedly preferable to wood for coolers, as it is a better conductor of caloric; but this advantage is of little avail in the summer season, when it is most required, as the air is not sufficiently cool to withdraw the heat from the metal itself. To the use of the zinc coolers very serious objections have been made, as it is asserted by those who have employed vessels of this metal, that the fermentations have proved very unsuccessful.

In stating my objection to the use of the *fanners*, on the ground of their agitating the worts, and preventing the deposit of the sediment which is thereby carried along with this into the fermenting tun; I am aware that I incur the imputation of being considered inimical to modern improvements—this sediment being by many considered as not detrimental, but highly beneficial to the worts; for they maintain that it is chiefly composed of the hop dreg, a most

valuable agent both in preserving the worts from acetifying in the coolers, and afterwards in promoting a vigorous fermentation. Were it proved that the sediment consists solely of hop dreg, and that it is composed of the mere dust or *lupulin* of the hop, I should consider its combining with the worts as highly beneficial; but as this is not the case, and as I have found, by experience, that this sediment contains a very small portion of the *lupulin*, I consider those impurities, when held in solution, as highly detrimental to the worts for fine ales, because, in the fermenting tun, they will be innoculated with the disagreeable coarse meally flavour which belongs to that sediment. Worts, at this stage, are most susceptible of imbibing any flavour, good or bad. This is, indeed, the case with all liquors; and so sensible of this fact are the wine-makers abroad, that smoking tobacco is strictly prohibited in their fermenting rooms.

On the other hand, it will be seen from the following quotation from Mr. Black's Practical Treatise on Brewing, that although his views on this subject were, at one time, in some respects similar to my own, his experience has, nevertheless, induced him to alter his opinions:—

"Many brewers are very much afraid of allowing any of the dreg from the hops to go into the coolers. I must confess, that I, at one time was of the same opinion, merely from having heard from others that it did harm. I continued of this opinion until better

instructed by my friend, Mr. Robert Stein, to whom I am indebted for much useful information on the subject. He made me, on one occasion, when, from causes to be hereafter explained, I certainly was very unsuccessful in my fermentations, throw a quantity of the hop dreg into the coolers along with the worts, and afterwards sweep the whole into the square. Instead of hurting the fermentation, it made it decidedly more vigorous than before, and ever since, I have successfully pursued the same practice.

"The hop dreg is also a great preservative to the wort in the coolers; for all know that worts, while they remain in the hops, are much less liable to get tainted than when drained off; precisely on the same principle, a little of the dreg or *fecula* of the hops is a preservative in the coolers, and the greater the quantity that goes over, the less is the risk of taint. I sometimes, therefore, rouse the hops in the hop-back, while the worts are draining off, for the purpose of throwing over more of the *fecula* into the coolers, than would have otherwise run over along with the worts. I well know the prejudice that exists on this subject, but I boldly start an opposite doctrine, in the full confidence that the experiment, once made, will ensure the permanent adoption of my system."

FERMENTATION.

We have now reached the sixth stage, namely, Fermentation; a process which is the most difficult of all to conduct properly, the most precarious in its results; but, at the same time, of the greatest importance to the operator. For, although he has been successful in all the preceding stages, yet, should he fail in this, the advantages which he has obtained will be of little avail, and complete disappointment must ensue, inasmuch as the produce will be wanting in every requisite property—in spirituosity, flavour, and transparency.

It is not my intention to discuss the theory of fermentation, a subject which would lead me far beyond the limits of a practical treatise, and be productive of little real benefit to the operator; for, much as has been written concerning fermentation, and confidently as many have asserted their knowledge of its secret causes and effects, the mystery in which its principles are involved continues to present an impregnable barrier; and those who dogmatically profess to have compassed this subtle and compli-

cated subject, only prove the extent of their ignorance and presumption.

In the management of this process, the Scottish brewers differ very materially from the English, as they do, indeed, during the whole of its succeeding stages. While the English brewers commence their fermentation at a high temperature, for the purpose of effecting a rapid attenuation; the former set out with a low temperature, and the process is consequently more protracted. These differences are very considerable; for, while the English brewers frequently set their worts as high as 75°, or, according to some practical writers, occasionally 80°, the Scottish seldom if ever exceed 58°, and, in some cases, fall so low as 44°. It must not be understood that 75° is a common temperature amongst the English, nor 44° amongst the Scottish brewers. These are extreme cases; but the average of the one may be taken at 65°, and of the other at 50°. These differences of heat necessarily cause corresponding differences in the time required to produce the same result; and accordingly, it is not uncommon in Scotland for brewers to have their gyles in the tun for twenty-one days, whilst in England, so long a period even as six days is considered as of rare occurrence.

To protract the fermentation by a gradual process was formerly the universal practice in Scotland; but, of late years, so great has been the demand in the English market for Scotch ales, that the brewers, for the obvious reason of securing to themselves a

speedy return on the capital embarked, have been induced so far to deviate from their former practice, as to set their tuns at a higher temperature, thereby hastening the process. This increased temperature, however, is still lower than that used by the English brewer. I am in a position to speak somewhat confidently on this point, having for a considerable time past been occupied in ascertaining, by every means in my power, the heats now employed by Scottish brewers; and from the information I have obtained, have been led to the conclusion that, when the atmosphere is tolerably cool, say about 42°, the average temperature employed by the Scottish brewers may be considered as about 53°.

As fermentation, however, cannot be carried on with any thing like uniformity independently of artificial aid, and as it requires for this purpose an agent, namely, yeast, technically called *store*, I must now briefly, but strongly, impress upon the brewer the absolute necessity of ascertaining the quality of this essential and powerful auxiliary. Much of the operator's success, in so far as the desired flavour and attenuation are concerned, depends upon his procuring a good and sound ferment, and from a stock which has been of an equal gravity to the wort for which it is now required. Should the ferment, or *store*, be the product of unsound worts, or be in any respect tainted, it will impart its noxious quality to the worts with which it is combined. It is asserted by scientific men, "that a vinous ferment induces the vin-

ous; that a ferment of the acetous kind brings on the acetous fermentation; and a putrid one, that fermentation which ends in putrefaction." Should the operator incautiously make use of *store* which has been procured from a stock that was originally of a much lower gravity than the wort for which it is intended, he will find it wanting in the *stamina* necessary to effect the desired attenuation; and even should he use a larger proportion, it will not be an equivalent.

These few remarks may suffice to show how important it is to procure the store in such perfection as will insure, in the gyle-tun, a regular fermentation; for, should the brewer be so far deceived as to make use of store of an inferior quality to that necessary for his purpose, he will find his fermentation proceeding in a very unsteady and sluggish manner; and it may be assumed in such cases, that nine times out of ten the ale will prove turbid and "*yeast bitten*," while at the same time, from the want of a competent knowledge of the quality of the agent employed, he may yet be unaware of the cause. Where brewings are frequent and successive, the danger of being deceived in the quality of the store cannot occur, as the operator will always have it in his power to use that which he knows to be sound, and calculated to secure a satisfactory result; but after repeated brewings from his successive ferments, it will degenerate in consequence of this frequent application, and, therefore, he will find a change of yeast neces-

sary. That such is the case, is not only my own opinion, but that of the various practical brewers whom I have consulted; all of whom, as well as myself, have found a change of store, if not absolutely necessary, at least highly advantageous. One writer, however, entertains an opinion very much the reverse, and which he thus expresses:—"Frequent brewings, also, are absolutely necessary, to insure a constant supply of good fresh yeast. It may be said, we can get a change of good fresh yeast at any time from another brew-house. True—but are you sure that this change will answer your purpose? Should the other brewer be languid, or out of trim in his fermentations, so will you, unless you can by proper means make the yeast what it ought to be. I have worked in a large establishment from year's end to year's end, without ever having the least occasion for a change of yeast, and could do so again at any time; and my fermentations shall be as healthy and vigorous as any one's."

Such is Mr. Black's opinion; but great as is the confidence with which that gentleman speaks of his anticipated success, founded upon his experience of the past, I am not the less inclined to adhere to my own views. Indeed, I could not at all rest satisfied with my operations, or place confidence in their progress, were I so situated as to be compelled to depend solely upon my store for successive fermentations "from year's end to year's

end," or even for a much shorter interval. Having quoted Mr. Black's opinion, which is directly opposed to my own, I may now venture to give an extract from the work of Mr. Richardson, whose sentiments are the result of long acknowledged experience.

" It is a well known fact that yeast, used as a ferment, and invariably continued for a length of time, the produce of one gyle supplying the ferment of the next, does so far degenerate, that (like the degeneracy of corn sown upon the same field which produces it for a succession of crops) it will not effect a perfect fermentation; and yet the same yeast, employed by another brewer, shall do its duty. In confirmation of this, having a concern in a vinegar brewery at Beverley, I am frequently necessitated to promote the fermentation there, by yeast taken from the brewery at Hull; and, to invigorate the same operation at the latter place, with yeast brought from the former; notwithstanding the malt employed at both places is made at the same malt-house, the process of brewing, as near as circumstances will admit, is the same, and the difference exists only in the water, one brewery being supplied by a well, the other by the river Hull. This is the more remarkable, as, when these exchanges take place, the yeast at Hull will not at all produce a fermentation to be depended on, though it operates perfectly well at Beverley, where the yeast is precisely in the same predicament, as far as respects its non-performance

there, and its perfect operation so exchanged. This latter was so strikingly exemplified to me in the course of the last summer, (1797), that the yeast produced sometimes at Beverley would in nowise ferment a loaf of bread, nor could it be trusted in the gyle-tun there, at the same time that it was highly instrumental in effecting a perfect fermentation in the brewery at Hull.

" How this difference of action and defect is to be accounted for, is perhaps beyond the reach of philosophical investigation to ascertain ; and this extraordinary fact, of a ferment failing in the performance of its office in the brewery where it was produced, yet working well in another, will probably long remain a subject of fruitless inquiry. It is also matter of surprise that the action which languishes under the apparent want of fermenting power in the yeast, is not to be *effectually* invigorated by any addition of quantity admissible into the wort, though a very small difference may be discernable ; and thence a rational inference is made on the subject of supplying the defect of quality complained of, however unconfirmed by the event."

The *store* which ought to be preferred is that produced from the last stage of the vinous fermentation, namely, from the stillions. Care should be taken that it has not been long exposed to the atmosphere, or allowed to remain in a warm situation ; because, in either case, it will fret or ferment, and consequently be deterioriated in *stamina*. It is impossible to give

any definite rule for regulating the quantity of yeast necessary to be employed, as it must depend upon a variety of circumstances; namely, 1*st*, The temperature at which the malt has been dried; 2*d*, The quality of the liquor used for mashing; 3*d*, The gravity of the worts; 4*th*, The heat at which the tun is set; and, in the 5*th* place—and these are certainly not the least important subjects of consideration—the season of the year, and the temperature of the atmosphere. It is generally affirmed, that the higher the gravity, and the lower the heat at which the fermentation is commenced, the more yeast will be required to obtain a uniform attenuation. Keeping in view these general rules, the operator must, in a great measure, be guided by experience as to the quantity of yeast which he uses, avoiding the greater evil, namely, that of over-storing his tun.

In brewing seasons, as has already been remarked, when the temperature averages about 42°, and the gravity of the wort ranges from 90 to 120, two pounds and a half of yeast are commonly used for each barrel of wort; but when the store is very good, I have found this rather too great a quantity. If the store be of a superior quality, a gallon of yeast will be found to weigh about eleven to twelve pounds.

The mode which the Scottish brewers adopt in pitching their tuns is very similar to that in England; though, generally speaking, they do not now, as formerly, let down a small portion of the worts

into the gyle-tun at a higher temperature, along with some of the store. That former practice, which appears to me very judicious, as it gives the brewer some idea of the strength of the store before he mingles it with the whole of his worts, is still employed by a few.

In the process of slow fermentation, formerly in use when the tun was pitched at 50°, there is little appearance of motion during the first twelve hours; and were it not for the slightly increased acceleration in the chipping of the wort, as it slowly approaches from the edge of the tun to the centre, the whole mass might seem to be inert. After the space just mentioned, however, the agitation becomes quite apparent, until, after about forty or fifty hours from the commencement, the whole surface is covered with a thick white curly foam. This foam continues to increase in height, until it assumes a rocky appearance, termed the cauliflower head. About this time it is customary to beat it in; an operation which is repeated morning and evening, until the tun has increased from eight to ten degrees of heat. By others, again, the head is beat in at an earlier stage.*

During the remainder of the time that the wort is in the tun, the head assumes various appearances.

* The operation of skimming is seldom or never performed in Scotland, except when it becomes necessary to check by this means too vigorous a fermentation, caused by an unexpected increase of heat in the tun.

Air bubbles continually form and break into each other, until the gas seems to be exhausted, when the head becomes flat, and appears darker and more dense. The heat of the tun for the last ten to twelve hours remains stationary, having previously increased gradually from the time of pitching. When this is found to take place, it is considered necessary immediately to commence cleansing; for, if the strictest attention be not applied at this critical period, injurious consequences must ensue.

Before proceeding to the operation of cleansing, a very important subject falls to be considered, namely, attenuation—over which a veil of impenetrable mystery has been attempted to be thrown. The gravity of the worts for the different qualities of ale, previous to fermentation and the final attenuation in the tun, form important secrets in the art of brewing; and of these every brewer is tenacious. At the same time, it is of the utmost consequence to select such an attenuation as shall prove amply spirituous and full bodied; and also, having once ascertained the gravities and the final attenuation, to be enabled to proceed in the same manner, in each successive brewing. Having, by these means satisfied the taste of his customers, he will at all times afford them an article of uniform quality, and so avoid the danger of being supplanted by others in the trade. These gravities and atte-

nuation are completely under the brewer's control, not being liable to the same casualties as in the case of heats in mashing and fermenting. His gravities and final attenuation, having been of a certain amount, and to his own satisfaction, he can decidedly insure them to be the same in all time coming;—always taking into view, of course, the price of malt and hops.

Before the ale duty was removed, the following were about the gravities and attenuations of the worts for the various qualities of ales made in Scotland:—

For £4 ale, from	80	to	86	attenuated	to 32	to 35.
£5 do. „	90		95	„	36	39.
£6 do. „	100		108	„	40	44.
£7 do. „	110		116	„	45	47.
£8 do. „	120		125	„	48	50.

Since, however, the duty, which was 15s. per hhd., was abolished, the brewers have reduced their prices £1 per hhd., so that what was £4 per hhd. is now only £3—£5 only £4, &c. &c. There is still an £8 ale in the market.

One of the results accruing from the many valuable discoveries made in 1806, at the instance of the Commissioners of Excise for Scotland, is the adoption of a very ingenious method of ascertaining the original gravity of any wash by partial evaporation. Although this expedient was em-

ployed at first only to discover the difference between the real and apparent attenuation, and the quantity of spirit contained in distillers' wash, it has been found equally efficient for other purposes of a similar kind. But, although it is a method adopted by some of the superior officers of Excise, as a check to prevent collusion or fraud in the distillery, yet it is hardly known to any other parties. Perhaps no better proof of its utility and accuracy can be stated than the fact, that the Excise have found it completely satisfactory. I may be allowed to quote the words of one of the general officers who is employed to conduct the experiment to which I have alluded, and who, in stating his observations, says, "*they come amazingly near the truth.*"

The distiller is bound by law to work at a certain gravity, not under 30 or above 80 degrees, according to Allan's Saccharometer, (Scotland;) and for every five degrees of attenuation, he must produce one gallon of proof spirit, or pay duty for that quantity. The following is the clause of the act by which this principle is enforced: "And be it further enacted, That for, and in respect of every one hundred gallons of wort or wash, which shall be brewed or made in the 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 which 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 * * *. And the officer shall also charge at the same rate and proportion of spirits for any lesser quantity of such wort or wash, and for any such difference of gravity which shall be less than five degrees."—Act 4th Geo. IV. cap. xciv. § lvi. By taking a sample from the still, even after it has been charged, and submitting it to examination by partial evaporation, the officer is enabled to ascertain whether the original gravity of the wash was really the same as declared by the distiller.

To me, then, it appeared obvious, that if this method were so effectual when applied to the wash of the distiller, and led to a conclusion so satisfactory, it would be no less applicable to the wort of the brewer, and might be made use of for the purpose of finding from ale, either in the cask or bottle, the original gravity of the wort. Having formed this opinion, I experimented upon the ales of Edinburgh brewers, varying in price from 32s. to £8 per hhd.; and to use the words already quoted, I am inclined to think that the results "*are amazingly near the truth.*" Not only are these experiments highly interesting in themselves as a matter of curiosity, but they are productive of advantages hitherto unknown, and which must prove very valuable to the brewer; for, by

ascertaining the original gravity and attenuation of Burton, or any other noted ale, he will be able to imitate it, with the assurance of a successful issue; while, without such knowledge, even should he be in possession of all the *mysteries* of heats, he will find it a matter of impossibility.

It was my first intention to have included in the following statement, the names of the different brewers whose respective ales have been reduced to their original gravities; but having communicated this intention to one of the parties alluded to, I found that much offence would be given to those brewers whose gravities appear very low; and having no wish, either directly or indirectly, to injure any class of tradesmen, I have, in reconsidering the matter, deemed it more expedient to insert (page 134 *et seq.*) the tables without the accompaniment of names, which, after all, could be of little real service, except to gratify the curiosity of the public. I have, therefore, simply classed them in alphabetical order, the name of each brewer being signified by a capital letter.

METHOD OF ASCERTAINING FROM ALE OF ANY AGE, THE ORIGINAL GRAVITY OF THE WORT BY MEANS OF PARTIAL EVAPORATION.

PARTIAL EVAPORATION.

For the purpose of conducting this process, the following apparatus is required:—A *saccharometer* and *sample tube*:—A *measure bottle*, large enough to contain a sufficient quantity of ale to allow the saccharometer to work freely in the sample tube, and which must have a ground glass stopper, perforated in the centre, in order to ascertain when the bottle is filled, which is done by fixing in the stopper, when the liquid will rise to the top of the stopper:—A *small thermometer*, which is constructed on the simplest plan, being merely a glass tube with the necessary portion of mercury, and with only one graduated mark on it, and that indicating 60° of temperature:—A *thin glass flask*, used by chemists in making experiments, capable of containing about two-thirds more than the bottle:—An *argand lamp*, to be supplied either with spirits of wine or oil; or

a *gas burner* instead, where there is gas:—And a *chemical retort stand*, with rings to support and secure the flask, so that it may be placed either near the flame, or raised above it, as required.

I now proceed to explain the mode of conducting the experiment. In the first place, take the gravity of the ale, which is to be experimented upon, in the usual manner. I have found it more correct to bring this ale to the temperature of 60°, instead of taking it at any temperature and using the sliding rule; and the greatest exactness is absolutely necessary in every part of the operation. But still with the greatest care it is impossible to accomplish this, as some portion of gas will remain and prevent a perfectly correct indication, especially where the original gravities of the ales have been very high. In the first edition I omitted to state, that a certain allowance should be made for the gas keeping the saccharometer above what it ought to be, and thereby making the gravity more than it really is. From repeated trials I have found, that when ales are from 110 to 125 original gravities, and have been attenuated from 40 to 45, say 43 that of the first examination should be 43.75 or so, they should be called only 43, allowing always on ales of such a high gravity .75. From 110 to 90, only .50. From 90 to 70, .30. From 70 to 60, .15. If the ale be bottled, the cork should be drawn several hours before the examination takes place, in order that the gas may have less influence in occasioning a false indica-

tion upon the instrument. The gravity being taken and noted, the measure bottle is filled, and should any gas remain, the bottle must continue without the stopper until it has entirely disappeared; the stopper is then put in; when the bottle, being quite full, (which is necessary,) the liquid will rise to the top of the bore in the stopper; and should it be more than filled, the excess will run off at this aperture. The bottle must be then carefully wiped, in order that no ale may be allowed to lodge round the stopper. The contents of the bottle are then emptied into the flask; and, in order that no portion of the ale may be left in the bottle, a little water is employed to detach what remains, which water is added to the liquid in the flask. The flask is then put on one of the rings of the stand, and a smaller ring is lowered to the neck to secure it; the flame is then applied, which will probably cause the liquid to boil within five minutes. And now the utmost vigilance is requisite to prevent the foam, which rises very rapidly just before it boils, from escaping, as the smallest loss of the liquid will materially affect the accuracy of the experiment. Indeed, it is necessary, just before the boiling point, to raise the flask, so that the heat may be lessened, and, during some time, occasionally to shift the lamp; for, without these precautions, the foam rises so rapidly, that some of it cannot fail to escape. This foam or froth will, in a short time, subside, when such precautions are no longer necessary, and the

liquid may be allowed to boil until it appears reduced to one-half in quantity, when the spirit which it contained will be entirely dissipated, as well as much of the watery particles evaporated. To be assured that this end has been fully accomplished, namely, the dissipation of the spirit, I allow one hour and ten minutes from the time it first boils for the completion of this process. The flask is next removed from the stand, and put into cold water to reduce its heat, after which the liquid, diminished in quantity, as has been stated, to about one half, is put into the measure-bottle; and, to make sure that none of the saccharum adhering to the flask remains, that vessel is thoroughly rinsed with pure cold water, which is then added to the wort in the bottle; but as this addition will not be sufficient to make up the original quantity, the deficiency is supplied with pure water, when the greatest attention is then necessary, that the bottle shall not be more than filled. A sufficient time must, however, be allowed for the froth in the bottle to subside, and it must be correctly ascertained that the bottle is quite full, by the liquid rising to the top of the hole of the stopper.

