John [illegible]

THE

THEORY and PRACTICE

OF

BREWING,

By MICHAEL COMBRUNE, Brewer.

Printed with Permiſſion of the Master, Wardens, and Court of
Assistants of the Worſhipful Company of BREWERS.

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MDCCLXII.

This Book is entered at STATIONERS HALL, *and every Copy is ſigned by the* AUTHOR.

TO

DOCTOR PETER SHAW

PHYSICIAN to his MAJESTY,

Fellow of the Royal COLLEGE of PHYSICIANS of LONDON,
and of the ROYAL SOCIETY.

SIR,

THE brewing of malt liquors has hitherto been conducted by ſuch vague traditional maxims, that an attempt to eſtabliſh it's practice on truer and more fixed principles, muſt, like every new eſſay, be attended with difficulties.

Your works, Sir, will be laſting monuments, not only of your great abilities, but alſo of your zeal for the improvement

ment of the arts, manufactures and commerce of your country. You will therefore permit me to place, under your patronage, this treatiſe, which, if it can boaſt no other merit, has that, of having been undertaken and finiſhed by your advice and council.

Some favor, I hope, will be ſhewn for this diſtant endeavour, to imitate the laudable example you have ſet, and whatever be the ſucceſs, I ſhall ever glory in the opportunity it has given me, of profeſſing myſelf publickly,

SIR,

Your moſt obedient,

and moſt obliged humble Servant,

Hampſtead, Middleſex,
December 15, 1761.

MICHAEL COMBRUNE.

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THE

PREFACE.

THE difference that appears in the ſeveral proceſſes of brewing, though executed with the ſame materials, by the ſame perſons, and to the ſame intent, is generally acknowledged. The uneaſineſs this muſt occaſion to thoſe, who are charged with the directive part of the buſineſs, cannot be ſmall: and, the more deſirous they are of well executing the charge incumbent on them, the greater is their diſappointment, when fruſtrated in their hopes. To remove this uncertainty, no method ſeems preferable to that of experiment, as it is that alone, which can eſtabliſh this, and any other art, upon a ſolid foundation. But thoſe, who have the courage, and grudge neither time nor expence, to multiply and to vary their trials, too often acquire the name of idle refiners, and, what is worſe, too frequently deſerve it. The operations of nature elude ſuperficial enquiries. Where we have few or no principles for our guides, many experiments are made, which tend only to confound or deceive. Effects ſeen, without a ſufficient knowledge of their cauſes, muſt often be neglected or viewed in an improper light; thoſe that are remembered are ſeldom faithfully reported, and, for want of diſtinguiſhing the ſeveral circumſtances that attend them, become the ſupport of old prejudices, or the foundation of new ones.

Whoever is attentive to the practical part of brewing will ſoon be convinced, that heat, or fire, is the principal agent therein, as this *element uſed in a greater or leſs degree, and differently applied, is the occaſion of the greateſt part of the variety we perceive. 'Tis but a few years ſince the thermometer has been found to be an inſtrument ſufficiently accurate for any purpoſes, where the meaſure of heat is required. And as it is the only one, with which we are enabled to examine the proceſſes of brewing, and to account for the difference in the effects, a theory of the art founded on practice muſt be of later date than it.*

So long ſince as the year 1741, *I began this enquiry, and never neglected any opportunity to conſult the artiſts of the trade, or to try ſuch experiments as I conceived might be conducive to my purpoſe. It is needleſs, perhaps ſhameful, to mention their number, or to ſpeak of the many diſappointments I met with in this purſuit. At laſt, flattering myſelf with having collected the true theory, aſſiſted and encouraged by men of abilities, I thought it fit the publick ſhould judge whether I had ſucceeded in my endeavours, and in* 1758 *the Eſſay on brewing was ſubmitted to them, either for their approbation, or that the errors therein might be pointed out. I have had no reaſon to repent of my temerity, ſince the novelty, more perhaps than the merit of this performance, has engaged the attention, I may add, the favor of ſome good judges. They have allowed my principles to be, at leaſt, plauſible, and their agreement with practice has ſince repeatedly convinced me, that they could not be far from truth.*

The Eſſay juſt mentioned, reviſed and corrected, naturally forms the firſt part or theory of the preſent treatiſe. The ſecond part is intirely practical. After giving a ſhort idea of the whole proceſs, I *reſume its different branches in as many chapters, and endeavour to lead the practitioner by the hand, ſo that he may, in every part, at all times, and under a variety of circumſtances, know what he is to do, and never be diſappointed in his object. As hops are much more unſtable in their prices than many other commodities, a rule is attempted to direct the purchaſing of them. Tables ſhewing the lengths of all ſorts of beers and ales, to be made at all the different prices expected, and the profits accruing therefrom are, for the ſame reaſons, exhibited. Previous to any brewing, I ſhow how to aſcertain numerically the proper heat for every maſh, the means to obtain ſuch a heat, and laſtly, the true quantities of water neceſſary for this end. Waſte of fuel or of labour will, by this means, be prevented. I examine how long worts are to boil, the heat they are to arrive at in order to ferment, what quantity of yeaſt is neceſſary to forward this operation, and by what rules the artiſt may be enabled to brew, in coppers of any dimenſions, as ſoon as the gauges thereof are delivered to him, every kind of malt liquor, and eſpecially pale ales or amber, where the art may be ſaid to be carried to its greateſt height.*

As much damage enſues from cellars not being attended to, a method of determining the proper ſtocks for them cannot be thought uſeleſs. Beers may incidentally be liable to diſeaſes, either by neglect, by being uſed too ſoon, or by being too long kept, and there are few houſes, dealing in porter, that do not experience how dearly they pay for the remedies applicable to ſuch caſes. As the ſervants to whom they apply for that purpoſe, are no ways acquainted with the proportions of the conſtituent parts of beers, or with the effects re-

reſulting therefrom, it has been thought a duty to diſcloſe this little ſcience, that the perſons concerned may relieve themſelves, and to ingredients, often inefficacious, ſometimes hurtful, ſubſtitute ſuch as are wholeſome, and at the ſame time the moſt conducive to their purpoſe.

To prevent errors is a means of rendering remedies uſeleſs, at leaſt leſs expenſive. As the principal view and intent of this work is to purſue the methods of obtaining fine and pellucid beers, and of brewing them ſo, that the whole of the fermentable parts of the malt may be extracted and the liquor become fit for uſe at the deſired ſeaſon, the expence of iſinglaſs uſed for brown beers muſt be greatly leſſened, and the train of noſtrums ſo generally applied by coopers in great meaſure avoided; the beer will be poſſeſſed of all the ſtrength it is ſuſceptible of, the expence of over large ſtocks become needleſs, and the weight of what in the brewery is termed an hoſpital, *by this means, removed.*

In ſo extenſive a branch of buſineſs, ſome benefit muſt accrue to the publick, from its being carried on in a juſt and uniform manner, and our malt liquors will better deſerve the name of wine.

Boerhaave, Shaw, Macquer, *and moſt of the great maſters in chemiſtry are far from limiting that name to the liquors produced from the juice of the grape; they extend it to all fermented vegetable juices, which, on diſtillation, yield an ardent ſpirit, and look on the ſtrength and faculty wine has to cheriſh nature, and preſerve itſelf, to be in proportion to the quantity it poſſeſſes of this liquid generally termed ſpirit of wine. This, when thoroughly pure and dephlegmated, is one and the ſame, whatever different vege-*

vegetable it is produced from. Barley wines poſſeſs the ſame ſpirituous principle, which is the preſervative part of the moſt valuable foreign wines, with a power of being brewed ſuperior or inferior to them in quality, and the other conſtituent parts of beer; beſide the ardent ſpirit juſt mentioned, will not, I believe, be eſteemed leſs wholeſome, than thoſe which make up the whole of grape wine.