Before, however, the bottle is quite full, the heat of the liquid must be taken by the small thermometer, in order to ascertain whether it is above 60°. If this be the case, it will be necessary to place the bottle in cold water, to reduce it to that degree; because, were we, after filling the bottle and empty-

ing it into the sample-tube for examination by the saccharometer in the usual way, to find it 80°, and now cool it down to 60° by immersing the tube in cold water, we should arrive at a very erroneous conclusion. The liquid in the bottle at 80° occupying more space than it would have done at 60°, less water has been employed to bring up the deficiency than ought to have been; the consequence of which is, that the specific gravity will be too high.

The contents must now be thoroughly mixed, and then returned into the sample-tube for examination by the saccharometer. By this instrument it will be discovered, that the wort, (as the liquid ought now to be called,) by the substitution of water in place of the dissipated spirit, is many degrees higher in gravity than the ale was previous to boiling, and the number of degrees will be in proportion to the attenuation;—the greater the attenuation, the greater the number of degrees, and *vice versa*. The difference between the original gravity of the wort, and that of the ale previous to boiling, is the *apparent* attenuation, because the spirit contained in it makes the extract appear lighter than it really is; but the difference after boiling, in consequence of this spirit being dissipated, is the *real* attenuation.

The gravity having been ascertained, the difference between it and that of the ale before boiling is noted, and this difference is to be subtracted from

1000, the weight of water. As in the former instance, so here also the saccharometer examination must be most carefully attended to. I have found it expedient in cases where the worts have been dense to allow a little on the saccharometer indications for any deficiency that may have taken place. For example, should a sample after the spirit has been dissipated, indicate upon the saccharometer 80, I would call it 80·25. If 80·25, then 80·50 and so on, allowing ·25 on every indication, but when worts after the spirit has been dissipated indicate under 30, no allowance is necessary. As many readers will find it difficult to obtain a low wine table, I have compiled one which gives 20 of difference between the first examination of the ale, and the second examination of the wort after the dissipation of the spirit, being a greater difference than in any of the ales which I have met with. This table, however, is only applicable to wort when reduced to the temperature of 60°; for, by referring to a table of low wines, it will be found, that opposite to this degree of gravity at any temperature is the number of gallons of proof spirit contained in every hundred gallons of such wash;—bearing in mind, however, that at each temperature a different indication is geivn.

		60_0	60_0	60_0	60_0
			.25	.50	.75
20	980	28.1	28.525	28.95	29.375
19	981	26.4	26.825	27.25	27.675
18	982	24.8	25.2	25.6	26.
17	983	23.2	23.6	24.	24.4
16	984	21.6	22.	22.4	22.8
15	985	20.	20.4	20.8	21.2
14	986	18.5	18.875	19.25	19.625
13	987	17.	17.375	17.75	18.125
12	988	15.5	15.875	16.25	16.625
11	989	14.	14.375	14.75	15.125
10	990	12.6	12.95	13.3	13.65
9	991	11.2	11.55	11.9	12.25
8	992	9.8	10.15	10.5	10.85
7	993	8.5	8.825	9.15	9.475
6	994	7.2			
5	995	5.9			
4	996	4.7			
3	997	3.5			
2	998	2.3			
1	999	1.1			
	1000	0.0			

The indications of the above table differ a little from Dr. Thomson's, inasmuch as he makes the quantity of spirit rather less. But they agree perfectly with Mr. Bates'.

Suppose, then, after we have dissipated the spirit from any sample of ale, and filled up the measure-bottle with water, we find that the liquor under examination has increased in gravity 12. We then subtract this 12 from 1000, (the weight of water,) and there remain 988. Opposite 988 in the low wine table, we find 15·5, which signifies that the ale under examination contained $15{\cdot}\frac{5}{10}$ of a gallon of proof spirit per cent. The point now to be considered is, what amount of attenuation would be re-

quired to produce that proportion of spirit? It has been already shewn, that the distiller must produce at least one gallon of proof spirit for every five degrees of attenuation. If it were possible to produce this quantity and no more for such attenuation, we should, by multiplying the number of gallons of spirit by five, obtain a perfectly accurate result, since a gallon of proof spirit could not be generated with less or more than that exact amount of attenuation. But it has been proved, as will be seen in the sixtieth clause of the same act already quoted, that five degrees of attenuation, when judiciously managed, will produce considerably more. This will be seen from the following:—"And be it farther enacted, That whenever the quantity of spirits which shall be actually distilled or produced, or which, under any of the provisions of this act, shall be deemed to be distilled or produced, from any wort or wash contained in any fermenting back, shall exceed the rate of one gallon and one-fifth part of a gallon of proof spirits from each and every one hundred gallons of such wort or wash, for and in respect of every five degrees of gravity of such wort or wash which 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 pursuant to this act, or as appearing on the first account taken thereof in the fermenting back, and the decreased gravity of such wort or wash, as appearing by the last account thereof, taken by the officer previous to

the distillation thereof, then, and in every such case, the officer shall keep a distinct account of every such excess of gravity, and shall set forth the same in his book or books, and in his return or charge against such distiller, under the head of Undue Excesses."

From this it is evident, that the distiller must not produce less than one gallon of proof spirit for every five degrees of attenuation, while he is allowed to produce one gallon and one-fifth of a gallon without being charged with undue excess; but if more than one gallon and one-fifth of a gallon be produced, he is charged with this surplus quantity as UNDUE EXCESS.

It has been proved by repeated and successful trials, that five degrees of attenuation produce more than a gallon of proof spirits; but never, so far as I have ascertained, so much as one gallon and one-fifth; even one gallon and one-tenth are seldom obtained; and as I have found, after repeated experiments, that 4·5 is the most accurate factor, I have employed it in all my operations on this subject. To put it to the strictest test, I not only employed it in trials of my own ales, the gravities of which I had, of course, recorded; but I tried it upon six different kinds given me for this purpose by a scientific friend, who also had their original gravities noted, but who was sceptical as to the possibility of my ascertaining the gravities of his ales by any means. He did not inform me of his gravities, until I put him in pos-

session of the results of my experiments; when, after comparing notes according to previous understanding, he produced his memoranda, of which the following is a correct statement. Under A. I have given my friend's gravities, and under B. those obtained by means of partial evaporation.

	A.	B.
No. 1.	75	76
2.	91	90·125
3.	122	122·37
4.	124	123
5.	129	129
6.	128	127·37

The reader will perceive from the above that there is not, in any of these six instances, upwards of the very trifling difference of one degree; and I am inclined to think that the error must rest with the noting of the original gravity, because, when the brewer takes his final gravity, it is generally from the coolers, and often when the temperature of the wort is under 60°. Worts, at this period, and especially for high-priced ales, are so very dense, that unless the greatest nicety is observed in preparing the instrument, by dipping it first into the wort and slightly wiping it, to detach the air bubbles, a false indication, to the extent of a degree or two, will be given.

If the results of these six experiments, as well as

in those of my own ales, have proved so "near the truth," they must be equally correct in all the other instances, because the very same method in every respect was adopted. Indeed, I have been so careful, that, fearing the instrument I made use of might, from the thickness of its stem, be in some measure inadequate for such minute investigations, although a perfectly new saccharometer, and satisfactorily accurate for ordinary purposes in brewing and wine-making, I had another instrument constructed with a very slender stem, having each of its degrees subdivided into five.

In addition to what I have said introductory of the table of brewers' gravities, I may here state, that the greater part of the ales made use of have been drawn by myself, and others in whom I could confide, from the original casks bearing the brewers' names and prices, and these ales were immediately sealed up and labelled to prevent the possibility of mistake. I was unable, however, to procure the whole of these samples according to this rule, and was obliged in several instances to purchase the ales in the bottle, and thereby run the risk of getting a four pound for a five pound ale, &c.; and, should any inaccuracies appear in the results as recorded, they must have arisen solely from this cause.

In 1840 the Directors of one of the largest breweries out of London, requested their manager to correspond with me, as they were desirous of being informed what remuneration I would expect for

examining by partial evaporation a few bottles of their beer, giving him the results; in answer to which I stated, that I did not examine ale for others on payment, but merely for information to myself in order for publication; at the same time, I would cheerfully comply with their wishes, if he would send the samples free of expense, and should he find my results were within one and one half degrees of his original gravities, that he would furnish me with them. He most politely agreed to those terms, and further enclosed me a draft for £4 to defray any expense I might incur in making the experiments. Eight quart bottles of beer of four kinds were forwarded sealed, and marked 1, 2, 3, 4. I accordingly examined them and sent the result by post, and received the following answer:—Sir, I feel much obliged to you for the promptness and extremely exact manner you have replied to my queries—for your satisfaction the gravities stand thus—

	Allan.
No. 1 —	65·07.....64·95
2 —	66·42.....65·90
3 —	70·20.....70·125
4 —	85'86.....83·25

It will be observed, that in No. 4, there is a difference of upwards of two degrees, this was occasioned as follow:—In the beer No. 4, which was in

a very excited state when under examination, the saccharometer indication from the bottle was 20·40, I called it 20·25, reducing the fractional parts only 15·, making, as I imagined, sufficient allowance for this; but on the following day, and after my letter had been posted, I placed the saccharometer in a portion of the same beer, the excitement had then completely subsided, when I found I should have called it 19·75, then the result would have been within half a degree of the original gravity sent me.

The important results arising from the experiments of which I have been treating, form a sufficient apology for this digression; and now I proceed to the last operation in brewing, namely, Cleansing.

TABLE I.

RESULTS OF EXPERIMENTS ON SCOTCH ALES BY MEANS OF PARTIAL EVAPORATION.

		Prices of Ale per Hogshead.	No. 1. Saccharometer, degree of the Ale when examined from the Bottle.	No. 2. Saccharometer, degree after the dissipation of the spirit, and water added.	Difference between No. 1. and No. 2. Shewing the attenuation arising from the spirit.	Proof Spirit per centum contained in the Ale.	Apparent Attenuation.	Original Gravity.	About the period when Brewed.	When Examined.	The Samples, whether taken from the Cask or Bottle.
1		L.7	61.	73.	12.	15.50.	69.75.	130.75.	Jan. 1837.	Mar. 1837.	Bottle.
2	A	7	60.	72.	12.	15.50.	69.75.	129.75.	Feb. „	Feb. „	„
3	A	7	61.50.	73.	11.50.	14.75.	66.37.	127.87.	April „	May „	„
4	A	6	45.	57.50.	12.50.	16.25.	73.12.	118.12.	Feb. „	Mar. „	„
5	A	6	47.	59.	12.	15.50.	69.75.	116.75.	Mar. „	April „	Cask.
6	A	6	46.50.	...	...	...	...	...	„ „	„ „	„
7	A	5	43.	54.	11.	14.	63.	106.	Feb. „	Mar. „	Bottle.
8	A	4	36.	46.	10.	12.6.	56.70.	92.70.	„ „	„ „	„
9	A	4	38.75.	48.75.	10.	12.6.	56.25.	95.	April „	April „	Cask.
10	A	3	25.25.	35.25.	10.	12.6.	56.70.	81.95.	„ „	„ „	„
1	B	6	42.	55.25.	13.25.	17.38.	78.2.	120.2.	Jan. „	Mar. „	Bottle.
2	B	6	45.50.	58.50.	13.	17.	73.	122.	Dec. 1836.	„ „	Cask.
3	B	5	41.	52.50.	11.50.	14.75.	66.3.	107.37.	Jan. 1837.	Feb. „	Bottle.
4	B	5	39.	50.50.	11.50.	14.75.	66.3.	105.37.	„ „	„ „	„
5	B	4	36.	45.50.	9.50.	11.9.	50.55.	89.55.	„ „	„ „	„
6	B	1,12s.	15.	...	...	...	...	...	„ „	„ „	„
1	C	6	43.	56.	13.	17.	76.50.	119.50.	Feb. „	Mar. „	Cask.
2	C	6	39.	52.50.	13.50.	17.75.	79.87.	118.87.	„ „	„ „	„
3	C	5	36.25.	48.25.	12.	15.50.	69.75.	106.	„ „	„ „	„
4	C	4	34.	44.	10.	12.60.	56.7.	90.7.	„ „	„ „	„

TABLE II.

RESULTS OF EXPERIMENTS ON SCOTCH ALES BY MEANS OF PARTIAL EVAPORATION.

		Prices of Ale per Hogshead.	No. 1. Saccharometer, degree of the Ale when examined from the bottle.	No. 2. Saccharometer, degree after the dissipation of the spirit, and water added.	Difference between No. 1. and No. 2. Shewing the attenuation arising from the Spirit.	Proof Spirit per centum.	Apparent Attenuation.	Original Gravity.	About the period when Brewed.	When Examined.	The Samples whether taken from the Cask or Bottle.
5	C	L.3	25.	34.	9.	11.2.	50.4.	75.40.	Jan. 1837.	Mar. 1837.	Bottle.
1	D	7	47.	59.50.	12.50.	16.25.	73.	120.1.	,, ,,	,, ,,	,,
2	D	7	43.	56.50.	13.50.	17.75.	79.87.	122.87.	Mar. ,,	,, ,,	Cask.
3	D	7	47.	60.	13.	17.	76.50.	123.50.	,, ,,	,, ,,	,,
4	D	6	30.25.	44.25.	14.	18.50.	83.25.	113.50.	,, ,,	,, ,,	,,
5	D	5	27.25.	41.	13.75.	17.75.	79.87.	107.12.	,, ,,	,, ,,	,,
6	D	4	34.50.	44.50.	10.	12.6.	56.70.	91.20.	,, ,,	April ,,	,,
7	D	4	39.50.	48.50.	9.	11.2.	50.4.	89.9.	April ,,	,, ,,	,,
1	E	7	54.25.	66.75.	12.50.	16.25.	73.12.	127.37.	,, ,,	,, ,,	
2	E	6	56.	67.50.	11.50.	14.75.	66.37.	122.37.	Jan. 1835.	,, ,,	Bottle.
3	E	6	51.75.	65.	13.25.	17.38.	78.21.	129.96.	,, ,,	,, ,,	,,
4	E	6	55.	66.75.	11.75.	15.13.	68.	123.	Mar. 1837.	,, ,,	,,
5	E	4	31.	41.25.	10.25.	13.	58.50.	89.50.	,, ,,	,, ,,	,,
6	E	4	30.50.	41.	10.50.	13.3.	59.85.	90.35.	,, ,,	,, ,,	,,
7	E	3	21.75.	31.50.	9.75.	12.25.	55.12.	76.87.	,, ,,	,, ,,	,,
1	F	5	38.50.	50.50.	12.	15.50.	69.75.	108.25.	Feb. ,,	,, ,,	Cask.
2	F	5	40.	51.50.	11.50.	14.75.	66.37.	106.37.	,, ,,	,, ,,	Bottle.
3	F	4	30.	40.25.	10.25.	12.95.	58.27.	88.27.	,, ,,	,, ,,	,,
1	G	5	35.	46.50.	11.50.	14.75.	66.37.	101.37.	,, ,,	,, ,,	,,
2	G	4	23.	35.	12.	15.50.	69.75.	92.75.	,, ,,	,, ,,	,,

TABLE III.

RESULTS OF EXPERIMENTS ON SCOTCH ALES BY MEANS OF PARTIAL EVAPORATION.

		Prices of Ales per Hogshead.	No. 1. Saccharometer, degree of the Ale when examined from the bottle.	No. 2. Saccharometer, degree after the dissipation of the spirit, and water added.	Difference between No. 1. and No. 2. Shewing the attenuation arising from the Spirit.	Proof Spirit per centum.	Apparent Attenuation.	Original Gravity.	About the period when Brewed	When Examined.	The Samples, whether taken from the Cask or Bottle.
1	H	L.6	38.	51.	13.	17.	76.50.	114.50.	Mar. 1837.	April 1837.	Cask.
2	H	5	31.25.	43.25.	12.	15.50.	69.50.	100.75.	,, ,,	,, ,,	,,
3	H	5	36.	47.	11.	14.	63.	99.	Dec. 1836.	Feb. ,,	Bottle.
1	I	6	41.50.	55.	13.50.	17.75.	79.87.	121.37.	Feb. 1837.	Mar. ,,	,,
2	I	4	22.	32.50.	10.50.	13.3.	59.85.	81.85.	Mar. ,,	April ,,	Cask.
3	I	3	24.	32.75.	8.75.	10.85.	48.82.	72.82.	Jan. ,,	Feb. ,,	,,
1	J	5	46.50.	57.	10.50.	13.3.	59.85.	106.35.	,, ,,	,, ,,	,,
2	J	4	32.	42.25.	10.25.	12.95.	58.27.	90.27.	,, ,,	,, ,,	,,
1	L	5	35.50.	46.75.	11.25.	14.37.	64.66.	100.16.	Feb. ,,	,, ,,	,,
1	M	5	44.25.	55.75.	11.50.	14.75.	66.37.	110.62.	,, ,,	,, ,,	,,
1	N	5	47.	56.50.	9.50.	11.9.	53.55.	100.55.	,, ,,	,, ,,	,,
1	O	5	41.	51.50.	10.50.	13.3.	59.85.	100.85.	Mar. ,,	Mar. ,,	,,
1	P	5	24.	36.50.	12.50.	16.25.	73.12.	97.12.	,, ,,	,, ,,	Bottle.
2	P	5	29.50.	41.25.	11.75.	15.12.	68.04.	97.54.	,, ,,	,, ,,	,,
1	Q	5	37.	46.50.	9.50.	11.9.	53.55.	90.55.	,, ,,	,, ,,	Cask.
2	Q	5	33.75.	43.90.	10.15.	12.80.	57.61.	91.36.	,, ,,	,, ,,	,,
1	R	3	27.	36.50.	9.50.	11.9.	53.55.	80.55.	,, ,,	,, ,,	Bottle.
1	S	7	50.	61.75.	11.75.	15.12.	68.	118.	Jan. ,,	Feb. ,,	Cask.
2	S	7	50.	62.	12.	15.50.	69.75.	119.75.	,, ,,	,, ,,	,,

TABLE IV.

RESULTS OF EXPERIMENTS ON SCOTCH ALES BY MEANS OF PARTIAL EVAPORATION.

		Prices of Ale per Hogshead.	No. 1. Saccharometer, degree of the Ale when examined from the bottle.	No. 2. Saccharometer, degree after the dissipation of the spirit, and water added.	Difference between No. 1. and No. 2. Shewing the attenuation arising from the spirit.	Proof Spirit per centum.	Apparent Attenuation.	Original Gravity.	About the period when Brewed.	When Examined.	The Samples whether taken from the Cask or Bottle.
1	T	L.6	44.50	54.50	10.	12.6.	56.70.	101.20.	Mar. 1837.	April 1837.	Bottle.
1	U*	8	64.	76.	12.	15.50.	69.75.	133.75.	Feb. „	Mar. „	Cask.
2	U*	4	24.	36.	12.	15.50.	69.75.	93.75.	„ „	„ „	„
3	U*	2	7.50	15.50.	8.	9.8.	44.1.	51.6.	„ „	„ „	„
1	V*	8	57.	69.	12.	15.50.	69.75.	126.75.	April „	May „	Bottle.
2	V*	7	59.25	69.75.	10.50.	13.3.	59.85.	119.1.	„ „	„ „	„
3	V*	7	49.	61.	12.	15.50.	69.75.	118.75.	Mar. „	April „	„
4	V*	5	43.	53.25.	10.25.	12.95.	58.27.	101.27.	„ „	„ „	„
5	V*	3	25.50	33.75.	8.25.	10.15.	45.67.	71.17.	„ „	„ „	„
6	V*	32s.	18.	22.25.	4.25.	5.	22.50.	40.50.	„ „	„ „	„
1	W*	7	52.	65.	13.	17.	76.50.	128.50.	Feb. „	Mar. „	Cask.
1	X*	7	56.50	68.	11.50.	14.75.	66.37.	122.37.	„ „	„ „	„
1	Y*	7	61.	71.50.	10.50.	13.3.	59.85.	120.85.	„ „	„ „	„
1	Home brewed		9.	22.	13.	17.	76.50.	85.50.	Oct. 1836.	„ „	Bottle.
2	do.		30.	43.25.	13.25.	17.38.	78.21.	108.21.	„ „	„ „	„

* The letters having stars are Scottish brewers, but not of Edinburgh.

CLEANSING.

When the brewer has found, as already mentioned, that the heat of the gyle has been for some time stationary, and rather decreasing than otherwise, it is then necessary to remove it. And here, the practice as followed in Scotland is quite different from that adopted in England; for, instead of being at once cleansed into casks, it is let down into a square of a size similar to that of the tun. Nearly the whole of the yeast which was on the surface, as well as that at the bottom, is left in the fermenting tun; and this retention of the yeast is accomplished by the cran, in the bottom of the tun, being screwed up about three-eights of an inch higher than its level. The gyle is then allowed to remain in the square from 12 to 36 hours, and before being run into casks, it is in fact moderately fine. When this is the case, and the fermentation appears quite exhausted, it is run into hogsheads, barrels, and half-hogsheads. These casks are not placed upon stillions, as is the practice in England, little or no yeast being thrown up, and whatever quantity is thrown up being allowed to remain; they

merely rest on the pavement of the cellar, and require no filling up until after the lapse of a few days, when they are *shived* down.

I have now carried the reader through the different stages in the process of brewing; but before proceeding to the conclusion of the treatise, I consider it but justice to the trade in Edinburgh to notice the following particulars. In using the term £6 *ale per hhd.*, I beg to make the reader aware, that a very improper practice has been gradually introduced by the trade in Edinburgh. A hogshead which ought to contain fifty-four gallons, and run from between twenty-seven to twenty-eight dozen, contains upwards of sixty gallons. Relative to this fact, I may be allowed to state what came under my own immediate notice a short time ago in the shop of a grocer, from whom I was obtaining ale for my evaporating experiments. Calling his attention to the half-hogshead from which the ale was drawn, I remarked that it appeared very large. "Yes," replied the grocer, "it runs sixteen dozen and three bottles; and when I have bottled the ale off, I send the cask to the brewery to get it refilled, taking care that no other shall be substituted in its place." From this it is evident, that his half-hogshead must contain thirty-two gallons, or that his bottles must be of a much smaller size than they ought to be. This is not a solitary instance, for I could relate many others of a similar description, were it necessary, farther to substantiate my statement. It is notorious that the

draymen are bribed to bring the dealers large casks. Besides these advantages to the grocer and malt-liquor dealers, the trade allow them six months running account, with 15 per cent. discount. Supposing then the ale of £6 per hogshead, and running sixty instead of fifty-four gallons, the loss here to the brewer, and the gain to the bottler, will be about thirteen shillings and fourpence; which, added to eighteen shillings, being 15 per cent. discount, will make a drawback to the dealer of one pound eleven shillings and fourpence; so that the brewer, for his nominal six pound ale, in reality only obtains four pounds eight shillings and fourpence.

There is another mischievous practice to be considered, and which causes great loss to the brewer. Many dealers give orders for more ale than they afterwards find they can dispose of; and not having a proper cellar, it is exposed during the whole summer to the most serious ordeal; while at the same time, in consequence of their taking out samples occasionally, and being careless in securing the spiles in the casks, many hogsheads are sent back to the brewer, instead of the pecuniary return which he was entitled to expect. This last mentioned evil a brewer cannot possibly escape; the former malpractice he may avoid, by selling his ale at a certain price per gallon, instead of selling it in casks bearing fictitious names; and this method has been adopted in Edinburgh by one brewer of a more independent spirit, whose example, it is to be hoped,

will be followed ere long by all his brethren in the trade.

PRACTICAL EXAMPLES IN BREWING.

In March 1837, I received a communication from a practical brewer in England, who is only known to me by the circumstance of his having first purchased a copy of my little work, entitled "THE BRITISH WINE MAKER AND DOMESTIC BREWER," and afterwards some of my wines. In this communication he expresses a wish to be informed of the method adopted by the Scottish brewers for producing their ales. As the queries contained in his letter are such as every brewer, who is anxious to obtain similar information, would desire to have satisfactorily answered, I cannot perhaps do better than insert the material portions of my correspondent's communication, and give, in conclusion, a summary reply:—

* * * "I am desirous of obtaining information as to the most approved practice in brewing it, (Scotch ale,) more especially the fermentation. There doubtless are brewers in your neighbourhood, as well as here, who are but imperfectly acquainted with the correct principles on which to conduct the fermentation, so as to ensure a uniform satisfactory result. Your book on making wine has led me to enter-

tain a favourable opinion of your experience in this important branch of brewing. I shall therefore be glad to avail myself of your assistance, in procuring *accurately* the *best* information on this subject. I will thank you to inform me what remuneration will be expected. I have had offers made since I have been in London, to instruct me in the Scotch practice of brewing; but I am apprehensive of being led into error, as I suspect some brewers have been here. * * * * If I were with you, I should ask the following questions. I will assume the malt to be brewed to be 160 imperial bushels, and of a quality which would produce at least 240 specific gravity per quarter by Allan's instrument.

"Queries. The hops per quarter at the different seasons of the year? The kind of hops preferred? For the first mash how many barrels (of thirty-six imperial gallons) of liquor per quarter are turned on? The heat? Time of mashing? Time on goods? Heat of tap? The same for the second, third, and fourth mashing? Assuming there are as above four mashes, do you divide the worts into three boilings, namely, the first boiling with part of the second wort; the remainder of the second wort with part of the third; the remainder of the third with the whole of the fourth? The time of boiling each wort? When let into fermenting squares or round? The heat, and pounds of yeast per barrel? and the process as it progresses day by day; shewing the attenuation and the increased heat until,

and when, cleansed from the gyle-tun? Whether, previous to cleansing, any flour and salt are added to stimulate the fermentation? Into what vessels do you cleanse the gyle from the fermenting vats or squares? The specific gravity, and the heat when cleansed? The time it is considered desirable for the ale to remain in the brewery before it is sent out? The specific gravity of the different sorts when sent out? The specific gravities of the worts of the different sorts of ale, and their relative prices at the present price of malt and hops? If a solution of isinglass is used in fining? The specific gravity of such solution, and the quantity used in fining a barrel of ale?"

To answer most of these queries, I have given an example of a brewing with the same quantity of malt as assumed by my correspondent, namely, 160 bushels; but the malt I employed, instead of producing per quarter 240 specific gravity, (Allan's instrument,) only produced 206·3, being 33·7 less per quarter. I obtained (see example) thirty-six barrels of ale at 103·5 gravity, and ten barrels of beer at 40. Had my malt been of such quality as to give 240 gravity, I should have obtained, for my ale of 103·5 gravity, forty-two barrels and seven gallons, with the same quantity of beer, namely, ten barrels. I have only to remark, that malt producing such a gravity as 240 is rarely to be met with in Scotland.

It is not customary with brewers here to mash a second time. The quantity of liquor generally used

for mashing is about one barrel and three firkins per quarter, and sometimes only one barrel and a half. The heat of the liquor varies from 78° to 85°, and the time of mashing about forty-five minutes. The time which the liquor is allowed to remain on the goods is from two to three hours. The heat of tap is from 146° to 150°. For ales of a high gravity, say from 105 to 115, the quantity of hops ranges from four to ten lbs. per quarter; in the winter brewings the average being about six lbs.; and in the spring brewings, for the ales intended for summer consumption, about eight lbs. The time of boiling these worts is from one hour to one hour and a half. As the Scottish brewers, properly speaking, mash but once, they cannot be said to have more than one wort; and the first running of this wort is the extract obtained from the malt by the liquor in the process of infusing, as well as a considerable portion of that which is obtained by sparging; the after-running is that which has been obtained wholly by sparging. The average heat of letting down the wort into the fermenting tun is about 53° in winter, and 51° in spring. The average proportion of store is about six lbs. to every three barrels. The increased temperature of the tun ranges from 12° to 17°.

The attenuations and gravities of the various kinds of ale will be found in the tables of experiments.

By some brewers the gyle is let down from the

fermenting tun into squares, at that period when its temperature is on the decrease. It is allowed to remain there from sixteen to twenty-four hours, and thence cleansed into hogsheads, barrels, and half-hogsheads; and it is not unusual to send this ale out in forty-eight hours after it has been cleansed. The Scottish brewers make no use of isinglass for finings; nor do I believe they have any occasion to employ such agents as flour and salt in order to stimulate fermentation.

EXAMPLE NO. 1.

March 1, 1836.—L.5 Ale.—Malt, 20 Quarters;—Hops, 160 lbs.—Temperature 42°.

Commenced brewing at 4 A. M., by turning into the mash-tun thirty-two barrels of liquor at 200°. When reduced in temperature to 180°, shot twenty quarters of pale malt into mash-tun; and raked and mashed with oars forty-five minutes. Finished mashing at 5 ho. 15 min., and strewed a bushel of grist over mash and covered up. At 8 o'clock set tap, (or, as they term it in Scotland, *slacked*,) uncovered, and commenced sparging at the same time, with liquor at 190°, and continued the operation until thirty-two barrels were sparged. Wort running quite fine with good appearance; temperature 148° and 110 gravity. At 11 ho. 30 min., ale wort all in

copper, which gauged forty-eight barrels, at gravity 83, Allan's Saccharometer. Previously, however, shut tap, and sparged on mash fifteen barrels of liquor for table beer.

Weighed one hundred and sixty lbs. of the best East Kent hops, and put them to the wort in the copper; and 12 wort came through, boiled briskly one hour and twenty-five minutes, and at 1 ho. 30 min. cast copper. At 2 ho. 30 min. spread in coolers. At 10 o'clock P.M. pitched tun with eight gallons and a half of store weighing 90 lbs., and let down wort at 50°, which gauged in the tun thirty-six barrels and a half, gravity 103·5.

The following table shews the heat of the tun during fermentation:—

March	2,	1	o'clock	P.M.	50°	March	9,	60°
„	3,	9	„	A.M.	50°	„	10,	61°
„	4,	9	„	„	52°	„	11,	62·5°
„	5,	8	„	„	56°	„	13,	63°
„	6,	10	„	„	58°	„	14,	63°
„	7,	8	„	„	58·5°	„	15,	62°
„	8,	8	„	„	59°			

March 15.—Removed the gyle from the tun into the square, the temperature of which when let down was 62°, and gravity 43.

March 16, 10 A.M.—Cleansed into hogsheads and barrels.

The summary of the foregoing example is as follows:—

Ale, 36 barrels, at gravity	103·5	=	3726
Beer, 10 „ at „	40	=	400
Quarters of Malt used,			20)4126
Value extracted from each quarter,			$206\frac{3}{10}$

EXAMPLE II.

March 8, 1836.—L.7 Ale and L.3 do. Malt, 24 Qrs. Hops, 195 lbs. Temp. 40°.

Commenced brewing at 5 A.M. by turning into mash-tun thirty-six barrels of liquor, at 198°.

When reduced in temperature to 183°, shot twenty-four quarters of pale malt, raked for five minutes, and set on the mashing-machine. Mashed twenty minutes; turned on two barrels of liquor at 185°; mashed for fifteen minutes longer; and then strewed a bushel of grist over mash, and covered up. At 9 o'clock set a tap, uncovered and commenced sparging with liquor at 185°. Wort running quite fine; heat of tap 149°, gravity 116. Continued sparging for this wort until twenty-three barrels were

sparged. At 9 ho. 15 min. put pump on the wort. At 12 ho. 30 min. L.7 ale wort all in copper; having previously sparged seventeen barrels of liquor for L.3 ale. The L.7 gauged 43 barrels at 105 gravity. Weighed 195 lbs. of Farnham hops, and mixed them with the wort in the copper. At one o'clock P.M. worts came through briskly 1 ho. 25 min. and cast copper at 2 ho. 30 min. At 3 ho. 20 min. all L.7 ale wort spread in coolers; and L.3 ale wort in copper, which gauged 19 barrels, at 40 gravity. At 4 ho. 30 min. wort came through, and boiled two hours; at 6 ho. 30 min. cast copper.

At 10 o'clock pitched tun with eleven gallons of yeast, weighing 110 lbs., and at 10 ho. 20 min. let down L.7 wort at 51°, which gauged in tun thirty-two barrels, at gravity 129, temperature 51°.

At 3 A.M., March 9th, pitched tun with thirty-six lbs. of store, and let down from the coolers the L.3 wort at 52°, which gauged, when all down, thirteen barrels, gravity 72, and temperature 52°.

Tun No. 1, L.7.				Tun No. 2, L.3			
March	9,	10 A.M.,	51°	March	9,	10 A.M.,	52°
„	10,	9 „	51.5	„	10,	9 „	52
„	11,	10 „	52°	„	11,	10 „	55°
„	12,	9 „	54°	„	12,	9 „	57°
„	13,	8 „	57°	„	13,	8 „	59°
„	14,	9 „	58°	„	14,	9 „	61°
„	15,	10 „	59°	„	15,	9 „	62°
„	16,	9 „	60°	„	16,	10 „	63°
„	17,	10 „	61°	„	17,	11 „	63°
„	18,	10 „	61.5°	„	18,	10 „	64°
„	19,	10 „	62°	„	19,	10 „	63°
„	20,	9 „	62.5°				
„	21,	8 „	63°				
„	22,	9 „	63°				
„	23,	8 „	62°				

The Summary of the foregoing example is as follows:—

	Bar.		lbs.
L.7 Ale, 32, at 129 gravity,		=	4128
L.3 do. 13, at 72 do.		=	936
Quarters Malt, . .			24)5064
Value extracted from each quarter,		=	211

INDIA BEERS.

Although this book is designated the Scottish Ale-Brewer, and is a practical treatise on the art of brewing ales, according to the system practised in Scotland, it may not be deemed out of place to diverge so far from the proposed object, as to introduce an article on brewing beers for the India market. This, I think, will not be unacceptable, but on the contrary may prove useful to those who wish to cultivate this branch of export trade, in which many of our eminent brewers in Britain have been engaged for the last twenty years.

For a long period, up to about 1820, this trade was almost exclusively in the hands of one individual. It is impossible perhaps to know what suggested to Mr. Hodgson the idea of brewing for the India Market, but from the unrivalled fame his beers soon acquired, and which they retained during many years in India, we may infer that his system was based on sound principles. It is well known, that the orders Mr. Hodgson received, were fully as many as he could well execute. The high preservation in which his beers were uniformly found at the

end of the voyage, and their continuing sound during any reasonable length of time in so unfavourable a climate, justly entitled him to the confidence of the public: in fact, Hodgson's beer was as well known in India, and as highly appreciated, as is London porter all over the world.

Mr. Hodgson's successful career was a sufficient stimulus to induce others to enter the field, although at great disadvantage, having to compete with so eminent a name. However, notwithstanding those difficulties, competitors still persevered, and eventually some of them succeeded in obtaining a large portion of the trade, and for several years past almost all the breweries in the neighbourhood of large sea-ports have occasionally been at work for the India market.

Formerly, in Edinburgh, there was only one firm that brewed for India; now there are several. Of late, the greatest competition appears to have been carried on by two rival brewers at Burton-on-Trent, who still continue with spirit to vie with each other. The vast quantity which they export to the India market will be seen by the following quotations, from the advertisements which recently appeared in almost all the provincial papers in Great Britain, and which I take leave to introduce as an evidence of the extent of their trade in this article. As I notice it solely for this purpose, it would be out of place to make any comment on their correspondence; therefore, under A is Messrs. Allsopp and

Sons' statement, and under B is that of Messrs. Bass and Co.

A		B	
From Oct. 1, 1842 to Oct. 1843 inclusive	Hhds.	From Oct. 1843 to Feb. 1, 1844.	Hhds.
Allsopp . .	9499	Bass . . .	6868
Bass . . .	4800	Allsopp . , .	5786
		Hodgson . .	606

Whether this export business comes up to their expectation, it is not for me to judge, but this I may safely affirm, that many who have brewed for this particular market have had good cause to repent of doing so.

I possess a letter from Bombay, dated July 1845, in which the writer mentions that he saw no less than eight hundred hogsheads of ———'s beer turned into the harbour, and adds, that a very great portion arrives in a bad state, consequently fetches, as he observes, "a mere song." This fact will not be doubted, when reference is made to a table I have given of the original gravities, ascertained by Partial Evaporation, of forty samples of beer made for the India market and home consumption, many of which will be seen to be miserably low. Even keeping beers for the home consumption, were they made from such low gravities as some to be found in this table, would certainly not stand over the summer. I may observe here, that several of the samples which I have now tested, have been to India and other foreign climates. The writer of the letter referred to adds, "that good sound beer always fetches its price in India."

India pale beer being so highly impregnated with the finest hops, has not only been appreciated in India as a refreshing beverage, but when used in moderation, is also considered as an excellent stomachic. So much is this the case, that when our countrymen returned home, they felt the want of their "Hodgson," and in consequence, it is more than probable that some of the influential among them urged the brewers to make a similar article for the home trade. They have done so, and their success has been far beyond their expectations. This success, no doubt, has been principally owing to the very favourable opinion entertained of its tonic qualities by several of our most eminent medical men, who have recommended it to their patients, as a strengthening, exhilirating, and wholesome beverage. What is called India beer is now very generally used in Great Britain. Such being the case, and as we are likely to find from our new relations in the East, a good market for this article, even in China, it is of the greatest importance to those who wish to compete with others, that they should acquire every information regarding the method of making those beers; and it must be evident, that to be put in possession of the original gravities and attenuations of the beers, of those who have been successful, will accomplish a very essential point towards it. For this purpose I have examined, by Partial Evaporation, forty samples from the London, Scottish, Burton, and other English provincial brewers.

I have entered more fully into the introductory part of this article than I intended, and for which I trust my readers will excuse me.

I shall now proceed at once to the details of the general system adopted by those with whom I have corresponded.

MALT.

This material ought to be of the best quality, pale though well dried, and not crushed too fine.

MASHING HEAT.

I assume that the brewer has his mashing liquor in the tun, and is waiting for its cooling down to his proposed heat. The question comes now to be—and a most important question it is—what degree of heat this should be, for, in the employing of a judicious heat in this process, the success of the brewer in a very great measure depends. It is almost unnecessary again to remark, that the constituent parts of malt, which are absolutely necessary for the brewer, are sugar, starch, and gluten, technically called Saccharum, Fecula, and Gluten. Each of these substances requires a different heat to dissolve it. First, the saccharum requires more than the fecula, and the gluten again much more than either. The brewer's object is to dissolve the whole of the saccharum and

fecula, but only a portion of the gluten, and upon a due proportion of the gluten which he requires (for require it he will) the character of the article he intends to produce greatly depends. Had he any method by which he could ascertain the exact portion of each of these substances, which the malt contains, he could then form some idea of the proportion of gluten necessary, and could regulate the heat of his first mash accordingly, so as to promote a desirable fermentation. If worts contain too much of this substance—gluten,—fermentation will proceed too vigorously, and, on the other hand, if they contain too little, the fermentation will be languid. Where brewers more generally err in the making of these beers is, by employing liquor at too high a temperature for the first mash; the original gravity being low, the gluten they extract by this means far exceeds the proper portion, and consequently fermentation becomes unmanageable. In corroboration of what I have just remarked, I may quote from the letter of a brewer, who wrote to me for advice on the subject:—"We are quite at a loss to account for our ale, being so very far attenuated of late, in spite of all our endeavours to prevent it; worts weighing 70 by Allan previously to fermentation, often being worked down to 18 or 20, and sometimes turning sour, even before it is sent out to the consumer. No matter how little yeast we use, the effects are still the same. We have even used so little as two pounds for six bushels, with no dif-

ferent effect. We merely allow the worts to rise about 1° of heat, and gain a slight head, and then cleanse into puncheons. They often attain to 75° in heat, causing thereby an unmanageable fermentation. When racked, the beer is almost invariably thick and cloudy, with a thin warm flavour, and, of course, too far attenuated."