The reaſons why Great-Britain hath not hitherto furniſhed foreign nations with this part of her product, but more eſpecially her ſeamen, are obvious. Our mariners, when at home, do not diſlike beer, either as to their palates or its effects on their conſtitution; but, when abroad, ſpirituous liquors, or new wines, often the product of an enemy's country, are ſubſtituted in lieu thereof. It is a principal duty in all commanders of ſhips to maintain their people in health, at the eaſieſt expence. The diſuſe of beers, on theſe occaſions, has been owing to the uncertainty of the principles by which they were brewed; the maintaining them ſound, in long voyages and in hot climates, could not be ſufficiently depended upon; and it was alſo ſuppoſed that they could not be procured at ſo eaſy a rate as wines, brandies, or rums are purchaſed abroad. The firſt of theſe objections the author hopes, by this work, to remove; and, were all the duties to be allowed on what would be brewed for this purpoſe, our ſeamen might be furniſhed with beer ſtronger than Spaniſh wine, and at a leſs expence, the mean prices of malt and hops being taken for ſeven years. It is true that, in times of peace, the ſeamen in his Majeſty's ſervice are not very numerous, but the number of thoſe then employed by the merchants is very conſiderable. I ſhould not have preſumed to mention this,

this, but becauſe of the encouragement that is given to the exportation of corn and to the uſe of ſails of Britiſh manufacture. It is computed that, in England and Wales, are brewed three millions five hundred thouſand quarters of malt yearly, for which purpoſe upwards of one hundred and fifteen thouſand weight of hops are uſed. The ſcheme here propoſed might become a means of encreaſing the conſumption of the growth of our country, viz. of barley, to more than one hundred thouſand quarters, and of hops to between fourteen and fifteen thouſand weight annually.

Whether this be an object deſerving the attention of the legiſlative power, or of the landed intereſt, and what might be the proper means to put it ſucceſsfully in practice, are conſiderations which do not belong to this place; it being ſufficient here to point out, how univerſally beneficial it is to eſtabliſh the art of brewing on true and invariable principles.

This being the firſt attempt, that has been made, to reduce this art to rules and principles, the Author hopes he has a juſt claim to the indulgence of the public, for any errors he unwillingly may have adopted, and far from believing that there is no room left for future improvements, he recommends it to thoſe, who, bleſſed with ſuperior talents and more leiſure than himſelf, may be inclined to try their skill in the ſame field, to follow cloſely the ſteps of NATURE, *and not to expect ever to overtake her.*

A COPY of DOCTOR SHAW's Letter, on peruſing the ESSAY beforementioned.

DEAR SIR,

I have, with pleaſure and improvement, read over your manuſcript; and ſhou'd be glad to ſee ſome other trades as juſtly reduced to rules as you have done that of brewing: which would not only be making a right application of philoſophical knowledge, but, at the ſame time, accommodate human life, in many reſpects, wherein it is ſtill deficient. Perhaps your example may excite ſome able men, to give us their reſpective trades, in the form of ſo many arts. For my own part, having long wiſhed to ſee ſome attempts of this kind, for the good of ſociety in general, I cannot but be particularly pleaſed with the nature, deſign, and execution of your Eſſay, and am,

DEAR SIR,

Your obliged Friend,

and humble Servant,

PETER SHAW.

Pall-Mall, July 20,
1758.

INTRODUCTION.

AN enquiry into the antiquity of the art of brewing would certainly be a curious, but, I fear, a very uſeleſs reſearch. In all probability, the inhabitants of the northern countries, ſoon after they ſettled there, found out a method of obtaining a liquor from grain, ſimilar to wine, and indeed the mention of beers, or barley-wines, by ſome hiſtorians, who treat of the colder parts of the globe, where grapes will not ripen, ſeems to put this matter beyond doubt. However we have no reaſon to believe that they arrived at any great degree of perfection in their art; for though the brewer's company at *London* were incorporated in the year 1427, and a company of the ſame nature was eſtabliſhed in *France*, many years before, yet it is certain, there was no good beer, either in *France*, or even in *England*, till much later.

The buſineſs of brewing formerly was, and now generally is, in the hands of men unacquainted with chemiſtry, and not conſcious that their art has any relation to that ſcience, though it is in reality a conſiderable branch of it. For want of a due knowledge of the elements and inſtruments neceſſary in brewing, and from never once imagining, that there were certain fixed and invariable principles, on which they ought to proceed, the advances the brewers made in their art could not but be ſlow.

In the reign of queen Elizabeth, malt began to be better made, and hops to be uſed; by the addition of theſe, the liquor was capable of being longer kept, and acquired the advantage of being meliorated by time. The ſuperiority of theſe two vegetables, over all others, for the purpoſes of brewing, being known and aſcertained, the legiſlative power prohibited the uſe of any thing elſe in the compoſition of beer. This law was certainly of the greateſt utility; by it, all ſophiſtication was prevented, and our beers became the beſt in *Europe*. But ſtill a great difference, in point of excellency, was obſerved in the ſame, but chiefly in different, places; this was in a great meaſure owing to a want of principles and rules to direct the artiſts, according to the variations of the malt in point of dryneſs, or of the ſeaſons of the year in that of heat. The ſame fault ſtill ſubſiſts, the Thermometer not being more generally uſed, an inſtrument, which, as it is now brought to perfection, for the aſcertaining the value of the degrees of heat, is the only one which the brewer can with certainty govern himſelf by.

The deſigns of all brewers are; 1. To extract the fermentable parts of the malt, in the moſt perfect manner. 2. To add hops in ſuch proportion, as experience teaches them will preſerve and meliorate the beer. And, 3. To employ ſuch a proportion of yeaſt, as is ſufficient to obtain a complete fermentation.

Perhaps

Perhaps it will be ſaid, that theſe three particulars are already ſufficiently underſtood, and that it would be a much more uſeful work, to publiſh remedies for the imperfections or diſeaſes, that beer is naturally or accidentally ſubject to, and which at preſent are deemed incurable, ſuch as cloudineſs, &c. But if the three deſigns, above laid down, be executed according to the rules of chemiſtry, ſuch remedies will not be wanted; for beer brewed upon true principles is, neither naturally nor accidentally, ſubject to cloudineſs, nor to many other diſorders often perceived in it. Hence it is evident, that ſome knowledge of chemiſtry is abſolutely neceſſary to complete the brewer, as, without the informations acquired from that ſcience, he muſt be unqualified to lay down rules for his practice, and to ſecure to himſelf the favor of the publick.

From true principles ſuch a method of brewing in winter, may be deduced, that the beer ſhall be fit for uſe, at any limited period of time, and in ſummer, the proceſs be carried on with more ſucceſs than it generally is. I do not mean to inſinuate that brewing can be better executed in ſummer than in winter; but only that, if neceſſity requires it, the operation may be performed, to a ſufficient degree of perfection, and much longer than is uſual, in the firſt of theſe ſeaſons.

Before we proceed, it may be neceſſary, or at leaſt convenient, to explain ſome few terms, and to trace the properties of fire, air and water, as far as they relate to brewing. I have not ſcrupled to make uſe of all the aſſiſtance I poſſibly could obtain, from the authors, who have treated of theſe ſubjects; and whenever I diſſent from them, it is becauſe, to my apprehenſion, nature evidently does ſo too. The reader is likewiſe deſired to obſerve, that this Eſſay is not deſigned to inform the learned in chemiſtry, nor do I pretend to exhauſt theſe ſubjects, but only to ſay as much of them as is neceſſary for a brewer to know.

* * *

AN

EXPLANATION
OF THE
TECHNICAL TERMS.

AS the principal object of this treatiſe is to be uſeful to thoſe concerned in the practical part of brewing, to ſave them the labour of any farther enquiry, it has been thought adviſable to avoid, as much as poſſible, the terms of art, and to prefix an explanation of thoſe that neceſſarily occur.

Acids are all thoſe things, which taſte ſour, as vinegar, juice of lemons, ſpirit of nitre, ſpirit of ſalt, &c. and are put in a violent agitation, by being mixed with certain earths, or the aſhes of vegetables. An acid enters, more or leſs, into the compoſition of all plants, and is produced by, or rather is the laſt effect of, fermentation. Mixed in a due proportion with an alkali, it conſtitutes a neutral ſalt, that is, a ſalt, wherein neither the acid nor alkali prevail. Acids are frequently termed acid ſalts, though generally they appear under a fluid form.

ALKALIES, or alkaline ſalts, are of a nature directly contrary to the acids, and generally manifeſt themſelves by effervеſcing therewith: they have an urinous taſte, and are produced from the aſhes of vegetables, and by ſeveral other means. They, as well as teſtaceous and calcarious ſubſtances, are frequently made uſe of by coopers to abſorb the acid parts of ſtale beer, and this they call *ſiſtning*.

AIR is a thin elaſtic fluid, ſurrounding the globe of the earth; it is abſolutely neceſſary to the preſervation, both of animal and vegetable life.

ALCOHOL is the pure ſpirit of wine, without the leaſt particle of water or phlegm.

ANIMALS are organized bodies, endued with ſenſation and life. Minerals are ſaid to grow and increaſe, plants to grow and live, but animals only to have ſenſation. Animal ſubſtances cannot ferment ſo as to produce by themſelves a vinous liquor; but there may be caſes, wherein ſome of their parts rather help than retard the act of fermentation.