From these circumstances, it appears evident that it would be futile to lay down invariable rules for fixing the heat of the first mash. Independently of what has been said, there are many reasons which prove that the laying down of regular stated heats, and acting up to fixed rules in this respect, would lead to ruinous results. It has been satisfactorily ascertained, that if the heat of the worts, when about half run down into the under-back is from 145° to 150°, a judicious mashing heat has been employed for the first mash, and it is the brewer's object to attain this desired point. It thus appears, that in the first place, the temperature of the air must be consulted; Secondly, the sort of beers intended to be produced; and, Thirdly, the proportion of gluten necessary for this purpose.

For example.—As the worts for the production of India beer are of low gravity, less of the gluten is required, and consequently less heat is necessary. Should the atmosphere, at the time of mashing, range from 40° to 45°, one hundred and sixty-eight to one hundred and seventy degrees will be required; —assuming that the brewing is to the extent of 20

quarters; for, if less, say 10 quarters, a higher degree of heat for the mashing liquor must be used. Should the temperature be from 35° to 40°, I should say 170° to 172°, or if the atmosphere range still lower, 173° to 175° will be necessary. With regard to the quantity of liquor to be apportioned for the first mash, one barrel and three firkins is about the medium quantity.

MASHING.

This process should be conducted as rapidly as circumstances will admit. It will take with a machine from twenty to twenty-five minutes, and should be performed under cover. Immediately after the machine has been stopped, the heat of the mash should be taken, in three or four different places, and the average recorded for future guidance. It is probable, that the average temperature of the mash, will then be found rather lower than 150°, which, as before stated, should be about the heat when the wort is afterwards half run down into the underback. The increase of temperature is occasioned by the heat, generated in the process of saccharification, that is to say, the converting the fecula, or starch, into sugar; latent heat having been converted into active. If however at the time of taking the average heat, the mash is found to be many degrees lower than 145° per quarter, then a

firkin of liquor, at 195° should be turned on, to bring it up to the required temperature, namely, about 150°. One hour, and forty minutes, to two hours, are fully sufficient to saturate the goods, and ensure transparency.

SPARGING.

The method of performing this operation, has already been fully described, in a former part under the head, "SPARGING;" therefore it is only necessary to proceed by stating, that it is advisable the mashing machine should be so constructed as to allow the sparging apparatus to work on its shaft. In this case the process may be performed under cover. The air will thus be excluded and the heat preserved.

Although it is not generally adopted, yet I would recommend this operation of sparging to commence a minute or two before the taps are "*slacked*;" and, for this particular beer, with liquor, ranging from 185° to 190°. It being assumed that two boilings will be necessary, as much of the worts is now run into the underback as will be required for the first boiling. The taps are then shut for a time, and the sparging discontinued, that is, if the liquor covers the goods, for, if it does not, more liquor must be sparged on before the taps are shut, it being highly detrimental to allow the surface of the goods to be dry.

BOILING.

The first division of the worts is now in the copper at nearly a boiling heat, and next comes to be considered the quantity of hops necessary, or perhaps more properly speaking, generally used by brewers who make this beer. The Burton brewers average from about 20 to 22 lbs. per quarter, and they generally prefer the East Kents; but the average of others, for this beer, is about 16 to 18 lbs. If the former quantity is to be used, it would be advisable to divide it thus :—Six pounds per quarter are first put into the copper, and boiled for twenty minutes, after which eight pounds per quarter are added, and with the first quantity boiled for fifty minutes longer, making in all one hour and ten minutes, and leaving the remaining eight pounds per quarter for the second wort. Previously however to this, the intelligent brewer has taken his copper guage, and the gravity of his first wort, that he may be directed what course he will have to pursue in order to make up his second.

This first wort being now into the hop-back, and the copper charged with the second, it is boiled with the remaining 8 lbs. of hops for two hours. It is to be borne in mind, that the hops from the first wort are not returned, but are allowed to remain in the hop-back, the wort still draining from them. At

the expiry of two hours, the second wort is run upon them, and by this means, much, if not all of the valuable matter imbibed by the hops from the first wort will be given to the second. To extract what remains from the second wort, after it has run from the hop-back, the brewer will use his own discretion, either by pressing, or by a return wort.

Although I have particularized twenty-two pounds of hops per quarter, this proportion appears to me unnecessarily large. I have at present beers of my own making, three, four, and five years old, as sound as they were when first bunged down, made with a far less quantity. To test these beers, I have exposed them to different temperatures, varying from 45° to 90°. At the same time, I must acknowledge, that although they have stood those tests, in this country, it is difficult to say what effect a long voyage and a hot climate might have upon them. The high character which they have obtained here, has induced several eminent brewers, in order to satisfy themselves, to wait upon me, and they have candidly acknowledged they have never seen beers of finer quality, and, besides, have expressed their surprise that their fame has not gone farther.

COOLING.

Reducing the temperature of the worts in the coolers is now generally accomplished by artificial

means, and with great rapidity, it being important that they should be reduced to the pitching temperature, with as little delay as possible.

FERMENTATION.

I have, in page 107, entered very fully and comprehensively into the detail of this important part of brewing; therefore, I have merely again to add, that unless fermentation is conducted on right principles, the brewer will not succeed in obtaining a favourable result. However, it is necessary to point out the difference between the management of these beers at this stage, and that of the ales made on the Scottish system. The latter, as already noticed, are conducted by a slow fermentation, whereas the India beers are carried through by a remarkably vigorous one, so much so, that the time the worts are in the fermenting tun, seldom exceeds twenty-four to thirty hours, and at an increase of temperature of about seven degrees. At the end of this period, they are well roused and cleansed into hogsheads or puncheons, and are farther attenuated down from 20 to 24 Allan.

The pitching heat varies in different establishments from 58° to 60°, according to the quantity of yeast employed, taking into consideration the temperature of the atmosphere, as well as that of the tun room. Assuming the atmosphere to be 38° to

42°, and the tun room to be 45°, then I should consider the heat for pitching ought to be 60°, with two pounds of yeast per barrel. This I regard as an average practice from November to March. If, however, the atmosphere is lower than 38°, say from 30° to 35°, then the pitching heat should be brought up to 62°, and the quantity of yeast should be a little increased.

The puncheons are filled up every two or three hours, as in the management of other beers; but still more caution is necessary to be observed here, in order, that while the cask is filled up with the ejected wort, that wort should be clean, and as free from yeast as possible. It is the brewer's aim, in filling up, to induce the wort to discharge its impurities; therefore, it is not only useless, but detrimental to return yeasty wort, which must again be so soon ejected, as it gives it the extra labour, and that at a time when fermentation is languid, and, consequently less able to accomplish this end—the discharging of its impurities. Should this caution be neglected, the consequence would be, that in a short time a portion of the yeast, instead of being discharged, would fall to the bottom of the cask, in the shape of lees.

There exists a practice in some breweries, when fermentation begins to be languid, of filling up with beer of a former brewing, instead of filling up with ejected wort. This I think a judicious practice,

and it is very successful in obtaining the desired end.

Fermentation in the casks is generally completed in fourteen or twenty days, according to circumstances. At the above period, if the brewing has been rightly managed, the beer will be tolerably fine. The beer is now racked into hogsheads, and allowed to remain until the *fancy* has completely subsided, when a pound or somewhat more of the finest hops, having been previously prepared by working them up with some of the beer, is put into each hogshead, which is immediately chived or bunged down.

I have adopted what I have found to be a very beneficial practice; instead of breaking the hops down with beer, I mash them with a little rich boiling ale wort at 100 or 110, Allan, and when cool, I add about a pound to each hogshead, with a little of the remaining worts. This provides nourishment for the beer, and renders it fuller to the palate. I consider it to be of great moment that the beer should be moderately fine before it is racked. This, however, is not the opinion of every brewer, for a celebrated Author of a Brewing Book, and one who states he has brewed with much success for the India market, affirms that beer for this trade will always keep better when it is racked off with a little of its own dreg, than when it approaches to fineness. He states that this may proceed from a portion of the

fecula from the hops remaining in the beer, which, as it preserves the worts in the coolers, may also preserve the beer when fermented. He remarks as follows :—" It is a well known fact, that should beer be fined down and racked before being sent out to the India market, it never turns out so well as when it retains a portion of its own dreg." I think it will appear evident that my practice is a much better one than that which he recommends. If it were possible that this dreg contained nothing but the fecula of the hops, as in the coolers, then in this case, the beer would be benefitted by leaving a portion of it in ; but I maintain, that the dreg of beer is little else than a collection of yeasty matter, with a very minute portion indeed of the fecula ; and that, therefore, if allowed to remain in the beer, it will prove a very excitable ingredient ; in fact, one above all others the most injurious imaginable, especially for beers which have to undergo the fatigue of so long a voyage, as well as being stored on arrival in a climate so unfavourable. I leave the intelligent brewer to judge which of the two is the better practice, and go on to conclude this article by giving the results of the forty different samples of India Beers, in two tables, No. 1 and No. 2.

From repeated examinations of these beers by Partial Evaporation, I have come to the following conclusion :—That the brewers either make their worts for the export trade, at least five or six degrees

higher than for the home consumption; or that the retailers in London, and in the provincial towns, mix them with others of a lower gravity. I have selected ten specimens from those made by the most noted brewers for the India market, and find their average gravity to be about 68. I have also selected ten by the same brewers for the home trade, and find the average gravity about 62. The remaining specimens made by brewers calling their beers "India Pale Ales," but at a much lower price, average about 55. Three or four of these last mentioned have stood the voyage out and home again, and although eighteen months old, I found them perfectly sound, and in good condition.

The prices of the beers stated in the tables may not all be strictly correct, as the parties who were kind enough to furnish me with the samples which had been to India, could only afford me information as to what was paid per tun. the year they were shipped.

TABLE I.

RESULTS OF EXPERIMENTS ON INDIA ALES BY MEANS OF PARTIAL EVAPORATION.

	Prices of Ales per Hogshead.	Export or Home Trade.	No. 1. Saccharometer, degree of the Ale when examined from the bottle.	No. 2. Saccharometer, degree after the dissipation of the spirit, and water added.	Difference between No. 1. and No. 2. Shewing the attenuation arising from the Spirit.	Proof Spirit per centum.	Original Gravity.	About the period when Brewed	The Samples, whether taken from the Cask or Bottle.
1	90s.	Export, India.	17.75.	18.25.	10.50.	13.3.	67.61.	Jan. 1844.	Bottle.
2	81s.	Home.	6.50.	15.	8.50.	10.5.	53.75.	April 1845.	Cask.
3	„	„	6.	14.75.	8.75.	10.85.	54.825.	Mar. 1845.	Bottle.
4	„	„	5.	14.50.	9.50.	11.9.	58.55.	Do. do.	Bottle.
5	„	„	5.	14.75.	9.75.	12.25.	60.125.	Do. do.	Do.
6	81s.		5.25.	14.75.	9.50.	11.9.	58.80.	Do. do.	Do,
7	84s.	Export.	5.25.	15.	9.75.	12.25.	60.375.	Dec. 1844.	Cask.
8	95s.	Export.	8.	18.75.	10.75.	13.65.	69.425.	Not known.	Do.
9	90s.	Do. India.	8.	18.25.	10.25.	12.95.	66.275.	Do. do.	Cask.
10	84s.	Do.	10.	19.25.	9.25.	11.55.	61.975.	Do. do.	Do.
11	81s.	Home.	12.	20.50.	8.50.	10.5.	59.25.	Do. do.	Do.
12	60s.	Export, India.	6.50.	15.	8.50.	10.5.	53.75.	1844.	Bottle.
13	60s.	Do. do.	5.	13.75.	8.75.	10.85.	53.82.	Do.	Do.
14	60s.		13.	20.50.	7.50.	9.15.	54.175.	Not known.	Do.
15	90s.	Export.	12.25.	21.25.	9.	11.2.	62.65.	1845.	Cask.
16	90s.	Do.	12.25.	21.50.	9.25.	11.55.	64.225.	Do.	Do.
17	90s.	Do.	12.	21.	9.	11.2.	62.40.	Do.	Do.
18	90s.	Do. India.	12.	21.50.	9.05.	11.9.	65.55.	Not known.	Bottle.
19	95s.	Do. do.	7.25.	17.75.	10.50.	13.3.	67.10.	Do.	Do.
20	90s.	Export.	7.50.	18.25.	10.75.	13.65.	68.925.	Do.	Do.

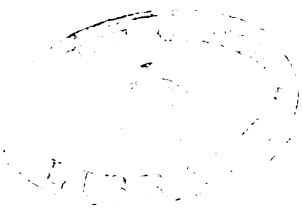


TABLE II.

RESULTS OF EXPERIMENTS ON INDIA ALES BY MEANS OF PARTIAL EVAPORATION.

	Prices of Ale per Hogshead.	Export or Home Trade.	No. 1. Saccharometer, degree of the Ale when examined from the bottle.	No. 2. Saccharometer, degree after the dissipation of the spirit, and water added.	Difference between No. 1. and No. 2. Shewing the attenuation arising from the Spirit.	Proof Spirit per centum.	Original Gravity.	About the period when Brewed.	The Samples whether taken from the Cask or Bottle.
21	90s.	Export, India.	10.50.	20.75.	10.25.	12,95.	68.525.	Feb. 1845.	Bottle.
22	„	Export.	6.	14.75.	8.75.	10.85.	54.825.	Jan. 1846.	Cask.
23	„	Home.	6.50.	15.25.	8.75.	10.85.	55.325.	„ „	Do.
24	„	Export.	5.	13.50.	8.50.	10.5.	52.25.	Mar „	Bottle.
25	65s.	Do.	5.25.	15.25.	10.	12.6.	61.95.	Jan. „	Do.
26	60s.	Do.	4.25.	12.25.	8.	9.8.	48.35.	April 1845.	Do.
27	60s.	Do.	4.25.	12.25.	8.	9.8.	48.35.	1845.	Cask.
28	63s.	Do.	5.50.	13.50.	8.	9.8.	49.60.	Do.	Do.
29	60s.	Home.	5.	12.25.	7.25.	8.82.	44.690.	1844.	Bottle.
30	„	Do.	4.25.	12.50.	8.25.	10.15.	49.925.	Not known.	Do.
31	60s.	Do.	6.	13.50.	7.50.	9.15.	47.175.	Do.	Do.
32	81s.	Export.	3.	13.25.	10.25.	12.95.	61.275.	Do.	Do.
33	81s.	Do.	3.25.	13.	9.75.	12.25.	58.375.	Do.	Do.
34	„	Do,	3.75.	13.50.	9.75.	12.25.	58.875.	April 1845.	Do.
35	63s.	Do.	3.25.	13.	9.25.	11.55.	55.225.	Do. do.	Do.
36	66s.	Do.	4.	13.	9.	11.2.	54.40.	Not known.	Do.
37	90s.	Do.	7.50.	18.25.	10.75.	13.65.	68.925.	1845.	Cask.
38	90s.	Do. India.	10.25.	20.75.	10.50.	13.3.	70.10.	1844.	Bottle.
39	„	Export.	9.	19.25.	10.25.	12.95.	67.275.	Do.	Do.
40	„		7.75.	18.50.	10.75.	13.65.	69.175.	1845.	Cask.

MALTING.

Malting is the process by which certain of the component parts of barley, and several other kinds of grain, are converted into a species of saccharine matter, through the agency of an artificial or forced vegetation.

The maltster's object, in the process of malting, is, to convert as much as possible of the fecula or starch of the barley into saccharum, of which it contains but little; and to reduce the quantity of gluten, of which it contains too great an abundance for the brewer's purpose. To attain this end with profit—simple as the process may appear—much practical knowledge and experience are required. To proceed exclusively upon theory, in malting, will, in nine cases out of ten, lead to unfavourable results. In fact, to be a good maltster, much experience along with unwearying observation, is absolutely necessary.

Previously to entering into the details of the process, it is proper to present a brief view of the nature and quality of the grain, usually employed for malting.

BARLEY.

Barley is acknowledged by all to be the grain best adapted for malting. So universal is this opinion, that barley is cultivated chiefly for this purpose, although, at the same time, much of it is used by the distiller unmalted. Wheat, oats, rye, and other kinds of grain have been occasionally malted; but none of these answer the brewer's purpose so well as barley. In illustration of this fact, I may mention, that being in Essex, in 1835, in which year a large quantity of wheat was malted, I had an opportunity of frequently drinking ale made from it, and it was not, in my opinion, so agreeable as that made from barley malt, which I had, until then, been accustomed to in that county. In addition to its harsh flavour, it was invariably grey in colour; and I have been informed since, that it did not give satisfaction.

With regard to the result of the analysis of barley, much contrariety of opinion exists among chemists; one asserting from his experiments that its component parts consist of only four ingredients, another as confidently stating six, and a third nine. It would be altogether an unprofitable task to enter into the merits of such discussions. However, it is so far satisfactory, that they all very nearly agree as to the quantity of saccharum, gum, and gluten; al-

though they differ materially as to the fecula. Saccharum, as already stated, is the ingredient which it is the maltster's study to increase, and this he will effect by judicious management, in nearly the following proportions :—

Barley.		Malt.	
Gum,	3½	Gum,	15½
Gluten,	4¾	Gluten,	1
Sugar,	5¼	Sugar,	16
Starch,	86½	Starch,	68
	100		100

It appears by the above analysis, that starch, or fecula, forms the principal component part of barley, and that the process of malting converts this fecula to a great extent into saccharum, or sugar. It is, therefore, desirable, in the selection of barley for malting, that the sample chosen should be that which contains the greatest portion of fecula, as unquestionably it is the most valuable part of the grain. To be able to form a correct opinion of the value of barley, from the quantity of starch it contains, is a very requisite acquirement to a maltster. This knowledge, however, can only be obtained by patient and diligent observation.

It is not my intention to enter into the abstract principles of malting, but merely to confine my re-

marks to the practical branch of the subject, and the means best calculated to ensure success in the process of converting barley into malt. Before proceeding further, then, the reader must be made aware, that there are three sorts or species of this grain grown in Britain, namely, barley, beer, and bigg. The first species is that universally cultivated in England, and the southern counties of Scotland. The last two are grown in the Highlands and Islands of Scotland. The pickles of barley are much longer, in every way, and heavier than those of the beer and bigg, while the skin is much thinner. The skin of barley itself, however, is more or less thin, according to the climate of the country in which it is cultivated, the skin being thinner as the climate is warmer; so that English barley may be generally known when compared with the best Scotch by this criterion.

In the selection of barley for malting, regard should be paid to the following properties: namely, the brightness and uniformity of the colour—which is a kind of pale yellow—the plumpness of the pickle, the thinness of the skin, and the complete absence of any approach to mustiness. When broken in two, the fecula should be white and free. Care ought to be taken, that new and old parcels are not intermixed. This may be known by the want of uniformity in colour and size; should the colour be dim and various, the skin thick, and the interior

horny—termed by the trade flinty—and of a blueish colour, this barley will never work well, and, consequently, when malted will be bad.

The Chevalier barley has become a great favourite for malting, and justly so. In the opinion of many who have amply proved, by testing its qualities, it is the kind best calculated for the maltster, as well as for the brewer. It is a matter of the greatest consequence to the interest of both, that the barley selected should be the heaviest, and the very best that can be procured. In proportion to the weight of the barley will be the weight of the malt; assuming, however, that the process of malting has been properly and thoroughly conducted. Although the best grain will, of course, be higher in price, yet, as the manufacturing expenses, as well as the duty, are the same as in the case of inferior barley, it is evident, that it is a matter of real economy to select the best barley, and, moreover, it must be acknowledged, that inferior grain cannot produce good malt, nor bad malt, good beer. The best barley weighs from 50 lbs. to 54 lbs. per Winchester bushel. The average specific gravity of twelve samples of barley, six of which were English, and six Scotch, was found to be 1.295.

MALTING.

This process may be divided into four stages, namely, steeping, couching, flooring, and kiln-drying.

STEEPING.

In order to cause the grain to germinate, it is necessary that it should imbibe a considerable quantity of moisture, and for this purpose the practice of steeping it in water, for a certain period, is unquestionably the most expeditious, as well as the best method. This part of the process is often very tedious, especially when the atmosphere is cold. The reason of this is the oleagenous substance with which the skin of the grain is covered, and which renders it impervious to the water, until this matter is dissolved; but this will be accomplished, after some time, by the water, which then finds its way to the interior of the grain. The precise amount of time which the grain requires to remain in the water cannot be determined here, as much depends upon the quality and age of the barley, as well as upon the season of the year, when it is to be malted. With respect to the first—the quality—the thinner and lighter the grain is, the shorter the time it will

require to steep, and the larger, drier, and bolder the barley is, the longer it ought to remain under the water. There is no process in any known manufacture, in which nature so directly operates, as in malting, and the closer we follow her footsteps, the nearer we may hope to arrive at the desired result. In fact, we ought to regard the malt-house as an artificial field.