ATMOSPHERE is that vaſt collection of air, with which the earth is ſurrounded to a conſiderable height.

ATTRACTION is an indefinite term, applicable to all actions whereby bodies tend towards one another, whether by virtue

virtue of their weight, magnetiſm, electricity, or any other power. It is not therefore the cauſe determining ſome bodies to approach one another, that is expreſſed by the word attraction, but the effect itſelf. The ſpace, through which this power extends, is called the *ſphere of attraction*.

BLACKING is a technical term uſed by coopers, to denote ſugar that is calcined, until it obtains the colour that occaſions the name. From it's acidity it is thought to be of ſome help to cloudy beers, and from it's colour is in part a means of hiding the defect.

BREWING is the operation of preparing beers and ales from malt.

BOILING may thus be accounted for. The minute particles of fuel, being by fire detached from each other, and becoming themſelves fire, paſs through the pores of the veſſel, and mix with the fluid. Theſe, being perpetually in an active ſtate, communicate their motion to the water: hence ariſes, at firſt, a ſmall inteſtine motion, and from a continued action in the firſt cauſe, the effect is encreaſed, and the motion of the liquor continually accelerated; by degrees, it becomes ſenſibly agitated, but the particles of the fire, acting chiefly on the particles, that compoſe the loweſt ſurface of the water, give them an impulſe upwards, by rendering them ſpecifically lighter, ſo as to determine them to aſcend according to the laws of equilibrium. Hence there is a conſtant flux of water from the bottom to the top of the veſſel, and reciprocally from the

top

top to the bottom. This appears to be the reaſon why water is hot at the top ſooner than at the bottom, and why an equal heat cannot be diſtributed through the whole. The thermometer therefore can be of little ſervice, to determine immediately the degree of heat, eſpecially in large veſſels, on which account it is better for brewers to heat a certain quantity juſt to the act of boiling, and to temper it, by adding a ſufficient quantity of cold water. Boiling water is incapable of receiving any increaſe of heat, though acted on by ever ſo great a fire, unleſs the atmoſphere becomes heavier, or the vapours of the water be confined. It occaſions the mercury to riſe, according to Farenheit's ſcale, to 212 degrees.

CLEANSING is the act of removing the beer from the ton, where it was firſt fermented, into the caſks.

CLOUDY is an epithet joined to ſuch beers, as, from the violent heat which has been given to the water, with which they were brewed, are loaded with more oils, than can be attenuated by fermentation, and incorporated with the water. A muddy and grey oil is ſeen floating on the ſurface of the beer, though the body of the liquor is often tranſparent; this oil is frequently collected in great quantity, and exceeds the power of any known menſtruum.

COHESION is that action, by which the particles of the ſame body adhere together, as if they were but one.

COLD is a relative term in oppoſition to heat. Its greateſt degree is not known, and it is ſuppoſed that the colder a body is, the leſs is the agitation of it's internal parts.

COLOUR; A greater or leſs degree of heat cauſes different colours in moſt bodies, and from a due obſervation of the colour of malt, we may determine what degree of heat it has been impreſſed with.

DENSITY expreſſes the cloſeneſs, compactneſs, or near approach of the parts of a body to one another: the more a body weighs in proportion to its bulk, the greater is its denſity. Gold is the denſeſt body in nature, becauſe there is none known of the ſame bulk, which weighs ſo much.

EARTH, is that foſſil matter or element, whereof our globe partly conſiſts.

EBULLITION is the boiling or bubbling of water, or any other liquor, when the fire has forced itſelf a paſſage through it. Brewers ſuppoſe water to be juſt beginning to boil, when they perceive a ſmall portion of it forced from the bottom upwards in a right line, ſo as to diſturb the ſurface: when the liquor is in this ſtate, they call it, *through*, or upon the point of ebullition. The vulgar notion that the water is hotter at this term than when it boils, is without any foundation.

EFFERVESCENCE is a ſudden agitation, ariſing in certain bodies upon mixing them together; this agitation moſt commonly generates heat.

ELASTICITY, or ſpringineſs, is that property of bodies, by which they reſtore themſelves to their former figure, after any preſſure or diſtenſion.

EXPANSION is the ſwelling or encreaſe of the bulk of bodies, from heat, or any other cauſe.

EXTRACT conſiſts of the parts of a body ſeparated from the reſt, by cold or hot water, and, upon the evaporation of the fluid, remaining in the veſſel.

FERMENTATION is a ſenſible internal motion of the particles of a mixture: by the continuance of this motion, the particles are gradually removed from their former ſituation, and, after ſome viſible ſeparation, joined together again in a different order and arrangement, ſo as to conſtitute a new compound. No liquors are capable of inebriating, except thoſe that have been fermented.

FIXED BODIES are thoſe, which, conſiſting of groſſer parts, cohering by a ſtrong attraction, and by that means leſs ſuſceptible of agitation, can, neither be ſeparated nor raiſed, without a ſtrong heat, or perhaps not without fermentation.

FIRE is only known by its properties, of which the chief are to penetrate and dilate all ſolid and fluid bodies.

FREEZING POINT is the degree of cold, at which water begins to be formed into ice, which according to Farenheit's ſcale is expreſſed by 32.

FOXED is a technical term, uſed by brewers, to indicate beers in a putrid ſtate.

GUMS are concreted vegetable juices, which tranſude thro' the bark of certain trees and harden upon the ſurface, they eaſily diſſolve in water, and by that means diſtinguiſh themſelves from balſams or reſins.

HERMETICALLY SEALED is a particular way of ſtopping the mouth of veſſels, ſo cloſe, that the moſt ſubtil ſpirit cannot fly out, which is done by heating the neck of the bottles, till it is juſt ready to melt, and then with a pair of hot pinchers by twiſting it cloſe together.

HOMOGENEOUS is an appellation given to ſuch parts or ſubjects, which are ſimilar or of the ſame nature and properties.

ISINGLASS is a preparation from a fiſh called huſo, ſomewhat bigger than the ſturgeon; a ſolution of which in ſtale beer is uſed, to fine or precipitate other beers: it is imported from *Ruſſia* by the *Dutch*, and from them to us.

LIGHT conſiſts of particles of matter inconceivably ſmall, capable of exciting in us the ſenſation of colours, by being reflected from every point of the ſurface of luminous bodies; but, notwithſtanding they are ſo exceeding ſmall, Sir Iſaac Newton has found means to divide a ſingle ray into ſeven diſtinct parts, viz. red, orange, yellow, green, blue, indigo, and violet.

MALT, in general, is any ſort of grain, firſt germinated, and then dried: that generally uſed is made of barley, which experience has found to be the fitteſt for this purpoſe.

MEDIUM is that ſpace, through which a body in motion paſſes: air is the medium, through which the bodies near the earth move; water is the medium wherein fiſhes live, and glaſs affords a medium or a free paſſage to light.

This term is alſo made uſe of, to expreſs the mean of two numbers, and ſometimes the middle between ſeveral quantities.

MUSTS are the unfermented juices of grapes, or of any other vegetable ſubſtances.

MENSTRUUM is any fluid, which is capable of interpoſing it's parts between thoſe of other bodies, and in this manner either diſſolves them perfectly, or extracts ſome part of them.

OIL is an unctuous, inflammable ſubſtance, drawn from ſeveral animal and vegetable ſubſtances.

PRECIPITATION. Iſinglaſs diſſolved becomes a glutinous and heavy body; this put into malt liquors intended to be fined carries down, by its weight, all thoſe ſwimming particles, which prevent its tranſparency; and this act is called fining, or precipitation.

RESINS, or balſams, are the oils of vegetables inſpiſſated and combined with a proportion of the acid ſalts; as well as they mix with any ſpirituous liquor, as little are they ſoluble in water, but they become ſo, either by the intervention of gums or ſoaps, or by the attenuating virtue of fermentation.

SALTS are ſubſtances ſharp and pungent, which readily diſſolve in water, and from thence, by evaporation, cryſtalliſe and appear in a ſolid form. They eaſily unite together, and form different compounds. Thus ſalts, compoſed of acids and alkalies, partake of both, and are called neutral.