The vessel employed by maltsters for steeping the grain is a square cistern made of wood, and lined with stone or lead. It is called the *steep*, and according to act of Parliament, must be permanently fixed, the sides and the ends being straight and at right angles, and of no greater depth than forty inches in any part thereof. It must have an even bottom, with no more inclination for the drip than half an inch, for every foot in length of such drip.

The quality of barley being measured, it should be well screened, *i. e.* sifted, to rid it of the seeds, and light and broken corn, which if allowed to remain, would prove not only unprofitable but very detrimental. At this stage, and before he proceeds further, the intelligent maltster ascertains the temperature both of the barley he intends to steep, and of the water he means to employ, and regulates the temperature of both accordingly; so that when they come together in the steep, they shall not exceed 50° nor be under 47°.

By some maltsters the barley is put into the *steep* and water run upon it, until it stands several inches

above the grain; by others, the water is run in first, and the barley shot in afterwards.

It is of the greatest importance that the water employed in this operation be good, and devoid of any, even the slightest bad flavour, for were it at all fœtid it would assuredly impart its noxious quality to the steeping grain. Rain water, if perfectly pure and sweet, or river water, is greatly preferable to hard water. From my own repeated observation, I am convinced very much depends on the quality of the water which is used for the steep, not only in respect to the after flavour of the malt, but to the increase of saccharum. It is an acknowledged fact, that malts, made in a district where good river water can be obtained, produce ale of a peculiarly fine and rich flavour. The ales made from the water of the River Trent, for instance, are proverbial for their excellence in point of flavour. My impression is, that if Burton or Nottingham brewers, were to brew from malts made in Essex or Hertfordshire, the article would be decidedly inferior in flavour to that which they now usually produce. No doubt the opinion of some is, that this peculiarity does not in any way depend upon the nature of the water employed in malting, but altogether upon the process of brewing; others again attribute it to difference in the management of the malting process itself. As this is the opinion of some, it may be as well here to notice, that the maltsters of the Midland Counties of England, generally adopt the sprinkling system,

and when this system is judiciously employed by honest men, I confess I consider that the converted starch or saccharum is of a superior quality. The worts produced from such malts are decidedly far richer than the worts produced from malts made in the Southern Counties, by maltsters who do not pursue this system. This may help to account for the peculiarly fine flavour of the Burton and Nottingham Ales. The following short extract contains the opinion of an able writer on the subject, with regard to the quality of water used for malting:—

"Were we to inquire by what means the same barley, with the same treatment, produces unequal portions of the saccharine matter, in different situations, we should perhaps find it principally owing to the different qualities of the water used for malting. Hard water is very unapt for every purpose of vegetation, and soft will vary its effects according to the predominating quality of its impregnations."

Before entering more minutely into detail, it is right to caution the inexperienced maltster against promiscuously mixing the different parcels he may have purchased, for where this is done a material injury is produced. The germination is unequal, and consequently the malt produced is of a very inferior quality; for in such miscellaneous parcels there will be bodies of different weights, and as the heavier requires to be longer in steep then the lighter kinds, the former will not have imbibed a sufficient quan-

tity of moisture, when the latter will be found ready for the couch.

The following remarks of Professor Donovan in regard to this matter are very judicious. He observes, "there is a mal-practice amongst maltsters which often occasions the worst consequences to the Brewer and Distiller, that is, the culpable negligence of not assorting the different parcels of barley that are intended to be malted, but steeping them all promiscuously in the same cistern. A careful maltster will keep separate the parcels of grain, which have grown in different soils or districts; he will avoid mixing old and new barley; and he will even separate the large from the small grain from the same batch by the process of screening. The different qualities should constitute different batches for steeping. If these particulars are not attended to, the consequence will be, that when the mixture of the different qualities is put into the one steep, the grains will not germinate equally, the germination of some will have proceeded considerably, while that of others will not have yet commenced. In some grains the saccharine matter will be exhausted, in others it will not be yet formed, and the whole product will be malt of a very inferior quality. This must necessarily happen, for in the case of different sizes it is obvious that the same steeping that will be barely sufficient to penetrate a large grain, will over steep a small one, and *vice versa*. Hence, after

equal steeping of unequal grains, the small ones may grow too much, and the large too little. With regard to different ages of barley, it must be remembered that time very much modifies the qualities of many seeds. Thus, every one knows the practice of gardeners, who, when they wish to restrain the luxuriant growth of a plant, keep the seeds by them for some years, and the object is thus certainly attained. The Brewer or Distiller, who is his own maltster, can always protect himself from injuries of this kind; but he must always be subject to them while he depends on others for the execution of this fiducial office."

We will now suppose that the water is in the steep or cistern, the temperature having been regulated in the manner described above; the number of quarters or bolls of barley (already screened) that are intended for steeping are then thrown in, raking the whole well about until the heap is quite level, the surface of the water being above it several inches. By this operation the good and heavy grain immediately after sinks to the bottom, while the refuse and seeds float on the surface. These should be skimmed off; otherwise they would add to the bulk, and, consequently, increase the duty, while at the same time they would deteriorate the malt. Shortly after this, the grain begins to swell, and continues to increase in bulk, until it acquires its maximum degree of expansion, the amount of which, after a sufficient time has been allowed for it to steep, will

in a great measure depend upon the quality of the grain, and its state of dryness when it is put into the cistern; therefore the increase must not be expected to be the same in every case. It has been calculated that the average expansion will amount to 18½ bushels in every 81½ bushels put to steep. This average having been duly considered by the Government officers, they have taken it for their standard.

Dr. Thomson differs however a little in opinion, regarding the above average, as from his experiments he states—"The quantity of moisture imbibed by the barley varies according to the goodness of the barley, and the length of time during which it is allowed to remain in the steep. But the general average may be stated as 0·47; for 100 lbs. of barley, steeped the usual time, weigh, newly taken out of the steep and dried, 147 lbs. English barley acquires more weight than Scotch barley, while Scotch barley acquires greater weight than bigg. But bigg cannot safely be steeped for so long a time as barley. The swell of the grain in the steep obviously depends upon the quantity of water absorbed; but it is not so great as that absorption, scarcely ever exceeding one fifth of the original bulk of the barley, while the increase of weight amounts to nearly one half of that of the original weight of the grain. The result of a good many trials by the writer of this article gives the bulk of one hundred measures of different kinds of barley, after steeping, as follows:—

English barley. . . . . 124 measures.
Scotch barley . . . . . 121.1—do.
Scotch bigg . . . . . 118.—do.

The greatest swell observed was from 100 to 183, which took place in barley from the county of Suffolk; the smallest was from 100 to 109, which took place in Perth bigg."

Maltsters differ very materially in the time they allow the grain to steep, and, in too many instances, instead of going to work in a systematic manner, guided by judgment, based upon observation and past experience, they merely follow the example of those by whom they have been initiated, without taking into account the quality of the grain they are using, the temperature of the atmosphere at the time, or the country in which they are malting. Dr. Thomson affirms that in Edinburgh he has seen the barley steeped by one maltster for 112 hours, while by another he has known it steeped only 92 hours. I consider a very fair average with good new Scotch barley in a favourable malting season to be 75, and in England with good Chevalier 60 hours. Mr. Collier affirms, that generally speaking 60 hours are sufficient, but of course his opinion is derived from what he has experienced of malting in England. Had he been a maltster in Scotland, he would have found that 60 hours were too short a period.

At all events, to make good malt, it is absolutely necessary that the barley should be thoroughly satu-

rated with water in the steep, the water absorbed there by the pores of the skin being destined for the production of the root. If in this stage the barley has not been completely saturated, the omission can never be repaired, because no water administered on the floor, particularly before the root is formed to attract it, can be equally distributed, as some of the grains will get too much, and others must of course come short of a due portion. Indeed, to sprinkle water upon the grain before the radicle is completely formed, is a very pernicious practice.

It is almost unnecessary for me to add, that by law the grain cannot be removed from the cistern in less than forty hours, because I purpose in every stage of the process to give the Excise regulation with regard to making malt.

By those who follow any fixed rule, the barley is allowed to remain in the steep until it is so soft that, when a few of the grains are taken out from various parts of the heap, and being placed between the finger and thumb for trial, yield readily to the pressure, the whole is considered sufficiently steeped. Before however making trial as above, we have a safe compass to steer by in the dipping-rod, an instrument which is applied from time to time for the purpose of ascertaining the increase of bulk, for as we are aware what the maximum should be, we may form a tolerably correct judgment when it approaches that maximum.

I strongly recommend the practice of changing the

steep-water several times during this process, for the purpose of carrying off that bitter, yellow, oleaginous matter which separates itself from the skin of the barley, and with which the water becomes so abundantly charged. This water, known by its fœtid smell, must, if allowed to remain, necessarily impregnate the grain with its disagreeable odour; and more especially will this be the case should the weather prove close or warm during the operation. In addition to this evil, the water is susceptible of being rendered sour and mucilaginous. These detrimental effects are prevented by changing it several times; but in this operation care ought to be observed that the water which is to supply the place of that which is run off should be as near to the latter in temperature as possible, and the average should be about 50°.

During the time the barley is in steep it is gauged several times by the Excise Officers; and as I formerly purposed, I now give the Excise regulations which refer to steeping.

"Every maltster, whether the malting premises be situated in the officers' residence or otherwise, is required by law to give 24 hours' notice in writing, before beginning to wet any corn or grain to be made into malt.

"In every such notice must be expressed the day and hour when such corn or grain is intended to be wetted or steeped, under the penalty of £100. But maltsters will not be subject to the last mentioned penalty, for not commencing to wet at the hour

expressed in the notice, provided the grain be covered with water before the expiration of three hours afterwards.

"No maltster can legally begin to wet or steep any corn or grain to be made into malt at any other time than between the hours of *eight* in the morning and *two* in the afternoon, under the penalty of £100.

"Maltsters are required to keep their corn or grain covered with water for the full space of *forty hours*, under the penalty of £100, and they may keep it covered with water in the cistern so many hours longer as shall be found necessary.

"And if any such maltster shall be desirous of draining the water from the corn or grain once during the time it shall be continued in steep, such intention with the day must be expressed in his notice to wet; but it is to be observed that maltsters are not in any case allowed to drain the water from any steeping of grain before the expiration of forty hours, oftener than once, and that only between the hours of *eight* in the morning, and *two* in the afternoon; and all such corn or grain must be again covered with water, before the expiration of one hour from the time the water began to be drained."

The steep-water having been run off, the grain is allowed to rest for some hours, in order to drain. This brings us to the second stage of malting, namely,

COUCHING.

The water being completely drained off, the grain is then thrown out, or emptied by a large valve, into the couch-frame. According to law, this frame must now be constructed as follows:—

"Couch-frames constructed since 2d July 1827, are by law required to be made or constructed with the sides and bottoms thereof straight and at right angles to each other, having three of such sides permanently made or constructed, and the other side thereof formed by moveable boards or planks of the substance of *two inches*, at the least, in thickness; such couch-frames to be supported on the outside, in every part thereof, so that the same, and every part thereof, may be of sufficient strength, not to bend or curve, or fail to preserve, when filled with corn, the same dimensions as when empty; and so that the officer may be enabled easily and conveniently to gauge in every part of such couch-frame, the corn or grain, contained therein, under the penalty of £100, and forfeiture of such corn or grain."

The grain being now in the couch-frame, is levelled with the greatest nicety, to enable the Excise officer to gauge it with accuracy; for it is by the couch-gauge that the duty on malt is usually levied.

In this position it must remain, according to Excise regulation, as follows:—

"All corn or grain emptied into the couch-frame must be laid flat and level by the maltster, and kept and continued so laid for the space of twenty-six hours at the least. But in cases where the same shall not have been gauged, and taken account of by the officer, within that time, such corn or grain is to be deemed to be in *couch*, and gauged, and taken an account of, *as in couch*, for the space of *thirty* hours, whether continued in the couch-frame or removed after the expiration of the said *twenty-six* hours, and before *thirty hours* therefrom, to the floor."

During the period the grain is in the couch, it will occupy more space than it did while in the cistern; but with the exception of a little heat being generated, no material alteration takes place. This heat, however, would rapidly increase, and would prove a serious evil, were it not checked by removing the grain from the *couch*-frame to the floor. And this brings us to the third and most important stage in the process of malting, namely,

FLOORING.

The skill of the maltster is here still more requisite than in the two preceding stages. The object he desires to accomplish is, to cause the germination

of the barley to be equal in every separate corn. This effect he endeavours to attain, by turning the heap he has taken from the couch-frame, and spreading it on the floor, to about the depth of from ten to sixteen inches, varying according to the temperature of the atmosphere. In about twenty-four hours an increase of temperature takes place, which is reduced by turning the grain. By this operation, a considerable degree of the heat escapes, but heat is again soon generated, and the heap, now from ten to sixteen inches in depth, would become overheated, and germination would proceed with destructive rapidity, were the heap allowed to remain at rest; but this consequence is prevented by constantly exposing new surfaces of the grain to the air by means of occasional turning.

During this interval, what is called by the maltsters, *sweating*, takes place, and the incipient germination, which had commenced before the grain was removed from the *couch*-frame, proceeds. About the fourth day, the rootlets will have freely come out, when the grain should gradually be spread thinner, until its depth does not exceed four inches, and the temperature of that quantity called "the Floor," should not exceed 50°; for there is a certain degree of heat which is best calculated for the production of good malt at this stage of the process, and at which vegetation will proceed equally and safely; but either above or below this temperature, the reverse would be the case. Variation of temperature, above all things,

should be avoided, as being highly injurious. It is almost superfluous to add, that in whatever way the "Floors" are worked, the heat will rise in proportion to the time they remain undisturbed, and the only method by which a maltster has to check this increase of temperature is by turning them. Caution is highly necessary even here, for too much turning will prove as injurious as too little. "Floors" should never be turned except in the case of necessity. A judicious maltster will keep all his "Floors" equal in temperature, from the steep to the kiln, and that heat should be, as just noticed, from 48° to 50°, for he knows well, if he neglects this, vegetation must proceed unequally. After the fourth day, the rootlets rapidly grow in length, and this growth would increase to the extent of two or three inches, (three-fourths of an inch being considered sufficient,) unless the tendency was checked by frequently turning the *floor*. The aim of a good maltster is to have those rootlets short and bushy. In fact, his skill may be tolerably well known by this criterion.

In about ninety hours the grain begins to absorb oxygen from the air, which it converts into carbonic acid. By this chemical action the temperature of the "Floor" rises until it becomes considerably higher than that of the atmosphere, while it is advisable not to allow it to exceed 50°. Excess of heat upon the "Floor" ought to be carefully avoided, for should it exist, a train of evils the most injurious to the

grain possible would follow. Malt, if forced by such means, will most assuredly be tender, so much so as to crumble with the slightest pressure, the husk separating from the kernel; and such malt would be very unprofitable to the brewer.

Very shortly after the rootlets make their appearance, the maltster begins to look for the *acrospire*, which is a germ that springs from the same extremity with the rootlets, and forces itself towards the opposite end between the husk and the kernel; and by about the eighth day after the grain has been removed from the steep, the acrospire will have advanced nearly one half up the grain. The attention of the maltster is now directed to carry this germ or acrospire very nearly to the other extremity of the grain, and to accomplish this he lays the grain a little deeper, and gradually increases it until it is ready for the kiln. But while he uses these means to encourage the growth of the germ, he must be very careful to arrest its progress, lest it grow beyond the prescribed limit. It is generally considered that the saccharum forms in the grain in a proportion relative to the growth of the acrospire. If the acrospire be grown only one half of the length of the grain, the saccharum will be deficient, because little has been formed; even if it be carried to two thirds, the same will be the case though in a less degree; but if on the contrary it be allowed to grow beyond the above limit, the grain will lose nearly the whole of the saccharum that has been formed, and the malt

when made will be totally unfit for the brewer's purpose. On this, however, as well as on other points already noticed, there is a difference of opinion, some asserting that the acrospire should not exceed one half the length of the grain, because beyond this the loss of saccharum commences. For my own part I am decidedly of opinion that if a maltster wishes to convert as much as possible of the starch and gluten contained in the barley into sugar, the further he carries the acrospire towards the point of four-fifths of the grain, the more he is likely to succeed in his object.

During the time the grain is on the "floor," should the germination appear to be languid, which is frequently the case, about the sixth or seventh day, sprinkling it with water will prove very beneficial. This languid germination is technically termed a "sickly floor," and is readily perceived by its appearance as well as by its peculiarly disagreeable smell. The operation of sprinkling is now allowed by law, by giving the Excise Officer twenty-four hours' notice, as will be seen at the conclusion of the remarks on "flooring."

This practice was formerly prohibited, but now that it is allowed, it is getting more and more into repute, and certainly deservedly so. Indeed there are seasons in malting when the neglect of it would prove in the highest degree injurious.

I cannot proceed farther without advising the young maltster to be cautious during the whole of the time the grain is on "the floor," of admitting

more light than is absolutely necessary for the working of the "floor," etc., because light, instead of promoting, retards germination. At the same time, he must bear in mind, that the light which is admitted, ought to be natural, not artificial, as the latter would consume the oxygen, which it is his interest to retain, it being an agent of the greatest consequence in the process of germination.

While the grain is on the floor, the heat which has been generated, combines with the carbonic acid which has been created, and converts it into carbonic acid gas, which gas being heavier than atmospheric air, remains for some time a little above the surface of the grain; but as the "floor" is constantly evolving heat, this gas becomes from time to time specifically lighter, until it fills to a considerable height the whole space of the apartment. As it is necessary that this gas should be removed both from the grain and from the room, and that its place should be supplied by pure atmospheric air, the windows must be occasionally opened, and the operation of turning performed.

Great caution is also necessary in the turning of the grain, lest it should be injured in the process, for if any of the barleycorns are damaged they will cease to germinate, become putrid, and impart a noxious quality to those surrounding them. To prevent as much as possible this evil, wooden shovels are used instead of those of iron. In many of the malting houses the maltsters make use of a piece of wood of

a peculiar form, technically called a "plough," turning it along the "floors" as a substitute for turning with a shovel. To "young floors" this practice can be of little use, and with "old pieces" where the rootlets are so apt to entwine, it must be very inefficient indeed: in this case the shovel is indispensible. I should imagine that this machine was invented by some working maltster who studied his own ease rather than his master's interest. By using the plough "the floors" cannot be turned, but merely stirred up; whereas it is the aim of an expert maltster to turn them over, strewing the grain so lightly as to appear like a descending shower. After the operation of turning, the avenues should be swept, that the scattered and trampled-upon barleycorns may not by any chance be mixed with the healthy grain on the 'floor."

Many maltsters who have not acquired much practical knowledge, place implicit confidence in the use of the thermometer for the purpose of guiding them as to the time when the "floor" should be turned. Although I entirely disapprove of this practice, and would by no means advise the working of the "floors" by this instrument alone, I would strongly recommend it as a very valuable assistant; but in using it the greatest attention is required that the heat taken should be the average one.

We are now drawing towards the close of this interesting stage, having assumed that the acrospire has advanced nearly as far as it ought.

Although if it be found that the growth of the acrospire is too rapid, it must be checked by occasional turning, and the admission of air, which will keep it in order, until the rootlets begin to wither; when the heap may be made thicker, in order that a little more heat may be generated for the purpose of mellowing the grain, before it goes to the kiln:—yet in this case, repeated turnings must still be resorted to until the grain appears divested of moisture. If we find by skinning a few pickles, that the interior is white in colour, and farinaceous, and will readily pulverize between the finger and thumb, the grain is ready for the kiln.

Before proceeding to the last stage of malting, I shall close this subject, by giving, as proposed, some extracts from the Act regarding sprinkling on the "floors:"—

"Corn or grain making into malt, must not be wetted, or sprinkled with water, before the expiration of twelve days, or 288 hours, after the same shall have been taken from, or out of the cistern, under the penalty of £200.

"But maltsters may sprinkle any 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, or giving twenty-four hours notice to the Officer of Excise, of his intention so to do, provided there shall not be on the floor, in the same malt-house, any grain which shall not have been so kept in the cistern 50 hours at least."

KILN-DRYING.

The malt-kiln is a room, the floor of which is in general now laid with iron plates, perforated with small holes. In the centre of the roof is a chimney or outlet, for the heated air and vapour to escape. Under the floor of this room is a moveable fire-place, in which a fire is made, when required, of coke, charcoal, culm, or wood. In the construction of the kiln, the greatest attention is requisite, but as almost every maltster has a peculiar opinion with regard to this, it would occupy too much space to enter into the several details; suffice it to say, that if the draught of the kiln be so great and irregular, as to require artificial aid to modify it, this is a proof that it is constructed on erroneous principles, for it is evident that the kiln in which a given quantity of grain can be dried, without impairing the colour, in the shortest time, and with the least fuel, is consequently the best.

The grain, now so far mellowed, as has been already described, is accordingly removed from the floor to the kiln, for the following purposes:—1*st*, to cause the remaining aqueous particles effectually to evaporate; 2*dly*, to impart to the malt that preserving principle which will enable the maltster and

brewer to preserve it unimpaired for a considerable time; and, 3*dly*, to give it the colour and other properties required. The nicest point in kiln-drying consists in drying the malt with such a gentle heat at first, as will gradually dissipate the moisture, and when this has been so far accomplished, then raising the temperature to such a height as will expel the moisture which may remain.

The necessity of a judicious management of this heat comes now to be considered. The malt, though mellowed when it is brought to the kiln, still contains much moisture, and were this moisture not thoroughly expelled, it would naturally, when taken from the kiln, and pressed together in a great heap, germinate afresh, and, if not prevented, would very probably ignite. At all events, this evil would arise; it would become mouldy, and acquire a very bad flavour.

Should the maltster, through ignorance or inattention, over-dry the malt, even although the process be gradual, it would become of such a tenacious nature, as to require a great length of time before it could be penetrated by the air, to relax or mellow it. Those evils may be avoided by due attention.

The malt having been spread on the floor of the kiln to the depth of about eight inches, and the surface raked, so as to make it perfectly level, a gentle fire is made, and the kiln is heated to a temperature not exceeding 70°. The thinner the malt

is spread upon the kiln-floor the better, in order that the heat may be equally distributed, and that the vapour may the more readily escape. The temperature of the kiln, as I have already remarked, should be no higher at the commencement of this stage than 70°. Were we to begin with a temperature much higher than this, the object we have in view would be defeated; for, instead of gradually expelling the remaining moisture, we would harden the external coat of the malt, and by that means shut up its pores, and render the passage for the vapour from the interior of the grain impossible.

While the malt is on the kiln, it is necessary to turn it four or five times a-day, that new surfaces may be exposed to the heat emitted through the perforated floor, and the escape of the steam be facilitated.

No specific time can be fixed upon for this operation. It greatly depends upon the skill of the kilnman and the size of the kiln-floor. If the kiln-floor be sufficiently large to admit of the whole grain that has been steeped to be laid to a depth not exceeding seven inches, for the palest malt 80 to 90 hours will be required; if, on the other hand, the depth does not exceed five inches, 60 to 70 hours would be sufficient. With regard to the depth, it may be as well here to remark, that it is highly necessary that a medium should be observed, for if the malt is laid at too great a depth on the kiln-floor, the draught would then be obstructed; and if, on the

other hand, it was laid too thin, the action of the fire on every part would close the pores before all the moisture was evaporated.

When the grain is considered thoroughly malted, the fire is withdrawn that it may gradually cool, but before it cools, it is well trodden for the purpose of separating the rootlets, technically called *cummings*, from the grain; and this is done while the malt is yet warm, because at this period the rootlets are crisp, and therefore are readily broken off. When this operation is accomplished, and the malt perfectly cool, it is thoroughly cleansed from the rootlets or *cummings* by means of a winnowing machine, or a screen, and afterwards stored away. Some, however, defer the separating of the *cummings* until the time when the malt is about to be used.

Malt is generally designated by four different terms, pale, amber, brown, and Patent or black malt, each of which at the commencement undergoes the very same management of kiln-drying, for in each the aqueous particles must be thoroughly dissipated, but as they all differ in colour, and that colour is imparted through the application of heat, the after management is somewhat different. Pale malt does not require the finishing off heat to exceed 140°, whereas that of the amber would require it to be 10° or 15° higher, if the heat be judiciously applied; brown again still higher by 15° to 20°, while to that of the black malt the heat must be raised to such a degree as will bring it to the colour required.

The amber, brown, and black malts, are generally used for porter, but more especially the two latter, and the best method of preparing them is with a very slow fire, until they are about two-thirds dry; the kiln is then to be shifted, and the malt allowed to remain for several hours, in a heap to mellow; the shifting of the kiln should if possible be accomplished in the evening, and on the following morning should be returned to it. The depth now should not exceed two inches. The fire at this time should be very brisk, and made of wood. The desired object is to snap and char the grain, and this the brisk fire will effect.

Mr Combrune, in his Treatise on Malting, has given a table of the results of some of his experiments of the different heats necessary to produce different shades of colour, but as he did not conduct those experiments on a right principle, the inferences he draws are not to be depended on. He asserts that malts, when urged by a fire of 175° begin to char and turn black, whereas Dr. Thomson says, "we have taken malt dried at the temperature of 175°, put into a garden pot, filled with soil, and have seen it vegetate apparently as well as raw grain placed in the same situation."

Many are the opinions with regard to the diminution of weight of barley, when made into malt; some asserting it to be about one-fifth, others one-fourth; Proust maintains that it is equal to one-third, and Dr. Thomson asserts, that it is not more than

one-twelfth; while they differ almost as much as to what it ought to gain in bulk. From my own experience, I consider that, in the very best Chevalier barley, the increase of measure should not exceed five per cent., else it will be at the expense of the saccharum; for beyond this increase, what the maltster gains in bulk he will lose in quality. In Scotch barley the increase rarely exceeds two per cent.

The interest of the maltster, who only malts for sale, differs widely from that of the brewer who purchases his malt. The profit of the former, in a great degree depends upon how much the bulk of the malt shall exceed that of the barley from which it is produced, and to accomplish this object, he is tempted to sacrifice that which is most valuable to the brewer—the saccharum of the malt. On the other hand, the sole object of the malting brewer is, not to increase the bulk, but to convert, as has been already noticed, as much of the fecula into saccharum as possible, using every endeavour to retain what he has gained.

To caution the inexperienced brewer, who is so situated as to be obliged to purchase his malt, against the practices of unprincipled men, who make it their business to deceive their customers, by imposing upon them malt which has been deteriorated in value, for the purpose of increasing its bulk, I may be allowed to quote a short extract from Wigney's Treatise on Malting and Brewing:—

"The maltster who manufactures for sale, is in-

terested in allowing the acrospire to grow to a greater extent, than the maltster who makes for his own consumption, in the double capacity of a maltster and brewer; because, by such means, he can obtain a greater increase, and consequently a greater profit; and by adventitious means also, he can make up an apparently excellent sample to the eye of the inexperienced. This is effected by working up the back well, as it is technically called sprinkling, a short time before it goes on the kiln, slightly blowing it on the kiln, and the occasional use of sulphur, for the purpose of bleaching. The effect of what is called blowing on the kiln, is to distend the grain in bulk, by converting the water imbibed by the grain, in consequence of sprinkling, into steam, which, acting expansively, distends the grain in every direction, giving to the malt a plump, fair appearance to the eye, and as a matter of course, measuring, what is called, well. This system is much practised in drying off brown porter malt, and the blowing is carried to a greater extent than with pale malt, and the consequent increase is very considerable, amounting in my own experience to three bushels, two gallons per quarter; or in more expressive terms, that eight bushels of barley will furnish eleven bushels, two gallons, of blown brown porter malt."

It may be asked, what time will be required from the commencement of the process, when the barley is put in steep, to the finishing-off of a "floor" of malt? In England from twenty to twenty-two days, may

be considered a tolerably correct estimate, when the brewer is his own maltster, and in Scotland twenty-four to twenty-six days. The following is the method used by the officers of Excise, to reduce gross bushels of malt to net:—

The principle upon which the different allowances are made upon malt in its various stages of operation, is a presumption that a 100 cistern or couch bushels, or 163 floor bushels, gauged after the grain has been emptied from the cistern, will make only, 81.5 net bushels. The following rules may therefore be useful:—

To reduce any given number of cistern bushels to their equivalent in dry malt, multiply the cistern or couch bushels by .815, and the product will be the equivalent in net bushels.

To reduce any number of floor bushels, multiply the given number of floor bushels by .5, the product will be the equivalent number of net bushels.

To find whether a floor gauge will produce a better charge then the cistern or couch bushels, to which such "floor" belongs, multiply the amount of the best cistern, or couch gauge by 1.63 and if the product be equal to, or exceed the amount of the floor gauge, the best cistern or couch gauge will be the charge, but if that product be less than the amount of the floor gauge, the floor gauge will be the charge.

Having now brought the four stages of malting to a close, I shall complete the subject by inserting a table shewing the whole process from beginning to

end, with Scotch and English barleys, but as I wish to render this short treatise as acceptable as possible, before doing so I shall make copious extracts from the Scotch Report by Drs. Hope, Thomson, and Coventry. This report is now very difficult to be obtained, and I consider it both theoretically and practically by far the best treatise extant on the subject. I will proceed by commencing my quotations from the couch.

"1. After the grain has been cast out of the steep, and put into the couch, it gradually becomes dry externally, the moisture that adhered being either dissipated, or absorbed. The temperature in the mean time gradually rises, and in about 96 hours, will usually be found to have increased about 10 degrees. This rise of temperature in the heap depends in some measure on the state of the atmosphere. If the air has become colder since the period of *casting*, the malt does not become so warm as it would otherwise do; while, on the other hand, if the air has become milder, the temperature of the malt experiences a corresponding increase. Ten degrees may be stated as nearly the medium of the different experiments. The smallest rise observed was 5°, the greatest 18°; the most common from 8° to 12°. It must be observed, however, that the rise of temperature depends greatly upon the choice of the maltster, who can check it at pleasure, by turning over the grain, and spreading it thinner upon the floor.

" About 96 hours after ' casting,' the grain which had become seemingly quite dry on the surface of the husks, turns again so moist, that it will wet the hand if we thrust it into the malting heap. The appearance of this moisture, which happens regularly after the malt has been some days on the floor, is called *sweating* by the maltsters: it continues for one day or two, and then disappears. During its continuance a pretty strong odour is exhaled, rather agreeable, and not unlike that of apples. If at this period, a portion of the malt be distilled in a steam bath, a little spirits will be found in the liquid which comes over. They may be made more apparent by mixing this liquid with sulphuric acid, and distilling a second time.

" Unless the malt be turned pretty frequently, as soon as the sweating comes on, the temperature increases with great rapidity. In one case, the turning was omitted for about 14 hours, and the temperature was observed as high as 80°.

" 2. It is just about the time of the sweating that the roots begin to make their appearance; each, at first, like a small white prominence at the bottom of the seed, which soon divides itself into three rootlets, and at last into four, five, or even seven. Those roots are, at first, very soft and tender; but, in a few days, they begin to wither and to acquire hardness. Many of them are broken off during the turning of the malt, and,

in that case, new roots generally succeed them, at least in the earliest stages of the process of malting.

" When the radicles have divided themselves into three roots, and have acquired some length (which usually happens in one, two, or three days after their appearance, according to circumstances,) the apple-like smell goes off, and is succeeded by another not unlike that of the *common rush*, when newly pulled. This smell continues during the whole time that the malt is on the floor; unless it be overpowered by a peculiar mouldy smell, which happens only when the grain is bad, and contains seeds incapable of germinating; or when a part of the malt has been bruised, during the turning, from the carelessness of the workmen.

" The length, number, and progress of the roots called ' *commings*,' by the maltsters, vary much according to circumstances. It is well known that, when barley is sown in a good soil, of a proper texture, the roots continue moderately short, and the chief effort of vegetation seems to be directed to the advancement of the stem; but, in loose ground, the former shoot out to a greater length, and the latter makes a less rapid progress. In malting, again, the roots have a much greater tendency to lengthen than even in the poorest and most open soils. Accordingly, if allowed to take their course on the malting floor, in a moist, warm heap, they grow to a

great length; in some cases, not less than two or three inches.

"The prime object of the maltster is to check this inordinate length, and this he accomplishes by frequently turning over the malt. By such treatment, its temperature is kept uniform, and the moisture is equally exhaled. There is, however, a considerable difference in the practice of malsters in this respect. Some allow the roots to get to 7-8ths of an inch long; others never wish to see them above half that length. As the roots are afterwards separated from the malt and thrown away, and as their length does not contribute to the progress of malting, the latter method seems preferable.

"3. The fourth or fifth day from the 'casting,' and about a day after the sprouting of the roots, the rudiment of the future *stem* may be seen to lengthen. It rises from the same extremity with the root, and advancing within the husk, at last issues from the opposite end of the seed, and assumes the form of a green blade of grass. But the process of malting is brought to a conclusion some time *before* the stem has made so much progress as to burst the husk. This rudiment of the stem is called by botanists *plumula*, but maltsters give it the name of *acrospire*.

"The progress of the acrospire is, at first, very rapid, like that of the roots. By the eighth day after 'casting,' it will have usually reached rather

more than one-half the length of the grain. But after this time, its progress becomes much more slow, so that frequently another week elapses, or even more, before it has made its way to near the end of the seed, when it is understood to be proper to finish the malting; were the malt allowed to lie longer on the floor, the progress of the acrospire becomes again rapid, so that it soon pushes its way out of the husk, and puts on a leafy appearance. When grain is in the earth, the progress of the acrospire is much more uniform and rapid. In that case, the supply of nourishment is abundant and constant, whereas, on the malt floor, the very contrary is the case.

"4. As the acrospire shoots along the grain, the appearance of the kernel, or mealy part of the corn, undergoes a considerable change. The glutinous and mucilaginous matter, which, perhaps, bind together the starchy particles, is taken up and removed. The colour becomes white, and the texture so loose, that the kernel crumbles to powder between the fingers. This change is progressive, it begins at that end of the seed where the roots are, and gradually proceeds onward to the other extremity, so that one portion of the kernel often appears in a friable state, while the other still retains the appearance of raw barley. It is the common opinion of maltsters, that this change of the grain always keeps pace with the acrospire; each seed being al-

tered as far as the point of the acrospire extends, and *no further*. And this opinion has been rather confirmed by our observation.

" The whole object of malting is to produce this change in the kernel. As soon as it has taken place, the seed is no longer in the state of raw grain, but of malt. The kernel is originally composed chiefly of starch, the particles of which seem to be enveloped by a species of gluten and mucilage. This cement, (or, perhaps, cellular membrane) is taken up and expended, in the first place, for the purposes of vegetation, and thus the starch is set at liberty, not, however, in the state of common starch, for its taste is somewhat sweetish, and it is completely soluble in water, which is not the case with the other. The object of malting being to procure this modified or altered starch, the process ought to be stopped as soon as it is fully disengaged and prepared. If the process has been rightly conducted, this object will be attained, as already mentioned, by the time the acrospire has come within a little of the end of the seed; but if it proceed farther, a sudden and very considerable loss occurs. Shortly after the acrospire has made its way out of the seed, the starchy matter undergoes a farther change, becomes milky, and is very soon absorbed; leaving nothing but the empty husk.

" 5. While the malt lies on the floor, each corn loses a certain portion of its weight. A part of this loss is only apparent, and occasioned by the exhala-

tion of the moisture which had been imbibed in the steep; but besides this, there is also a real loss of weight.

"If a given weight of the corn, 500 grains troy, for example, while malting, be taken daily from the floor, weighed accurately, and then dried upon a steam bath, till it ceases to lose weight, the loss at first will be considerably more than two-thirds of the weight; but as the malting advances, the loss becomes less, and, at last, approaches very nearly to two-thirds."

If the malting be continued after the acrospire has reached the farthest extremity of the corn, the loss of weight sustained is still greater than what has been stated above, and it proceeds at a much greater rate. Hence appears the great impropriety of allowing the acrospire to advance too far. It is in the power of a maltster, merely by permitting his grain to remain a day or two longer on the floor than is necessary, to make the malt of any sort of grain whatever, as unproductive as he pleases.

"6. The loss of weight, as well as the progress of the malting, depends much upon the temperature; two things respecting which require attention. 1. To keep it as equal as possible; and, 2. To keep it at the proper pitch, neither too high nor too low. Unless the first precaution be attended to, the progress of the malt is very unequal, some parts being fully ready, before others have advanced half way. This inequality is attended with a great loss of

weight, because many of the farthest advanced corns must be sacrificed to the progress of the rest. It is chiefly prevented by keeping the thickness of all parts of the malt as equal as possible, and by turning it over without delay, whenever an inequality of temperature can be detected in any portion of it.

" A high temperature is more injurious at the beginning ' of the flooring,' than after the malt has made some progress. Should the heat be in excess, the radicles advance too rapidly, while the kernel does not undergo the wished-for change, but becomes clammy, like birdlime, a condition which is most apt to supervene in the early stage of the process, when the grain is very moist. Hence the proper temperature may be judged of pretty correctly, from the rootlets or ' commings.' If they be pretty equal, and do not exceed half an inch in length, we may consider the temperature as having been proper; but when they lengthen suddenly and unequally, there must have been an excess of heat."

In the experiments made by Dr. Thomson, the heat varied very much; the best malt he made had 56° for its average temperature, ranging between 52° and 60°, and he was of opinion that the smaller the grain is, the lower the temperature should be kept to make it the more valuable.

" IV. Such are the most remarkable circumstances that happen while the grain is on the floor, the most important part of the whole process of malting. When the grain is thought to be suffici-

ently malted, the farther progress of vegetation is stopped by putting it on the kiln. The kiln consists of a chamber floored with plates, full of very small holes, or with wire or haircloth. The malt is spread upon this floor to the depth of from 3 to 6 inches, and a very moderate fire of charcoal is kindled in an apartment below it. The heated air passes up through the malt, and makes it escape by the roof of the kiln, where there is an aperture for the purpose. During its passage, it becomes loaded with moisture, and thus gradually dries the malt for a considerable time; the fire is kept so low as not to heat the malt higher than the temperature of the human body. As the drying advances, the temperature is gradually raised till it rises to 140° or even higher, according to the object in view. The colour of the liquor to be produced from the malt depends upon the temperature at which the latter is dried. If that liquor is wished to be pale, the malt is dried at a low heat; but if brown, like *porter*, the heat is considerably increased. We have observed the temperature of the malt often as high as 160° and 170° and, on one occasion, at 186°. Indeed, we have reason to believe, that malt is sometimes dried at a heat little less than that of boiling water. Even pale malt may have been exposed to a heat of 170°, and malt may be made brown at a lower temperature: for it is not so much the temperature, as the suddenness with which it is raised, while the malt is still moist, which alters the colour: the ease with which the soluble

part of malt alters its colour and its taste, when exposed to heat, constitutes one of its most remarkable characters. This facility of change or decomposition is considerably increased by the presence of moisture. If pale malt be properly dried, it does not lose the power of vegetating; but this power is destroyed if the heat be too suddenly urged.

"The time during which the malt is on the kiln, varies with the temperature and the quantity of malt dried, from forty to eighty hours, which were the extremes in our experiments. While upon the kiln, the malt is occasionally burned.

"V. The last process is the cleaning of the malt. While still warm upon the kiln, it is usually trodden upon by the workmen, to separate the radicles or *commings;* which are at that time brittle, but soon become tough by absorbing moisture. The commings, thus detached, are afterwards separated by passing the malt through the common fanners; or, instead of this mode of cleaning, an instrument called a *harp*, well known to the brewers, is employed. The quantity of rootlets and broken parts of husks, thus detached from the malted grain, varies according to circumstances, but is always considerable.

"The malt thus obtained weighs about one-fifth less than the raw grain from which it was produced; but this diminution of weight varies somewhat according to the temperature of the kiln; the least in

our trials was 19 per cent., the greatest 27, the average, about 23.

" A great part of this loss of weight is to be ascribed to the kiln-drying; and consists of nothing else than the moisture which previously existed in the raw grain, and of which it would have been deprived by the heat of the kiln, as well as the malt. In order to ascertain how much of the loss was owing to this cause, the raw grain should have been kiln-dried and weighed just before it was put into the steep. In that case, the difference between the weight of the malt and the kiln-dried grain, would have indicated the quantity of loss of substance really sustained by grain during the process of malting. As this method was not practicable in pursuing trials on a large scale, we had recourse to another, less precise indeed, but sufficient to give us a notion of the loss of weight actually sustained by the malt. Portions of the raw grain, and of the newly dried malt, were exposed to the same temperature upon a steam-bath. The loss of weight sustained by the grain being called *a*, and that by the malt *b*, it is obvious that *a*—*b* represents the loss of weight which the grain would have sustained, had it been dried on the kiln at the same temperature as the malt. This substracted from the difference between the weight of the raw grain and the malt, gave the real loss of weight sustained by the grain during the process of malting.