SETT: a griſt of malt is by brewers ſaid to be ſett, when, inſtead of ſeparating for extraction, it runs in clods, encreaſes in heat, and coagulates. The cauſe of this accident is the over quantity of fire in the water applied to the firſt extraction. The air included in the griſt, which is a principal agent in extraction, being thereby expelled, the maſs remains inert, and its parts, adhering too cloſely together, are with difficulty ſeparated. Though an immediate application of more cold water to the griſt is the only remedy, yet in general, as the coheſion is ſpeedy and ſtrong, it ſeldom takes effect. New malts, which have not yet loſt the heat they received from the kiln, are moſt apt to lead the brewer into this error.

SUGAR or ſaccharine ſalts, are properly thoſe, that come from the ſugar canes; many plants, fruits and grains give ſweet juices reducible to the ſame form, and ſuppoſed to be acids ſmoothed over with oils; all vegetable ſweets are capable of fermenting ſpontaneouſly when crude; if boiled, they require an addition of yeaſt to make them perform that act. Malt, or its extracts, have all the properties of ſaccharine ſalts.

SULPHUR. Though by ſulphur is commonly underſtood the mineral ſubſtance called brimſtone, yet in chemiſtry it is frequently uſed to ſignify in general any oily ſubſtance, inflammable by fire, and, without ſome ſaline addition, indiſſoluble in water.

SOAP or SAPONACEOUS JUICES. Common ſoap is made of oil mixed with alkaline ſalts: this mixture cauſes a froth on being agitated in water. The oils of vegetables are, in ſome degree, mixed with their ſalts; and, according to the nature of theſe ſalts, appear either reſinous or ſaponaceous, that is, ſoluble or indiſſoluble in water. Sugar is a kind of ſoap, rendering oil miſcible with water; and therefore all the bodies, from which ſaccharine ſalts may be extracted, are truly ſaponaceous.

VEGETABLE is a term applied to plants, conſidered as capable of growth, having veſſels and parts for this purpoſe, but generally ſuppoſed to have no ſenſation.

VINEGAR is an acid penetrating liquor, prepared from wine, beer, cyder, or a muſt, which has been fermented as far as it was capable.

VITRIOL is, in general, a metalline ſubſtance combined with the ſtrongeſt acid ſalt known. This acid, being ſeparated from the metal, differs in nothing from that which is extracted from alum, and from brimſtone. It is improperly called ſpirit of vitriol, when

when diluted with water, and, with as little propriety, oil, when free from it. This is commonly uſed in the brewery, in order to precipitate or fine brown beers, that are ſtubborn or nearly cloudy. Twelve ounces of this oil is a quantity many times put into a ſingle butt of beer, though the uſe thereof had much better be wholly baniſhed from the trade.

VOLATILE BODIES are thoſe, which, either from their ſmallneſs or their form, do not cohere very ſtrongly together, and being moſt ſuſceptible of thoſe agitations, which keep liquors in a fluid ſtate, are moſt eaſily ſeparated and rarified into vapour, with a gentle heat, and on the contrary condenſed and brought down with cold.

WINE is a briſk, agreeable, ſpirituous, fluid cordial, drawn from fermented vegetable bodies. In this ſenſe beers and ales may be called, and really are, barley wines.

WORTS are the unfermented extracts of malt.

YEAST is both the flowers and lees of a fermented wort, the former of theſe being elaſtic air enveloped in a ſubject leſs ſtrong and leſs conſiſtent than the latter.

PRINCIPLES OF THE THEORY of BREWING.

SECTION I.

Of FIRE.

THOUGH fire is the chief cauſe, and principle of almoſt every change in bodies; and though perſons untaught in chemiſtry imagine, that they underſtand its nature, yet certain it is, that there is nothing more incomprehenſible, or that eludes ſo much our niceſt reſearch. The ſenſes are very inadequate judges of it; the eye may be deceived and ſuppoſe no fire, in a bar of iron, becauſe it does not appear red, though at the ſame time it may contain enough to generate pain: the touch is equally unfaithful, for a body containing numberleſs particles of heat, will feel cold, if it is much more ſo than ourſelves.

The great and fundamental difference among philoſophers, in reſpect to the nature of fire, is, whether it be originally ſuch, formed by the Creator himſelf at the beginning of things; or whether it be mechanically producible in bodies, by ſome alteration produced in the particles thereof. It is certain, that heat may be generated in any body by attrition; but whether it exiſted there before, or was cauſed immediately by the motion, is a matter of no great import to the art of brewing; for the effects, with which we are alone concerned, are the ſame.

Fire expands all bodies, both ſolid and fluid. If an iron rod, juſt capable of paſſing through a ring of the ſame metal, is heated red-hot, it will be encreaſed in length, and ſo much ſwelled as not to be able to paſs through the ring, as before *: if a fluid is put into a bellied glaſs, with a long ſlender neck, and properly marked, the fluid, by being heated, will manifeſtly riſe to a conſiderable height.

The expanſion of fluids, by heat, is different, in different fluids; with ſome exceptions, it may be ſaid to be in proportion to their denſity. Pure rain water, gradually heated to ebullition, is expanded one 84th part of its bulk, ſo that 85 gallons of

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* There is a very ſingular exception in regard to iron itſelf in this reſpect. It is only a certain degree of heat that expands this metal; (and that much leſs than any other either more or leſs denſe;) when melted, it occupies a leſs ſpace than when in a ſolid form. This ought to caution us againſt general rules, by which nature appears by no means to be bound. See *Mem. de l'Acad. des Scienc.* p. 273.

boiling

boiling water will, when cold, meaſure no more than 84; and 85 gallons of boiling wort will not yield ſo much, becauſe worts contain many oily particles, which, though leſs denſe than water, have the property of being more expanſible: hence we ſee the reaſon why a copper, containing a given number of barrels of boiling wort, will not produce the ſame number of barrels of beer when cold.

Bodies are weakned or looſened in their texture by fire: the hardeſt, by an encreaſed degree of heat, will liquify and run; and vegetables are reſolved and ſeparated by it into their conſtituent parts. It muſt be owned that vegetables ſeem at firſt, on being expoſed to the fire, to become rigid or ſtiff; but this is owing to the evaporation of the aqueous particles, which prevented a cloſer adheſion of the ſolid matter. It is only in this manner that fire ſtrengthens ſome bodies that were before weak.

That the texture of bodies ſhould be looſened by fire, ſeems a conſequence of expanſion; for a body cannot be expanded but by its particles receding farther from one another; and if theſe be not able to regain the ſituation they had when cold, the body will remain looſer in its texture, than before it ſuffered the action of fire. This is the caſe of barley when malted.

Fire may be conveyed through moſt bodies, as air, water, aſhes, ſand, &c. The effect ſeems to be different according to the different conveyances. A difference appears between boiling and roaſting, yet they anſwer the ſame purpoſe, that of of preſerving the ſubject; and this, in proportion to the degree of heat it has ſuffered. Malts, the more they are dried, the longer are they capable of maintaining themſelves in a ſound ſtate, and the liquor brewed with them will, in proportion to their dryneſs, keep the longer ſound. The hotter the water is applied to malt, provided its heat doth not exceed the higheſt extracting degree, the more durable and ſounder will the extract be.

The laſt conſideration of fire or heat, that relates to brewing, is the knowledge of its different degrees, and how to regulate them. Till of late, chemiſts, and all others, were much to ſeek in this reſpect; they diſtinguiſhed more or leſs fire in a very vague and indeterminate manner, as the firſt, ſecond, third, and fourth degree of heat, meaning no preciſe heat, or heat meaſured by any ſtandard; but, by the invention of the thermometer, we are enabled to regulate our fires with the utmoſt preciſion. Thermometers are formed on different ſcales; and therefore when any degree of heat is mentioned, in order to avoid confuſion, the ſcale made uſe of ſhould be indicated. I have conſtantly uſed Fahrenheit's, as it is the moſt perfect and the moſt generally received. According to this inſtrument, 32 degrees is the freezing point, or where water firſt begins to harden into ice; from 32 to 90 degrees are the limits of vegetation, according to the different plants that receive thoſe or the intermediate heats. The 40th degree is marked by Boerhaave as the firſt fermentable heat, and the 80th as the laſt: 47 degrees I have found to be generally the medium

medium heat of London throughout the year in the ſhade; 98 degrees is ſaid to be that of our bodies when in health, as from 105 to 112 are its degrees when in a fever. At 175 degrees the pureſt and higheſt-rectified ſpirits of wine boil, and at this degree I have found well grown malts to charr, at 212 degrees water boils, at 600 degrees quickſilver and oil of vitriol. Gold, ſilver, iron, and moſt other metals in fuſion exceed this heat; greater ſtill than any of theſe is the heat in the focus of the burning lens of Tſchirnhauſen, or of the concave mirror made by Villette; they are ſaid to volatiliſe metals and vitrify bricks. Thus far experiments have reached; but how much more, or how much leſs, the power of this element extends, will probably be for ever unknown.

SECTION II.

Of AIR.

NONE of the operations, either of nature or art, can be carried on without the action or aſſiſtance of air. It is a principal agent in fermentation; and therefore brewers ought to be well acquainted at leaſt with its principal properties and powers.

By air we mean a fluid, ſcarcely perceptible to our ſenſes, and diſcovering itſelf only by the reſiſtance it makes to bodies. We find it every where incumbent on the ſurface of the globe, riſing

riſing to a conſiderable height, and commonly known by the name of atmoſphere. The weight of air is to that of water as 1 to 850, and its gravitating force equal to that of a column of water of 33 feet high; ſo that an area of one foot ſquare receives, from air, a preſſure equal to 2080 pounds weight.

Elaſticity is a property belonging to only one of the four elements, namely, air, and it varies in proportion to the compreſſing weights. We ſcarcely find this element, (any more than the others,) in a pure ſtate: one thouſandth part of common air, ſays Boerhaave, conſiſts of aqueous, ſpirituous, oily, ſaline, and other particles ſcattered through it. Theſe are not, or but little compreſſible, and in general prevent fermentation: conſequently where the air is pureſt, fermentation is beſt carried on. The ſame author ſuſpects, that the ultimate particles of air cohere together, ſo as not eaſily to inſinuate themſelves into the ſmalleſt pores, either of ſolids or fluids. Hence thoſe acquainted with brewing eaſily account, why very hot water, which forces ſtrong and pinguious particles from malt, forms at the ſame time extracts unfavourable for fermentation, as oils are an obſtruction to the free entrance of air; and from an analogous reaſon, why in weak extracts fermentation is ſo much accelerated, that the whole ſoon becomes ſour.

Air, like other bodies, is expanded and rarified by heat, and exerts its elaſticity in proportion to the number of degrees of fire it has received; the hotter therefore the ſeaſon is, the more active and violent will the fermentation be.

Air abounds with water, and is perpetually penetrating and inſinuating itſelf into every thing capable of receiving it. Its weight, or gravitating force, muſt neceſſarily produce numberleſs effects. The water contained in the air is rendered more active by its motion; hence the ſaline, gummous and ſaponaceous particles it meets with are looſened in their texture, and, in ſome degree, diſſolved. As principles like theſe are the chief conſtituent parts of malt, the reaſon is obvious why thoſe that are old, or have lain a proper time expoſed to the influence of the air, diſſolve more readily, or, in other words, yield a more copious extract than others.

All bodies in a paſſive ſtate, remaining a ſufficient time in the ſame place, become of the ſame degree of heat with the air itſelf. On this account the water, lying in the backs uſed by brewers, is nearly of the ſame degree of heat as the thermometer ſhews the open air in the ſhade to be. When this inſtrument indicates a cold below the freezing point, or 32 degrees, if the water does not then become ice, the reaſon is, becauſe it has not been expoſed long enough to be thoroughly affected by ſuch a cold. For water does not immediately aſſume the ſame degree of temperature with the air, principally on account of its denſity, alſo from its being pumped out of deep and hot wells, from its being kept in motion, and from many other incidents. Under theſe circumſtances, no great error can ariſe to eſtimate its heat equal to 33 degrees.

Air is not eaſily expelled from bodies, either ſolid or fluid. Water requires two hours boiling to be diſcharged of the greateſt part of it's air. That it may be thus expelled by heat appears from this; water, if boiled the ſpace abovementioned, inſtead of having any air bubbles when it is froze, as ice commonly has, becomes a ſolid maſs like cryſtal.

As air joined to water contributes ſo powerfully to render that fluid more active, that water which has endured fire the leaſt time, provided it be hot enough, will make the ſtrongeſt extracts.

Worts or muſts, as they contain great quantities of ſalts and oils, require a greater degree of heat to make them boil: conſequently more air is expelled from boiling worts, than from boiling water in the ſame time; and as air doth not inſtantaneouſly re-enter thoſe bodies, when cold, they would never ferment of themſelves. Were it not for the ſubſtitute of yeaſt, to ſupply the deficiency of air loſt by boiling, they would fox or putrify, for want of that internal elaſtic air, which is abſolutely neceſſary to fermentation.

Though there is air in every fluid, it differs in quantity in different fluids; ſo that no rule can be laid down for the quantity of air, which worts ſhould contain. Probably the quantity, ſufficient to ſaturate one ſort, will not be an adequate proportion for another.

Air in this manner encompaſſes, is in contact with, confines, and compreſſes all bodies. It inſinuates itſelf into their penetrable paſſages, exerts all its power either on ſolids, or fluids, and finding in bodies ſome elements to which it has a tendency, unites with them. By its weight and perpetual motion, it ſtrongly agitates thoſe parts of the bodies in which it is contained, rubs, and intermixes them intimately together. By diſuniting ſome, and joining others, it produces very ſingular effects, not eaſily accompliſhed by any other means. That this element has ſuch ſurpriſing powers is evident from the following experiment. “Fermentable parts duly prepared and diſpoſed in the vacuum of Mr. Boyle's air-pump will not ferment, though acted upon by a proper heat; but, diſcharging their air, remain unchanged.

SECTION III.

Of WATER.

AS water is perpetually an object of our ſenſes, and made uſe of for moſt of the purpoſes of life, it might be imagined that the nature of this element was perfectly underſtood: but they who have enquired into it with the greateſt care, find it very difficult to form a right notion of it. One reaſon of this difficulty is, that water is not eaſily ſeparated from other bodies, or other bodies from water. Hartſhorn, by being long dried, reſiſts a file more than iron; yet, on diſtillation it yields much water. I have already obſerved, that air is intimately mixed, with, and poſſibly never intirely ſeparated from it, but in a *vacuum*; how is it poſſible then ever to obtain water perfectly pure?

In its moſt perfect ſtate, we underſtand it to be a liquor very fluid, inodorous, inſipid, pellucid, and colourleſs, which, in a certain degree of cold, freezes into a brittle, hard, glaſſy ice.

Lightneſs is reckoned a perfection in water, that, which weighs leſs being in general the pureſt. Hence the great difficulty of determining the ſtandard weight it ſhould have. Fountain, river, or well waters, by their admixture with ſaline, earthly, ſulphureous, and vitriolic ſubſtances, are rendered much heavier

heavier than in their natural ſtate; on the other hand an increaſe of heat, or an addition of air, by varying the expanſion, diminiſhes the weight of water. A pint of rain-water, ſuppoſed to be the pureſt, is ſaid to weigh 15 ounces, 1 drachm, and 50 grains; but for the reaſons juſt now mentioned, this muſt differ in proportion as the ſeaſons of the year do from each other.

Another property of water, which it has in common with other liquors, is its fluidity, which is ſo great that a very ſmall degree of heat, above the freezing point, makes it evaporate. Few brewers, I believe, have examined how great a proportion of the quantity of water, uſed in brewing, is loſt by evaporation. The purer it is, the more readily it evaporates. Sea-water, which is ſuppoſed to contain one fortieth part of ſalt, more forcibly reſiſts the power of fire, and waſtes much leſs, than that which is pure. Notwithſtanding this, as fire ultimately divides moſt, if not all, bodies, and ſeparates the denſe parts from the rare, a ſtrong continued ebullition may be a means of freeing, in ſome meaſure, the muſt from impurities, if any ſuch were in the water.

The ultimate particles of this element, Boerhaave believed to be much leſs than thoſe of air, as water paſſes through the pores and interſtices of wood, which never tranſmit the leaſt elaſtic air; nor is there, ſays he, any known fluid, (fire excepted, which forces itſelf through every ſubject) whoſe parts are more penetrating than thoſe of water. Yet as water is not an univerſal diſſolver, there are veſſels which will contain it, though they will let paſs even the thick ſyrup of ſugar, for ſugar makes its way by diſſolving the tenacious and oily ſubſtance of the wood; which water cannot do.

Water, when fully ſaturated by fire, is ſaid to boil, and by the impulſe of that element, comes under a ſtrong ebullition. Juſt before this violent agitation takes place, I have already obſerved, that it occupies one eighty fifth more ſpace than when cold: ſo that a brewer who would be exact, when he intends to reduce his liquor to a certain degree of heat, muſt allow for this expanſion, abating therefrom the quantity of ſteam exhaled.