"The difference between the raw grain and the malt may be called the *apparent loss*, as much of it was owing to moisture, which the malt gradually imbibes again when exposed to the air.

"In the trials made by the learned authors of the Scotch report, the loss of weight proceeding from the dissipation of moisture, varied from 8 to 18 per cent., and the real loss from 6 to 12, according to the process. The average loss from the dissipation of moisture, may be considered as 14 per cent., and the average real loss may be stated at 8 per cent.

"About $\frac{4}{10}$ths of this loss must be ascribed to the commings which are separated by cleaning the malt. If they be deducted, the loss sustained in malting does not exceed an average of 5 per cent. If we reckon the loss in the steep at $1\frac{1}{2}$ per cent., there will remain $3\frac{1}{2}$ per cent. for loss upon the floor; but of this, $1\frac{1}{2}$ per cent. may be safely reckoned for waste, consisting chiefly of small corns and commings, lost during the kiln-drying, and the transporting of the malt from place to place. From this statement, it follows that, at an average, 100 lbs. of barley will yield 78 of newly dried malt; so that there is a loss of about 22 lbs. Of this loss, 14 pounds are to be ascribed to moisture, a considerable portion of which the malt receives again by standing. The real loss consists of the remaining 8 pounds, which are thus accounted for:—

Lost in steep, . .	1½
Lost on floor, . .	3
Commings, . .	3
Waste, . . .	0½
	8

" The bulk of the malt generally exceeds that of the raw grain, though this does not always happen. The average, for instance, of all our maltings of Scotch barley gave almost exactly bulk for bulk, yet, in some instances, 100 bushels of barley yielded 109 of malt. Others, of course, must have fallen as much short. The average of the English barley was 105 bushels of malt from 100 of grain; that of the bigg 99. The greatest produce was 112 bushels of malt from 100 of barley; the least 93. Probably, too, the inequality might be owing partly to the unequal degrees in which, in different cases, the malts, or both the grain and malts, had been cleaned. In our trials, the bigg did not deviate so far from equality as the barley.

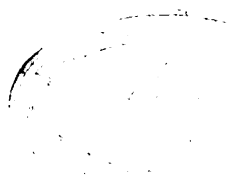
" The weight of the malt varies also considerably; but, in general a bushel of good malt, when newly dried, weighs about three-fourths of a bushel of raw grain.

The following table, compiled by Dr. Thomson, shows the result of a considerable number of trials made in malting different varieties of barleys, both English and Scotch.

TABLE

SHEWING THE RESULT OF A CONSIDERABLE NUMBER OF TRIALS IN MALTING DIFFERENT VARIETIES OF BARLEYS, BOTH ENGLISH AND SCOTCH.

BARLEY. *First Quality.*	Weight Per Bushel, in lbs.	Bushels measured out.	Swimmings in Bushels.	Bushels really Steeped.	Swimmings in lbs. Avoirdupois.	Weight of grain really Steeped. in lbs.	Hours in Steep.	Swell per cent. in Steep.	Swell per cent. in Couch.	Days on Floor.	Clean Malt in Bushels.	Weight of Clean Malt per Bushel. lbs.	Apparent loss of Weight per cent.
English.													
Norfolk.....	50.375	150	1.4	148.60	43.18	7509.82	116	16	23.08	18	162.75	36.58	20.0
Norfolk.....	50.375	150	1.75	148.25	43.00	7513.50	93.75		21.5	16	155.00	38.40	21.2
Kent.....	49.750	90	1.96	88.09	56.45	4421.05	86	25	28	12	98	34.88	23.0
Kent.....	49.914	90	1.75	88.25	40.50	4442.63	52	15.7	19.7	17	93.87	35.76	25
Suffolk.....	50.508	150	2.68	147.32	84.15	7494.00	49		23.3	13	149.75	40.56	21.
Suffolk.....	50.859	72	1.28	70.72	29.44	3632.40	44		16.8	13	71.31	39.11	23.2
Average.....	50.297						73.4	18.9	22.06	14.6		37.55	22.2
Scotch.													
Berwick and Haddington....	53.093	114.75	1.23	113.52	23.87	6068.60	119		19.8	18	14.18	39.60	25.4
Haddington....	52.190	60	0.5	59.50	13.75	3117.50	92	21		20	64.50	38.06	21
Haddington....	52.190	75	0.3	74.70	11.26	3902.80	112	21	21	19	77	39.18	23
Linlithgow.....	51.062	66	0.56	65.44	18.34	3352.81	109	24.5	18.7	9	69.5	39.09	19
Perth.....	50.226	66	0.75	65.25	21.00	3293.95	57		27.3		66.86	38.18	22.49
Fife.....	51.539	148	1.62	146.38	40.00	7578.78	81		25.3	14	146.54	38.80	25.07
Angus.....	49.312	66	1.68	64.32	44.37	3210.25	80	25.8	23.8	8	66.6	36.76	24
Edinburgh.....	52.164	111	1.50	109.5	41.37	5748.82	76	23	23.8	14	108	41.92	21
Edinburgh.....	52.164	90	1.25	88.75	34.47	4660.29	52.5	14.8	16.7	16	91.12	40.24	22
Average.....	51.549						86.5	21.7	19.6	13		39.09	22.6



RELATIVE VALUE OF MALT AND SUGAR.

As Government has now allowed the unlimited use of sugar in breweries, the all-absorbing question with brewers is, What is the relative value of malt and sugar? It may be of advantage here to treat the matter *practically*, especially as the public prints have teemed lately with *theoretical* and *visionary* notions on this important question. It will be my endeavour to enter minutely into the advantages and disadvantages which would accrue from the substituting of sugar for malt. Notwithstanding the long columns and pages which have been written on this subject, the above question has not been properly solved. Those who have brought the matter before the public, appear to be neither practical nor impartial men, but mere theorists, writing to serve a particular end. These writers in favour of sugar are the more anxiously listened to, because from the total failure of the potato, and the partial failure of the barley crop, malt has risen to so enormous a price—even to the extent of 50 per cent.—that brewers are most anxious to avail themselves of any substitute allowable by law. At the same time, it is natural to suppose, that a judicious and cautious brew-

er, before he changes that system in which he has been thoroughly initiated, will maturely consider whether he is likely to derive much, or even any advantage by so doing. It is my intention farther, to give the results of a twelve years' practical experience—and I think I shall be able to do so without any very lengthened detail—so as to enable both the public and private brewer to come to a decision, whether the substitution of sugar for malt is advantageous or not. My own opinion is, that by substituting sugar entirely for malt, the brewer would incur a loss rather than derive a benefit, even at the present prices of those articles.

It is evident that much variety of opinion exists among brewers, as to the quantity of saccharum which malt contains, and this arises from the saccharometer giving only an indication of specific gravity, whether that gravity is from pure saccharum held in solution, or from saccharum combined with gum, gluten, and other substances. Again, when we look to the analysis of malt by scientific men, we see also in their statements a discrepancy as to the amount of starch, as well as in regard to the properties of unascertained matter, although with respect to the amount of sugar, they all very nearly agree—viz,, an average of sixteen parts in one hundred.

From actual experience I have come to the conclusion, that upwards of two hundred pounds of extractive matter, can be obtained from a quarter of malt, being equal in value to about 190 lbs. of sugar

to a brewer, providing the malt is of good quality, and weighing from 310 to 320 lbs. per quarter; but if very superior indeed, and weighing from 330 to 350, upwards of 220 lbs. may be extracted.

For example, I will work with a quarter of malt, assuming it to weigh 330 lbs; and after giving the result of this, I shall give a similar result with a brewing of 206¼ lbs. of sugar, which is the only accurate way of ascertaining the relative value, and being all that is necessary for a brewer's information.

A quarter of malt, 330 lbs., is in the mash-tun. I extract for the first wort forty gallons, the gravity being 90—amounting for the whole to 3600. From repeated sparges I extract 42 gallons more, gravity 69, amounting to 2898. These worts are for ale. I draw off the remainder from the mash, and I sparge for the keeping beer to make up 36 gallons, gravity 39, amounting to 1404. There are in all 118 gallons, amounting to 7902, making an average gravity of nearly 67 per gallon. Therefore from the quarter of malt I have obtained about 219½ lbs. of extractive matter, leaving still, upwards of 5 per cent. in the goods, which could be extracted if required; for I maintain, that a brewer of ordinary capacity, can obtain extractive matter to the amount of two-thirds of the original weight of the malt, and were he anxious to acquire more, he might probably increase that quantity to three-fourths. Also, when I speak of drawing off from a quarter of

malt 219½ lbs. of fermentable extract, my calculation is not excessive, for there are some brewers of the present day who assert they can extract from a quarter of fine malt 240 to 250 lbs.

I must add, however, that although I assert that two thirds and upwards of the weight of the malt may be as valuable to a brewer as the same weight of sugar extract; yet, let it be clearly understood, I don't mean that these two-thirds are pure saccharum, for I admit the presence of certain unknown substances in combination, which have not yet been satisfactorily analyzed even by the most eminent chemists. Were it possible, however, to deprive the worts of these substances—which theorists say add weight without value—I am convinced they would not be so valuable for the production of good, sound, and saleable beer, as a superabundance of saccharum in brewers' worts, without a certain portion of mucilaginous or glutinous matter, would be detrimental rather than otherwise.

I have assumed that it will require 206¼ lbs. of sugar to produce the same number of gallons of worts, and of the same gravity of 67, as a quarter of malt; and I have considered the malt as weighing 330 lbs, extracting two-thirds, namely, about 220 lbs:—taking for granted that it is the best malt, and calculating it at the high value it now bears in the market, 90s. per quarter, and the sugar at the rate of 56s. per cwt.; for a cheaper sugar will not generally give 36 gravity.

One quarter of malt 330 lbs., price £4, 10s., yielding, (according to an experiment afterwards detailed,) a gravity of 24 per pound of malt, will give 7920. To produce this amount of gravity, namely 7920, there would be required 206¼ lbs. of sugar, which at 56s. per cwt. would cost £5, 3s. 1½d.

The weight of sugar stated is 206¼ lbs. At first sight it might appear that it would require 220 lbs., but we must make this allowance, namely, that every 16 lbs. of sugar occupies the place of a gallon of water, so that from the 220, thirteen and three fourth lbs. must be deducted for the space the sugar occupies when put among the water, or, technically, brewer's liquor. Also, to make this matter clearly understood, the reader must be made aware that every pound of sugar at 56s. or 58s. per cwt. should yield a gravity of 36 upon Allan's Saccharometer; and that every pound of saccharine extract from malt should yield the same gravity.

From this it clearly appears, that even at the present very high price of malt, (I have quoted the highest,) 90s. per quarter, there will be no saving in substituting sugar, for at 56s. per cwt. the 206¼ lbs. would cost £5, 3s. 1½d., leaving a balance of 13s 1½d. in favour of malt.

This I shall consider the first objection; but before proceeding to the second, I may just notice, that there are brewers who have asserted, that they have procured malt weighing much more than 330 lbs. per quarter. I quote the following statement con-

tained in a letter from a brewer in Somersetshire to one in Lancashire, who wrote to me for my opinion on the subject. "I am glad to inform you that the malt of this season, (1841) is vastly superior to last. Our extract since Michaelmas is 96 lbs. per quarter. I have in some instances obtained as much as 98, 100, 106, and one case, on a sample of fine chevalier barley, weighing previously to malting, 56 lbs. per bushel, 110 lbs; the malt weighing 362 lbs. per quarter." This last enormous extract is equal by Allan to 275 per quarter. The Lancashire brewer states, that on one or two occasions he has obtained from malt made from fine chevalier barley, weighing 43 lbs. imperial bushel, 253 by Allan per quarter.

I now proceed to the second objection, to the entire substitution of sugar for malt, and which is a very important one—that beers which are made entirely from sugar, are not drinkable so soon as those made from malt, in consequence of their being so excessively sweet and luscious, and that even should means be used to disguise this by putting in an extra quantity of hops, still, although the bitter may predominate, the sweet remains. Indeed, beer made entirely from sugar, always requires more hops than that made from malt. Besides delay to a brewer is a very great objection, as one of his chief aims is to bring his beer early to maturity, and thereby ensure a quick return: and if sugar were entirely used in the making of beer, or even as an auxiliary in too great a proportion, it would destroy its

characteristic taste and quality. Beers made from sugar alone never have the same fulness of flavour as those made from malt; and indeed even when they are made from very high gravities, they are never palatable before the expiry of six or twelve months.

It will be seen by the following extract from the Sugar Distillery Parliamentary Report, 1807, that it was there held that sugar could not be substituted for malt without a pecuniary sacrifice, and that independently it would not produce an article of equal flavour and marketable quality. After having examined the persons most competent to give them information, in page 4: they remark—"It appears to the committee, that taking the price of the quarter of malt, capable of producing 80 lbs. of saccharine matter at 82 shillings, the quantity of sugar necessary to produce an equal proportion of saccharine matter, must be 1 cwt. 3 qrs. 1 lb. (197 lbs.,) which at 58s. the cwt. would amount to 101s. 6d. in price, making a difference, in favour of the malt, of 19s. 6d. in that given quantity. It is stated, besides, in evidence, that the beer produced from sugar, even if the prices would admit of it, is not equal in any degree to that produced from its equivalent quantity of malt; and consequently, that *the brewers would not use sugar in their manufactory, unless they were prohibited by law from using grain.*" Mr. Jackson, a commissioner of excise, who was examined by the Committee remarks: "I recollect that about the year 1800 or 1801, when sugar was by law permitted to be used in the brewery, on account of the

scarcity of grain at that time, very little sugar was used. One or two brewers in London, two at Manchester, and some at Liverpool, were the only brewers I recollect to have used it, and they very soon discontinued it. The price of malt at that time was, as far as I recollect, five guineas a quarter, and sugar, including the duty, about 52s. per cwt." I might quote from Mr. Martineau, an eminent London brewer, and others, examined before the same committee, but do not think it necessary.

Perhaps, however, it may not be amiss to give another quotation, and that from a practical brewer, who is the author of a very excellent, scientific, and practical Treatise on Brewing. It appears that this gentleman made a brewing from three quarters of malt, the weight of which when ground, was 925.5 lbs.

From this he extracted 7.6 barrels of ale wort, of 30 lbs. gravity, amounting to	228 lbs.
5 barrels of return wort of 2.5 lbs.	12.5
"Hops (if not pressed) retain the worts in which they are last boiled to the extent of a barrel in 60 or 70 lbs. according to their quality. In this case, there were 13½ lbs. which could not, conveniently, be boiled with the return, and consequently contained about one-fifth of the gravity of a barrel of the ale worts,	6
	246.5.

So that the whole gravity extracted was 246.5, or about 82 lbs. per quarter; that is, 80 lbs. independent of what was left among the hops.

"In order to ascertain the weight of kernel from which this gravity was obtained, the grains were taken from the mash-tun and dried (at a low heat to prevent them being charred) until they appeared to be of the same dryness as the malt was, when ground. In this state they weighed 308 lbs., which deducted from 925.5, the original weight of the malt, leaves 617.5, being the weight extracted. Dividing this by 246.5, (the amount of gravity communicated by the worts,) we have 2.505, the proportion of dry malt required to form a pound of specific gravity. This proportion differs nearly one per cent. from the average table given in the first part of the Art of Brewing; but from the foregoing and other similarexperiments made since that table was constructed, we are convinced 2.5 is very nearly the truth; and consequently the brewer may be satisfied, that two and a half times, as indicated by the brewer's saccharometer, (the instrument with which these experiments were made) will show the real weight of extract which he has drawn from his malt."

He proceeds to state:—" Further, on reviewing the experiment just described, it appears that

The weight of the malt was .	925.5 lbs.
The weight of the extract, .	617.5 ..
Leaving in the grains, . .	308 ..

These numbers, being proportioned to 100, show that 100 lbs. of malt gave out 66.7 lbs. of extract, leaving 33.3 lbs. of dry grains; which agrees very nearly with the results of the experiments mentioned before; although these results were drawn from other materials. It is natural to inquire of what this remaining portion consists.

" According to Dr. Thomson, the cuticle of the barley constitutes about one-sixth of the weight of the whole grain. Malt is specifically lighter than the barley from which it was made, but its husk remains unaltered; and, most probably, (though we have not ourselves ascertained the fact,) will weigh one-fifth, at least, of the grist. The analysis of a hundred parts of this malt will therefore stand thus:—

Saccharine matter extracted, .	66.7
Cuticle, ...	20
Unascertained matter, . .	13.3
	100

"Of this 13.3, a large portion might have been extracted by subsequent sparges; for, in the case in question, we actually obtained 5 per cent. additional, by mashing the dried grains, thus reducing the unascertained matter to 8.3; and this might have been still further reduced, for something always remains in the grains which cannot be drained off. Nearly four-fifths of the whole weight of the malt may, therefore, be assuredly converted iuto saccharine matter, capable of being fermented into beer, and distilled into alcohol."

So much for a brewer's opinion of the value of malt extract, and in favour of malt.

There is another serious objection to the substitution of sugar, and which, I fear, may have escaped the notice of many brewers, who are now very sanguine of deriving benefit from the privileges granted them by the legislature; and this is, their having neither yeast nor grains to dispose of, nor store for their subsequent brewings.

At the brewery in the neighbourhood of London, where I was brought up, we considered that the amount from the sales of the grains and yeast defrayed the total working expenses of the brewery: at the same time, I am open to acknowledge, that at that period, there were no yeast brewers; and bakers had no alternative but to apply to the ale brewer for ferment for their bread. The yeast which comes from the sugar extract is alike useless for brewing and baking.

Having experienced the results I have just stated, I have come to the conclusion, that it is not advantageous to substitute sugar for malt, but the very reverse, and I beg to assure the reader, that if he doubts my statements, and persists in adopting this new agent, he will have ample cause to regret it. I am the more decided and anxious to give my opinion, because the notions entertained both by practical and unpractical men are perfectly absurd. One man, who is a brewer of 40 years' standing, I am informed, feels confident that he will obtain as much saccharum from 112 lbs. of sugar, as he would get from a quarter of malt 86 density by Dring and Fage, *i. e.* Allan 215 gravity. If this were even probable, I should be inclined to ask the question—From what *data* he proposes to regulate his original gravities for the different qualities of beers he intends brewing? I rest assured that he will obtain no more from 112 lbs. of sugar than 63 gallons, supposing the gravity to be 72, being exactly one-third less than what he would obtain from a quarter of malt of the value he states. Again, let us suppose this brewer was in the habit of adopting, say a gravity of 90 Allan, for a certain priced ale; according to his account, by substituting sugar and obtaining an article equal to this, he must produce it from at least about one-third less gravity, that is to say, his formerly 90 gravity must be reduced to 60. If he attenuates his 90 gravity, say three-fifths, his final attenuation would be 36. Working on the same system with the sugar,

it would be only 24 gravity. The question to be considered is now—Is it at all—I don't say probable—possible, that any ale or beer produced with that gravity and attenuation, could be compared with that made from malt extract of from 90 attenuated to 36? In the one case, from the malt extract, we have a full-bodied, generous, palatable beer, and this we know from experience. Will we have it in the other case? Another asserts that 100 lbs. of sugar will produce the same quantity and gravity of raw wort as a quarter of the best malt. I could quote many more of those absurd statements, but it would only be waste of time and space.

The statements that appear from time to time in the public prints, are equally visionary and absurd. I may notice one of them wherein the writer asserts that a quarter of malt, according to the brewers' view, is as the weight it imparts to the water. A quarter of malt will afford from 200 to 220 lbs. of matter soluble in water, the density of which in a dry state is about 1.54. The weight of a quarter of malt is about 330 lbs., so that if 330 lbs. impart 220 lbs. in water, we have about two-thirds of its weight taken up in the process of brewing. But he adds, that 220 is a high product, and assumes the average at 200. He also states, that the extractive matter only contains gum, sugar, and starch, and that of those substances sugar alone is really valuable, remarking, that the starch and gum impart weight without value, for neither gum nor starch as long as

they retain that state, add either flavour or strength to the beer they exist in. He then assumes the following analysis of a quarter of malt, and afterwards shows what portion he supposes, (for he merely *supposes*,) of the product is imparted to the water. I may here quote his own words with which he prefaces the analysis. "If a quarter of malt contain the following products, and 200 lbs. of them be imparted to water, we shall see how far that quarter of malt is intrinsically valuable to the brewer, and be enabled to compare its worth with sugar and molasses.