As water, by boiling, may be ſaid to be filled or ſaturated with as much fire as it can contain, ſo may it be with any other ſubſtance capable of being diſſolved in it. But though it will diſſolve only a given quantity of any particular ſubſtance, it may at the ſame time take in a certain proportion of ſome other. Four ounces of pure rain water will melt but one ounce of common ſalt, and after taking this as the utmoſt of its quantity, it will ſtill receive two ſcruples of another kind of ſalt, viz. nitre. In the ſame manner the ſtrongeſt extract of malt is ſtill capable of receiving the properties belonging to the hops: but in a limited proportion. This appears from the thin bitter pellicle, that often ſwims on the ſurface of the firſt wort of brown beers, which commonly are overcharged with hops, by putting the whole quantity of them at firſt therein; the water not being capable of ſuſpending all that the heat diſſolves, it no ſooner cools but theſe parts riſe on the top. This may ſerve as a hint to prevent this error, by ſuffering the firſt wort to have no more hops boiled therein than what it can ſuſtain; and as this muſt be different in proportion to the heat of the extracts and quantity of water uſed, two or three experiments are neceſſary to indicate the due proportion for the ſeveral ſorts of drink. This however ſhould always be extended to the utmoſt; for the firſt wort, from its nature and conſtituent parts, ſtands moſt in need of the preſervative quality imparted by the hops.

Water acts very differently, as a menſtruum, according to the quantity of fire it contains: conſequently its heat is a point of the utmoſt importance with regard to brewing, and muſt be properly varied according to the dryneſs and nature of the malt; as it is applied either in the firſt or laſt maſhes, and in proportion alſo to the time the beer is intended to be kept. Theſe ends can, in my opinion, be obtained to a degree of numerical certitude.

Nutrition cannot be carried on without water, though likely water itſelf is not the matter of nouriſhment, but only the vehicle.

Water is as neceſſary to fermentation as heat or air. The farmer, who ſtacks his hay or corn before it is thoroughly dried, ſoon experiences the terrible effects of too much moiſture, or water, reſiding therein: all vegetables therefore intended to be long kept, ought to be well dried. The brewer ſhould carefully avoid purchaſing hops that are ſlack bagged, or kept in a moiſt place, or malt that has been ſprinkled with water ſoon after it was taken from the kiln. By means of the moiſture, a fermentation begins, which for want of a ſufficient quantity of air, is ſoon ſtopped; but the heat thereby generated remaining, every ſeed begins to grow, and forms a moſs which dies, and leaves a putrid muſty taſte behind, always prevailing, more or leſs, in beer made from ſuch grain.

That water is by no means an univerſal ſolvent, as ſome people have believed, has been already obſerved. It certainly does not act as ſuch on metals, gems, ſtones, and many other ſubſtances: it is not in itſelf capable of diſſolving oils, but is miſcible with highly rectified ſpirits of wine, or alcohol, which is the pureſt vegetable oil in nature. All ſaponaceous bodies, whether artificial or natural, fixed or volatile, readily melt therein; and as many parts of the malt are diſſoluble in it, they muſt either be, or become by heat, of the nature of ſoap, that is, equally miſcible with oils and water.

When a ſaponaceous ſubſtance is diſſolved in water, it lathers, froths, and bears a head; hence, in extracts of malt, we find theſe ſigns in the underback. Weak and ſlack liquors, which contain the ſalts of the malt without a ſufficient quantity of the oils, yield no froth, and generally let part of the griſt fall undiſſolved in a whitiſh flour. Somewhat like this happens, when the water for the extract is over-heated, for then as more oils are extracted than are ſufficient to ballance the ſalts, the extract

comes

comes down as before, with little or no froth or head, but without depoſiting any flour in the underback. Should the heat of the water be increaſed beyond this laſt mentioned degree, ſo as to impede the action of the air neceſſary to extract with, that error would take place which is termed by brewers *ſetting the goods*: inſtead of a good extract, the whole runs into inſeparable clods or lumps, from whence the griſt is ſeldom or never recovered.

This might be a proper place to obſerve the difference between rain, ſpring, river, and pond waters; but as the art of brewing is very little affected by the difference of waters, if they be equally ſoft, but rather depends on the due regulation of heat, and as ſoft waters are found in moſt places where brewing is neceſſary, it is evident, that any ſort of beer or ale may be brewed with equal ſucceſs, where malt and hops can be procured proper for the reſpective purpoſes. If hitherto prejudices and intereſt have appropriated to ſome places a reputation for particular ſort of drinks, it has aroſe from hence: the principles of the art being totally unknown, the event depended on experience only, and lucky combinations were more frequent where the greateſt practice was. Thus for want of knowing the true reaſon of the different properties obſerved in the ſeveral drinks, the cauſe of their excellencies or defects was ignorantly attributed to the water made uſe of, and the inhabitants of particular places ſoon found an advantage, in availing themſelves of this local reputation. But juſt and true principles, followed by as juſt a practice, muſt render the art more univerſal, and add dignity to the profeſſion, by eſtabliſhing the merit of our barley wines on knowledge, not on prejudice. This truth would appear in a ſtronger light, were I to extend the obſervations farther on this element; but as the ſubject of water has been fully treated of by Boerhaave, Shaw, and Hales, it would be tedious to add any thing more upon it.

* * *

SECT. IV.

SECTION IV.

Of EARTH.

REGULARITY requires that ſome notice ſhould be taken of this element. The great writer on chemiſtry, ſo often mentioned, defines it to be a ſimple, hard, friable, foſſil body, fixed in the fire, but not melting in it, nor diſſoluble in water, air, alcohol or oil. Theſe are the characters of pure earth, which, no more than any of the other elements, comes within our reach, free from admixture. Though it is one of the component parts of all vegetables, yet as deſignedly it is never made uſe of in brewing, except ſometimes for the purpoſe of precipitation, it is unneceſſary to ſay any thing more upon it: whoever deſires to be farther informed concerning its properties may conſult all, or any of the authors before-mentioned.

SECTION V.

Of the THERMOMETER.

THIS inſtrument is deſigned for meaſuring the increaſe or decreaſe of heat. By doing it numerically, it fixes in our minds the quantity of fire, which any body is at any time impregnated with. If different bodies are brought together, though each poſſeſſes a different degree of heat, it teaches us to diſcover what degree of heat they will arrive at when thoroughly mixed, ſuppoſing efferveſcence to produce no alteration in their heat.

The inventor of this admirable inſtrument is not certainly known, though the merit of the diſcovery has been aſcribed to ſeveral great men, of different nations, in order to do them, and their countries honour. It came to us from Italy, about the beginning of the ſixteenth century. The firſt inventors were far from bringing this inſtrument to its preſent degree of perfection. As it was not then hermetically ſealed, the contained fluid was, at the ſame time, influenceed by the weight of the air, and by the expanſion of heat. The academy of Florence added this improvement to their thermometers, which ſoon made them more generally received; but as the higheſt degree of heat of the inſtrument, conſtructed by the Florentine gentlemen, was fixed by the action of the ſtrongeſt rays of the ſun in their country, this vague determination, varying in almoſt every place, and the want of a fixed and univerſal ſcale, rendered all the obſervations, made with ſuch thermometers, of little uſe to us. Boyle

Boyle, Halley, Newton, and ſeveral other great men thought this inſtrument highly worthy of their attention. They endeavoured to fix two invariable points, to reckon from, and by means of theſe, to eſtabliſh a proper diviſion. Monſieur Amontons is ſaid to have firſt made uſe of the degree of boiling water, for graduating his mercurial thermometers. Farenheit indeed found, that the preſſure of the air in its greateſt latitude, would cauſe a variation of ſix degrees in that point, he therefore concluded, that a thermometer made at the time when the air is in its middle ſtate, might be ſufficiently exact for almoſt every purpoſe. Long before this degree of heat, viz. that of boiling water was perfectly ſettled, many means were propoſed to determine another. The degree of temperature in a deep cave or cellar, where no external air could reach, was imagined by many, a proper one; but what that degree truly was, and whether it was fixed and univerſal, was found too difficult to be determined. At laſt the freezing point of water was thought of, and though ſome doubts aroſe with Dr. Halley, and others, whether water conſtantly froze at the ſame degree of cold, Dr. Martine has ſince, by ſeveral experiments, proved this to be beyond all doubt, and this degree is now received for as fixed a point, as that of boiling water.

Theſe two degrees being thus determined, the next buſineſs was the diviſion of the intermediate ſpace on ſome ſcale, that could be generally received. Though there ſeemed to be no difficulty in this, philoſophers of different countries have not been uniform in their determinations, and that which is uſed in the thermometer now the moſt common, and in other reſpects the moſt perfect, is far from being the ſimpleſt.

The liquid wherewith thermometers were to be filled, became the object of another enquiry. Sir Iſaac Newton employed, for this purpoſe, linſeed oil: but this being an unctuous body, is apt to adhere to the ſides of the glaſs, and when ſuddenly affected by cold, for want of the parts which thus ſtick to the ſides, does not ſhew the true degree.

Tinged water was employed by others; but this freezing, when Farenheit's thermometer points 32 degrees, and boiling, when it riſes to 212, was, from thence, incapable of denoting any more intenſe cold or heat.

Spirit of wine, which endures much cold without ſtagnating, was next made uſe of; but this liquor being ſuſceptible of no greater degree of heat, than that, which in Farenheit's ſcale is expreſſed by 175, was not capable of being uſed, where boiling water was concerned.

At laſt the propereſt fluid, to anſwer every purpoſe, was found to be mercury. This has never been known to freeze *, and will not boil under a heat of 600 degrees; beſides, it is free from every inconveniency attending other liquors.

As the inſtrument is entirely founded on this, that heat or fire expands all bodies, as cold condenſes them, there was a neceſſity of employing a fluid eaſy to be dilated. A

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* Lately indeed by ſuch intenſe cold, as can only be procured with the greateſt ari, and in the coldeſt climates, mercury is ſaid to have been ſtagnated or fixed.

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quantity of it is ſeated in one part or reſervoir. This being expanded by heat, is puſhed forward into a fine tube, or capillary cylinder, ſo ſmall, that the motion of the fluid in it is ſpeedy and perceptible. Some thermometers have been conſtructed with their reſervoir compoſed of a larger cylinder: now they are generally made globular. The ſmaller the bulb is, the ſooner it is heated through, and the finer and ſmaller the tube is, the greater will be the length of it, and the more diſtinct the degrees. It is ſcarcely poſſible that any glaſs cylinder, ſo very ſmall, ſhould be perfectly regular; the quickſilver, during the expanſion, paſſing through ſome parts of the tube wider than others, the degrees will be ſhorter in the firſt caſe, and longer in the latter. If the diviſions therefore are made equal between the boiling and freezing points, a thermometer conſiſting of ſuch a tube cannot be true. To rectify this inconveniency, the ingenious Mr. Bird of London, puts into the tube about the length of an inch of mercury; and meaſuring, with a pair of compaſſes, the exact length of this body of quickſilver in one place, he moves it from one end to the other, carefully obſerving, in the ſeveral places, how much it increaſes or diminiſhes in length, and thereby aſcertains where, and how much, the degrees are to be varied. By this contrivance his thermometers are perfectly accurate, and exceed all that were ever made before.

I ſhall not trouble my reader with the number of calculations that have been made, to expreſs the quantity of particles

cles of the liquor contained in the bulb, in order to determine how much it is dilated: this Dr. Martine ſeems to think a more curious than uſeful enquiry. It is ſufficient for our purpoſe to know, how the beſt thermometers ought to be conſtructed: they who have leiſure and inclination, may be agreeably entertained by the author laſt cited.

By obſerving the riſe of the mercury in the thermometer, during any given time, as, for inſtance, during the time of the day, we aſcertain the degree and value of the heat of every part of the day, and may hereafter nearly fix the medium of the whole time. By repeated experiments, it appears, that the medium heat of any day is uſually indicated at eight o'clock in the morning, if the inſtrument is placed in the ſhade, in a northern ſituation, and out of the reach of any accidental heat.

Though water is not ſo readily affected as air by heat and cold, yet as all bodies, that are long expoſed in the ſame place, become of the ſame degree of heat with the air itſelf, no great error can ariſe from eſtimating water, in general, to be of the ſame heat as the air, at eight o'clock in the morning, in the ſhade.

The thermometer teaches us, that the heat of boiling water is equal to 212 degrees, and by calculation we may know what quantity of cold water is neceſſary to bring it to any degree we chooſe; ſo that though the inſtrument cannot be uſed in large veſſels, where the water is heating, yet

yet, by the power of numbers, the heat may be aſcertained with the greateſt accuracy. The rule is this: multiply 212, the heat of boiling water, by the number of barrels of water thus heated, (ſuppoſe 22) and the number of barrels of cold water to be added to the former, (ſuppoſe 10,) by the heat of the air at eight o'clock, (ſuppoſe 50,) add theſe two products together, and divide by the ſum of the barrels, the quotient ſhews the degree of heat of the water, mixed together.

212 heat of boiling water — 50 deg. heat of air at 8.
22 barrels to be made to boil — 10 barrels of cold water
424 — 500
424
22 — 4664
10 — 500
ſum 32 of barrels)5164($161+\frac{1}{3}$ degrees, will be the heat of the water, when mixed together.
32
196
192
44
32
12

The calculation may be extended to three or more bodies, provided they be brought to the ſame denomination. Suppoſe 32 barrels of water to be uſed where there is a griſt

griſt of 20 quarters of malt, if theſe 20 quarters of malt are of a volume or bulk equal to 11 barrels of water, and the malt by having lain expoſed to the air, is of the ſame degree of heat with the air, in order to know the heat of the maſh, the calculation muſt be thus continued.

$161+\frac{1}{3}$	$161+\frac{1}{3}$ heat of water	50 degrees of heat of malt.
	32 barrels of water	11 barrels, volume of malt.
	333	550
	483	
32 water	5163	
11 malt	550	
43	) 5713 (132 degrees, which will be the heat of the maſh.	
	43	
	141	
	129	
	123	
	86	
	37	

We ſhall meet hereafter with ſome incidents, which occaſion a difference in the calculation, but it will be time enough to mention them in the practical part.

The thermometer by ſhewing the different degrees of heat of each part of the year, informs us at the ſame time, how neceſſary it is, that the extracts of ſmall beer ſhould vary in proportion to ſuch heats, as alſo what quantity of hops ought to be uſed at different times; how much yeaſt is requiſite, at each ſtated ſeaſon, to carry on a due fermentation; and what variation is to be made in the length of time, that worts ought to boil. Indeed without this knowledge, beers, though brewed in their due ſeaſon, cannot be regularly fermented, and whenever they prove good, ſo often may it be ſaid, that fortune was on the brewer's ſide.

Beers are depoſited in cellars, to prevent their being affected by the variations of heat and cold in the external air. By means of the thermometer, may be determined the heat of theſe cellars, the temper the liquor is to be kept in, and whether it will ſooner or later come forward.

The brewing ſeaſon, and the reaſon why ſuch a ſeaſon is fitteſt for brewing, can only be diſcovered by this inſtrùment. It points out likewiſe our chance for ſucceſs, ſometimes in the hotteſt months.

As all vegetable fermentation is carried on in heats, between ſome ſettled points, we are, by this inſtrument, taught to put our worts together at ſuch a temperature, that they ſhall neither be evaporated by too great a heat, nor retarded by too much cold.

If curioſity ſhould lead us ſo far, we might likewiſe determine, by it, the particular ſtrength of each wort, or of every maſh; for if water boils at 212 degrees, oil at 600, and worts be a compoſition of water, oil and ſalt, the more the heat of a boiling wort exceeds that of boiling water, the more oils and ſalts muſt it contain, or the ſtronger is the wort.

A given quantity of hops, boiled in a given quantity of water, muſt have a ſimilar effect, conſequently the intrinſic value of this vegetable may, in the ſame manner, be aſcertained.

The more the malts are dried, the more do they alter in color, from a white to a light yellow, next to an amber, farther on to a brown, until at laſt the color becomes ſpeckled with black; in which ſtate we frequently ſee it. If more fire or heat is continued, the grain will at laſt charr, and become intirely black. By obſerving the degrees of heat neceſſary to produce theſe alterations, we may, by the mere inſpection of the malt, know with what degree of fire it has been dried; and fixing upon that which beſt ſuits our purpoſe direct, with the greateſt accuracy, the heat of the firſt maſh, a thing of the utmoſt conſequence to the right management of the proceſs of brewing.

If I had not already ſaid enough to convince the brewer of the utility of this inſtrument, how curious he ought to be in the choice, and how well acquainted with the uſe of it, I would tell him, that the heat gained by the effervеſcing of malt is to be determined by it alone; that the heat

heat loſt by maſhing, by the water in its paſſage from the copper to the ton, or by the extract coming down into the underback, can be found by no other means; and above all, that there is no other way to know with certainty the heat of every extraction.