"A quarter of malt contains:—

Resin,	3.3 lbs.
Gum,	52.8 ..
Albumen and gluten,	6.6 ..
Starch,	168.3 ..
Sugar,	49.5 ..
Hardein,	49.5 ..
	330.0 ..

"Taken up by the water:—

Gum,	52.8 lbs.
Starch,	97.6 ..
Sugar,	49.6 ..
Total,	200.0 .."

It would have been more satisfactory for the information of the practical brewer, had he given the supposition of 220 lbs., and shown what would have

been taken up had the product been so, instead of 200. Would he have made it up with hardein? He could not have added more gum, for he supposes the whole of that substance taken up. Again, why is the portion of starch so small, and why the total omission of the albumen and gluten, the only fermenting principle of the wort? I confess his analysis to me is perfectly unintelligible. With regard to hardein, if he can prove that it is a component part of the malt, I can also prove that a great part of it is convertible into starch, and finally into sugar.

After giving this analysis he goes on, and I again quote his own words. "Admitting that all the starch is converted to sugar, we have 147 lbs. of available matter from a quarter of malt, consequently we have data by which we can estimate its real value. Taking the density of malt extract therefore at 1.54 and sugar at 1.59, we perceive that we require about equal weight to produce the same effect; consequently, to make a density from sugar that shall equal that from a quarter of malt affording 200 lbs. of extractive matter, it is clear that we must employ the same weight, that is, 200 lbs.; because if malt extract be 1.54, and sugar 1.59, the gallon will weigh in the first case 15.4 lbs., and in the second 15.9 lbs. and their volumes will be .6493 and .6288 respectively. It will be seen that sugar is rather superior in density to malt extract, but disregarding the slight difference, we may for our present purpose view them

as equal; and if we take the brewers' view of the case, that weight is value, we must say that 200 lbs. of sugar and a quarter of malt are one and the same thing. Consequently, their value in this sense stands thus; malt at 90s. per quarter, equals sugar at 50s. 4d., and molasses at 35s. 8d. the cwt., so that malt could be advantageously used at the present time at 90s. per quarter; simply because, if this view be correct, the sugar is the dearest.

"This view of the brewers, however, cannot be maintained, unless they can show the whole of their extractive to be sugar, or that it becomes so in the course of fermentation, a circumstance, by the bye, that too many facts disprove," &c. &c.

This may appear to the mere theorist as a most learned and scientific statement, but to the practical brewer it will be a most unsatisfactory, if not an unintelligible one, without any foundation on facts.

Once more, were this statement correct, what advantage would the brewer derive from procuring malt that would give him per quarter 86, 100, 105, or 110 density, or 205, 250, 262, 275 specific gravity? Whatever matter is taken up by the water beyond the gravity of 147, he asserts is only gum, which according to his own showing is not only valueless but detrimental, for he goes on to say, "We have seen that 200 lbs. of malt extract cannot possibly contain according to analysis more than 147 lbs. of sugar, and that the difference 52.8 lbs. is gum. Now it is manifest from what is known, that this gum re-

mains in the beer unchanged up to a certain stage, which is long after the period the beer is used for drinking, and, therefore, as gum is incapable of being acted on vinously, and as it imparts no flavour, it is clearly so much dead matter."

Let us imagine for a moment, beer, the original gravity of which was 100 reduced to 35, holding in solution so enormous a quantity of what he elsewhere calls "starchy matter," what would its appearance and taste be?

In contradistinction let us see what one of the most eminent, scientific, and practical ale brewers, of upwards of forty years' standing, states. This gentleman's known capability was such, that he was appointed some years ago by a Committee of the House of Commons, to investigate the subject of the relative value of malt and sugar worts.

"Wort may be considered as consisting of sugar dissolved in water, and the strength of wort is always proportioned to the quantity of the saccharine matter contained in a given measure of the liquid. And hence, the gravity of worts when compared with the gravity of water, may, in all cases, be received and trusted to, as the measure of their value; which is confirmed, incontrovertibly in the practice of both distillers and brewers; the first of whom find the proportion of proof spirit, obtained from any given quantity of their wash, to be in an exact ratio to the gravity of such wash under correct uniformity in all parts of the process. And under the same circum-

stances, the brewer obtains a greater or less price for his beer, according to the gravity of his worts; or, (which is the same) accordiug to the quantity of malt allotted to make snch worts.

"A bushel of ripe and well-cleaned barley will weigh from 50 to 52 lbs.; of which weight one-fifth part is lost by germination and evaporation in malting, and not more, provided it be malted with a view to the quality, rather than to an injurious increase of measure. In the latter case, a full fourth part of the original weight of the barley is lost in the malting. From a bushel of perfect malt, weighing 40 to 42 lbs., may be drawn 25 lbs. of solid extract, of equal value and usefulness to a distiller or to a brewer, as 25 pounds of sugar, in the state as the last is sold in the shops. For the saccharine matter, contained in the extract of malt, is not more (if so much) diminished by the very small portion of mucilage, which mingles with it, when running from the mashing-tun, than the sugar is weakened by its hydrogenous or watery particles."

I shall now proceed to give an account of some practical observations which I have myself made, and first, as to the relative qualities of sugar.

EXPERIMENT.

Since the government allowed the introduction of sugar into breweries, I have made several experi-

ments, and find that the generality of sugars now imported are more valuable to the wine-maker—consequently to the brewer—than those imported formerly which did not average 35 gravity. I especially allude to those from the East Indies, which have been always considered as being less valuable for the amount of sweet they yielded, than those from the West Indies. What I mean by 35 of gravity is this, that if one pound of sugar be thoroughly incorporated with an entire imperial gallon of water, Allan's Saccharometer would indicate 35. To ascertain the gravities I have proceeded as follows:

I procured a measure bottle capable of containing exactly 10 ounces of water, this being the 16th part of a gallon. I then weighed 1 ounce of sugar, which is the 16th part of a pound, and thoroughly incorporated it with the 10 ounces of water, and then I returned it to the measure bottle, and found it had increased in bulk to the extent of nearly one 16th part. When returning the contents of the measure bottle to the sample tube for examination by the Saccharometer, I found its indication. By this, of course, we are to assume the sugars are neither more or less valuable to a wine-maker or brewer, than the gravity they impart.

With regard to malt extract.—I procured from a highly respectable brewer a pound of the best malt he had, and mashed it in a small experimenting mash-tub, which I have for the purpose. On this pound of malt I poured three-fourths of a gallon of

liquor at 182°, put the mash-tub before the fire, and allowed it to remain infusing for an hour and a-half. I then sparged on a quart of liquor at 195°, and set the tap until I ran off three quarts of the extract. I then sparged on another quart at 195° running off a quart, which made up the gallon. As the pound of malt would scarcely absorb a pint, and a quart must be accounted for, there must remain with the goods a pint. I then put three pints of cold water upon the goods and mashed them thoroughly up, and drew off three pints and one gill. Upon weighing a sample from the gallon, I found its gravity to be 21.50, and afterwards weighed the gravity of the returned wort (if it may be so called) filling it up with water to make it a gallon, in order to facilitate the calculation. This gallon of wort weighed 2.75. The result is as follows;—

		S. G.
One gallon of the first extract,	"	21·50
" " return wort,	"	2·75
Total		24·25

being as nearly as possible the amount of gravity which two-thirds of a pound of the best sugar would give, allowing the .25 for the increase of bulk.

In order to complete the experiment, I took the grains from the mash-tub and dried them, when I found they weighed not 5 ounces and a-half, which would have been 5.50, but so *nearly* 5 and a-half, that I called them 5.40. These ounces being

brought into specific gravity by being multiplied by 2.25 give a gravity of 12.150. Thus:—

		S. G.	OZ.
1 gallon of first extract,		21.50 ...	9.50
1 do. return wort,	"	2.75 ...	1.50
*Weight of grains 5.40 ounces,	"	12.150 ...	5.40
	Total	36.400	16.40

This over weight in the grains must have been occasioned by their not having been thoroughly dried, owing to the want of proper implements; and, besides, by having been before the fire for upwards of 30 hours, they must have been subjected to the addition of much extraneous matter.

I will now show what was the result with the same weight of sugar, namely, 1 lb. of the very best Dhobahs, at 58s. per cwt.

One pound of this sugar was put into two one gallon measures, eight ounces in each, with two quarts of boiling water in each, and when thoroughly dissolved each measure was filled up with cold water and well incorporated. At 60° I found the gravity of each to be 18.1. This exceeds $36\frac{1}{8}$ in consequence of the superior quality of the sugar. It will be seen by the first of these experiments, that I have succeeded in proving what I affirmed, namely, that any brewer of ordinary capacity can obtain at least

* This weight of grains, 5.40 ounces, was brought into specific gravity merely to show that had it been sugar giving a gravity of 36, by multiplying each ounce by 2.25, it would have given the 12.150; and proving that sixteen ounces of malt are as valuable to a brewer as nearly 10-70 ounces of good sugar.

two-thirds of the weight of the malt he uses; and by the second, that 1 lb. of sugar extract is not more valuable to him than the same quantity of malt extract.

After having entered so far into the merits of the subject, I now come to the last, and what I consider the most important part, namely, to show how sugar may be advantageously used in brewing.

Sugar to be available and to lead to a satisfactory result, must be only used as an auxiliary in brewing, and that not exceeding 25 per cent.; for, as already noticed, if a superabundance is made use of, the result will be only disappointment.

The use of sugar is most required in those establishments where beers of a high gravity are regularly made, such as those at Burton, Edinburgh, &c. Many of the brewers in those places will accept the privilege of using this article as a great boon.

For the sake of argument, I will suppose (and it is no unlikely case,) that a brewer has a large order for a high-priced ale, and has no immediate demand for one of an inferior quality. He feels quite at a loss how to proceed, so as to derive the advantages which he would enjoy, had he also a sale for beers of a lower gravity. From his first running for the higher-priced ales, he has extracted so large a portion of the fine rich wort, that he has only left in the mash-tun what would be fit for ales of inferior quality, which contains much more of the mucilaginous matter than those before extracted.

The brewer thus having an abundance of glutinous or mucilaginous matter, with an inadequate quantity of the saccharine, will now be able to supply the deficiency to the extent he requires, always taking into consideration, however, that if he uses the very best sugar, (for which he will pay more than 52s. per cwt.) the gravity of his wort will be increased by Allan's Saccharometer 36 per gallon for each pound of sugar; but to prevent disappointment here, his safest course will be to consider the increase at 35, remembering at the same time, that whatever quantity of sugar he employs, the bulk will be proportionably increased.

I have now beer made in this way, *i. e.* with sugar as an auxiliary, six years old of a very superior quality—so very fine indeed, that a report of its excellence having reached the ears of one of our distinguished Edinburgh brewers, he called for the purpose of examining it, and being satisfied of its high character, he remarked, if he could make such beer, he could sell any quantity of it at the rate of 12s. per dozen. The original gravity of this beer did not exceed 85.

As it appears to be of paramount importance at this period, to the brewer who is desirous of making trial of sugar, to gain every information on the subject; I now proceed to give him what knowledge I have acquired from personal and practical experience; being confident he will find it more valuable than those visionary theories, which indeed will only lead to

error and disappointment. The following applies generally to beers brewed in spring, and more particularly to India beers.

Sugar when used as an auxiliary, may be added to the wort either in the copper, or in the fermenting tun. Both of those practices I have adopted in quarter brewings for my own family use; and for experiment I have divided the portion of sugar intended to be used, putting the one half into the copper and reserving the other half for the fermenting-tun, to be mixed with the wort there about 12 hours before cleansing. Previously to this, I skimmed the tun, and added a small quantity of salt and flour, which had been mixed and dried at the fire for this purpose. This I think a better method than putting the whole of the sugar into the copper with the hops; especially in case the tun should have generated too much heat. After the desired attenuation the beer was cleansed.

The most valuable part of my information now comes to be detailed, and that information will be especially available for beers for India, or for keeping beers.

A strong decoction of the finest Farnham or East Kent hops, should be made at the rate of about from 35 to 40 lbs. to the hogshead, and boiled for about 15 minutes in a copper, where the steam is condensed, after which time the hops are strained, and again saturated in cold water and strained the second time. The second strained liquor is put into the copper, and

sugar to the extent of 9 lbs. of the best East India is put to each gallon of this second infusion of hops. This syrup is made to boil until completely freed from its refuse by repeated skimming. When this is effected, the first decoction of hops is to be added to the syrup, and boiled down until its gravity is about 250.* The addition of a gallon of this extract to a hogshead of beer at the time of racking, will give it that character which it is almost impossible to describe, at the same time that it will afford it nourishment, fulness to the palate, and strength ; and unquestionably secure its soundness. When this is properly considered, it will be perfectly apparent that this method is out of sight preferable to the present uncouth one, of mashing dry hops and putting them in the cask at the time of bunging down. There is still another advantage gained by adopting this method. In consequence of the low original gravities of India beers, they contain more of the fermenting principle than others which are made from a higher gravity, and therefore it often becomes necessary to check both in the tun and on the stillions, in order that their attenuations should not be allowed to proceed beyond the desired point, for should they do so, although more spirit would be generated, the beer would be thin to the palate and astringently bitter. By the addition of this dose of syrup this evil is effectually remedied.

* As the hops still retain much of their value, they may be used again for brewing purposes.

I would strongly recommend those who propose to use sugar in their brewery, to procure the following experimenting apparatus. A measure bottle with a glass stopper having an orifice running up through the centre of it, and a graduated glass tube, and a good experimenting saccharometer. The graduated glass tube will answer also as tube for the saccharometer.

The measure bottle should be made so as to contain exactly 10 ounces and 5 eighths of an ounce of water at 60°. Water is poured into the bottle until it cuts a graduated line which should be marked exactly at the bottom of the neck of the bottle. This line indicates the measure of 10 ounces. The neck should be made to contain the 5 eighths, with a graduated line at each eighth. Therefore it will require 5 graduated lines, the first at the bottom of the neck indicating 10 ounces, the second line, 10 ounces and 1 eighth, and so on; so that the 10 ounces 5 eighths will completely fill the bottle, which will be seen when the stopper is put in, by the liquor coming up to the top of the stopper through its orifice.

The glass graduated measure should have a lip to it, in order to facilitate the pouring out of the liquor. It should contain 12 ounces of water at 60°. The first graduated line should be marked at 10 ounces, or if prefered it may be graduated indicating each ounce. Above 10 ounces it must be graduated for each eighth of an ounce up to 10 ounces 5 eighths.

The saccharometer I use is so arranged, that distilled water, at 60° sinks at 0. when the 30 weight is upon it; consequently it will weigh any fluid lighter than water to the specific gravity of 970. Its stem is graduated so as to indicate only 3 degrees of specific gravity, and each degree is subdivided into tenths. It has 8 weights. The first a 3 weight, the second 5, the third 10, the fourth 20, the fifth 30, the sixth 40, the seventh 50, the eighth 100. I can by this instrument weigh any saccharine fluid with the greatest correctness to 140, and a spirituous fluid providing its specific gravity exceeds 970. A brewer with a measure bottle and a saccharometer will be at all times able, and with little trouble, to ascertain the gravity of the sugar he intends to use, and by that means be at once enabled to judge with accuracy what quantity will be necessary to bring up his worts to the required gravity. Having described the apparatus, I proceed to detail the mode of testing the sugar.

The measure bottle should be filled with water at 60°, so that it cuts the graduated line at the bottom of the neck indicating 10 ounces. An ounce of sugar avoirdupois should be accurately weighed, and put into the graduated glass tube, a small portion of water from the measure bottle put on the sugar and mixed thoroughly with it. When this is accomplished another portion of the water is added, which renders the liquid more fluid, and makes any bit of undissolved sugar discernible. Every bit or lump of

sugar remaining is now broken, and the whole dissolved. The remainder of the water from the measure bottle is to be added, and the whole thoroughly mixed, after which the saccharometer is then applied and the gravity noted. Before, however, the gravity is noted, the thermometer should be employed to ascertain the temperature of the fluid under examination, which should be 60°.

If the experiment has been properly conducted, by returning the saccharine liquid into the measure bottle, it will be found nearly to fill it up, allowing about a 32d part of an ounce for what will hang about the tube. The water used is 10 ounces, but the ounce of sugar will increase the volume of the saccharine liquid 1 sixteenth part of 10 ounces, namely, 5 eighths of 1 ounce.

It is necessary to be assured, that when samples of sugar are obtained they should be newly drawn, for should they have been drawn for many days, and kept in a warm counting-house or in a person's pocket, if a solution of such samples be examined the result will lead to error.

Corresponding very lately with a brewer, I find he is inclined to make use of refined sugar in preference to raw. Were I to offer an opinion, I would say his views were incorrect, and that for two reasons. First, for the greater expense of refined sugar, say at the least 14s. per cwt., while at the same time it imparts very little additional value to the wort. Secondly, refined sugar, in consequence

of the process it has undergone, is deprived of the small portion of fermenting principle it contained in its unrefined state.

I will close this paper by giving the brewer a rule to direct him, how he may ascertain what quantity of sugar is necessary to bring his worts to any desired specific gravity.

EXAMPLE.

Say we have a brewing of a quarter of malt; the quantity of wort in the copper 120 gallons, and the gravity of which is 70. We intend to increase this gravity to 90 by adding sugar. Subtract 70 from 90, multiplying 20 (the difference) by 120, being the number of gallons, the amount will be 2400. Then divide the 2400 by the gravity you have previously found each pound of sugar to impart to a gallon of water; suppose we say 35, bearing in mind that for every sixteen pounds of sugar dissolved, the bulk of the liquor will be increased one gallon.

How much sugar is required to raise 120 gallons of wort of the gravity of 70, to the gravity of 90, supposing the sugar to give a gravity of 35.

$90—70 = 20 + 120 = 2400 \div 35 = 68.57$

TABLE.

Showing the different specific gravities of saccharine liquids, in which one pound of sugar has been dissolved in each gallon of water at 60°, from a variety of samples consisting of Refined, Crushed, West India, Mauritius, Bengal, &c. from 48s. to 80s. per cwt.

No.	Names.	Price.	Gravity.	No.	Names.	Price.	Gravity.	No.	Names.	Price.	Gravity.
1	Fine Mauritius,	56s.	36.1	11	Titler (Scotch,)	68s.	37.10	21	Yellow Corsesepore,*	58s. 6d.	36.25
2	„ Jamaica,	55s.	35.5	12	„ English,	68s.	37.2	22	„ Mauritius,*	51s.	36.5
3	„ do. damp,		33.9	13	Dhobah,*	60s.	36.9	23	Fine Havannah,*	54s.	36.9
4	„ Crushed,	53s.	35.“	14	Grenada,*	48s.	35.7	24	„ Mauritius,	53s.	36.7
5	Havannah,	51s 6d.	35.9	15	Do. *	52s.	36.“	25	Very fine Bengal,	60s.	36.6
6	Fine do. damp.	54s.	34.5	16	Corsesipore,*	59s.	36.1	26	Java,*		37.
7	Bengal,	56s.	36.4	17	Do. *	58s.	36.“	27	Titler,	70s.	37.25
8	Do. fine,	58s.	36.6	18	Dhobah,*	56s.	36.7	28	Fine Benares,*		37.50
9	Double refined,	80s.	36.6	19	Low Benares,*	52s.	37.60	29	Jamaica,	55s.	36.1
10	Refined,	74s.	36.50	20	Yellow Havannah,*	49s.	36.5	30	Do.	54s.	36.

The above were the current prices of the sugar, of the 10th March 1847. Those samples marked with stars, were kindly furnished by one of the most extensive houses in the Trade, they were not however newly drawn.

The following were the specific gravities of miscellaneous saccharine liquids, also containing one pound weight of each specified substance dissolved in one gallon of water at 60°.

1	Sugar Candy,	10½d.	37.5	6	Cuba Honey,	60s.	29.3	11	Jamaica Molasses,	29s. 6d.	29.7
2	Do.	„	37.1	7	Grecian do.	66s.	29.1	12	do. do.	39s.	29.5
3	Scotch Honey,		30.50	8	Irish do.	30s.	26.50	13	Malt Scotch,	85s.	24.25
4	American do.	40s.	29.25	9	Golden Syrup,	32s.	27.9	14	do. do.	85s.	24.30
5	Jersey do.	45s.	31.6	10	French,	31s.	29.7	15	do. do.	84s.	24.

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