I know very well, that good beer was made before the thermometer was known, and ſtill is, by many, who are intirely ignorant of it; but this, if not wholly the effect of chance, cannot be ſaid to be very diſtant from it. They who carry on this proceſs, unaſſiſted by principles and the uſe of the thermometer, cannot but confeſs, that they are frequently unſucceſsful, whereas did they carefully and with knowledge apply this inſtrument, they certainly never would be diſappointed. It is equally true, that the brewing art has, for a long ſpace of time, been governed by tradition alone, and this but ill conveyed; if lucky combinations have ſometimes flattered the beſt practitioners, faulty drinks have as often made them feel the want of certain and well eſtabliſhed principles. It is juſt as abſurd for a brewer to refuſe the uſe of the thermometer, as it would be for an architect to throw away his rule, as unſerviceable, becauſe the firſt houſe, probably, was built without one.

SECTION VI.

Of the VINE, its FRUITS and JUICES.

IT is now time to conſider more diſtinctly the object we have in view, and the propereſt means to attain it.

Any fermented liquor, that in diſtillation yields an inflammable ſpirit miſcible with water, may be called wine, whatever vegetable matter it is produced from. Now as beer and ales contain a ſpirit exactly anſwerable to this definition, brewing may juſtly be called the art of making wines from corn. Thoſe indeed, which are the produce of the grape, have a particular claim to that name, either becauſe they are probably the moſt ancient and the moſt univerſal, or that a great part of their previous preparation is owing to the care of nature itſelf. By obſerving the agents ſhe employs, and the circumſtances under which ſhe acts, we ſhall find ourſelves enabled to follow her ſteps, and to imitate her operations.

Moſt grapes contain juices, which, when fermented, become in time as light and pellucid as water, and are poſſeſſed of fine ſpirituous parts ſufficient to cheriſh, comfort, and even inebriate. But theſe properties of vinoſity are not obſerved

obſerved equally in the fruits of all vines; ſome of them are found leſs, others not at all proper for this purpoſe. It is therefore neceſſary to examine ſome circumſtances attending the formation and ripening of thoſe grapes, whoſe juices produce the fineſt liquors of that kind.

All grapes, when they firſt bud forth, are auſtere and ſour. Whether this is the effect of the autumnal remaining ſap, or of the new raiſed vernal one, is neither very eaſy nor very material to determine. This however plainly appears, that the juice, in that ſtate, conſiſts of little elſe than an acid combined with a taſteleſs water. When the fruit is ripe, it becomes full of a rich, ſweet, and highly flavoured juice. The color, conſiſtency, and ſaccharine taſte of that juice ſhow, that, by the power of heat, a conſiderable quantity of oil has been raiſed, and that the originally acid ſalts are now ſo changed as to poſſeſs the properties of thoſe, which are called ſaponaceous, or lixivial.

In England, grapes are probably produced under the leaſt heat they can be raiſed by. They diſcover themſelves in their firſt ſhape, about June, when the medium between the heat of the ſun's beams, and that of the night, is from 58 to 60 degrees in Fahrenheit's thermometer. This therefore is the degree of heat, by which the acid ſalts are produced or introduced into the grape.

The higheſt degrees of heat, in the countries, where grapes come to perfect maturity, have been obſerved to be

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in various parts of Italy, Spain and Greece 100, and at Montpelier 88, in the ſhade, to which, according to Dr. Lining's obſervations, 20 degrees muſt be added for the effect of the ſun's beams. The greateſt heat then in Italy will amount to 120 degrees, and in the ſouth of France to 108. Theſe approach nearly to the heats ever obſerved in the hotteſt climates, which in Aſtracan, Syria, Senegal, and Carolina were from 124 to 126.

Thoſe countries, where the heat is the greateſt, produce in general the richeſt fruits, that is the moſt impregnated with ſweet, thick and oily juices. We are told that, among the Tockay wine-hills, that one which directly fronts the ſouth, and is the moſt expoſed to the ſun, produces the ſweeteſt and richeſt grapes. It is called the *ſugar-hill*, and the delicious wines extracted from this particular ſpot, are all depoſited in the cellars of the Imperial family. Thoſe grapes, as well as ſome in the Canaries, and in other places, which, by being ſuffered to remain the longeſt on the tree, with their ſtems half cut through, have their juices highly concentrated, produce that ſpecies of ſweet oily and balmy wines, which, from that operation, are called *ſack*, from the French word *ſec* or *dry*.

In all diſtillations, water and acid ſalts riſe firſt. A more conſiderable degree of fire is required for the elevation of oils, and a ſtill greater one for that of thoſe lixivial ſalts, which render thoſe oils miſcible with water. Nature puts this

this proceſs before our eyes, in the formation and maturation of grapes, and it is by the imitation of what ſhe does, that the inhabitants of different countries improve the advantages both of their ſoil and of their air.

In order to illuſtrate the doctrine, that grapes are endued with various properties, in proportion to the heat of the air, which they have been expoſed to, let us remember what Boerhaave has obſerved, that in very hot weather, the oleous corpuſcles of the earth are carried up into the air, and deſcending again, render the ſhowers and dews in ſummer very different from the pure ſnow in winter. The firſt are acrid and diſpoſed to froth, the laſt is tranſparent and inſipid. Hence ſummer rain, or rain falling in hot weather, is always fruitful, whereas that in cold weather is ſcarcely ſo at all. In winter the air abounds with acid parts, neither ſmoothed by oils or rarefied by heat, cold being the condenſing power, as heat is the opener of nature. In ſummer, the air dilating itſelf, penetrates every where, and gives to the rain a diſpoſition to froth, occaſioned by the admixture of oleous and aerial particles. Thus the acid ſalts, previouſly exiſting in the grapes, and neceſſary to their preſervation, are neutralized by heat, covered or blended with oil, and changed by both in a ſaccharine form. Now in proportion as theſe acids are more or leſs ſharp, and counterbalanced by a greater or leſſer quantity of oils, the juices of the grapes approach more or leſs to the ſtate of perfection, which fermentation requires.

There are indeed many places, as Jamaica, Barbadoes, &c. where neither the loweſt or higheſt degree of heat, proper for the production of grapes, is obſerved, and in which the vines cannot be cultivated with advantage. By comparing the heat of thoſe places with that in Italy and Montpelier, it appears, that this defect is not owing to the exceſſive heats of theſe countries, but to their conſtancy and uniformity; the temperature of the air never being ſo low as the degree neceſſary for the firſt production of the fruit. Whenever the cultivation of the vine is attempted in theſe countries, the grapes on their firſt appearance are ſhaded and ſkreened from the beams of the ſun, which, in their infancy, they are not able to bear.

Hence we learn, that nature employs leſſer heats to form than to ripen the juices of this fruit, or to beſtow on them a power of maintaining themſelves, for ſome time, in a ſound ſtate. We have inveſtigated the loweſt degrees of heat, in which grapes are produced, and nearly the higheſt they ever receive to ripen them. Let us call the firſt the *germinating* degrees, and the laſt thoſe of *maturation*. If 50 or 60 be the loweſt of the one, and 124 or 126 the higheſt of the other, and if a certain power of acids is neceſſary for the germination of the grapes, which muſt be counterbalanced by an equal power of oils raiſed by the heat of the ſun for their maturation, then the medium of theſe two numbers, or 92, may be ſaid to be a degree, at which this fruit cannot poſſibly be produced, and inferior to that by which

which it is maturated. At Panama the loweſt degree of heat is 72, to which 20 being added, for the ſun's beams, the ſum will be 92, and conſequently no grapes can grow there, except the vines be placed in the ſhade.

If we recollect that we can ſcarcely make wine, which will preſerve itſelf, of grapes produced in England, we ſhall be induced to think, that the reaſon of this defect is the want of the high degrees of heat. Our ſun ſeldom raiſes the thermometer to 100 degrees, and that but for a ſhort continuance. Our medium heat is far inferior to 92, and hence we ſee, at ſeveral diſtant terms in ſummer, new germinated grapes, but ſeldom any perfectly ripe. Theſe obſervations, the uſe of which in brewing will hereafter appear, likewiſe point out to us, what part of our plantations are fit to produce this fruit, and to what degree of perfection.

A perfect fermentation is the aim of the wine-maker, and this cannot be obtained, but with juices, whoſe parts may be intimately blended and united, that is according to our definition, that are perfectly ſaponaceous. Wines, that have that quality, will ferment of themſelves, become ſpontaneouſly bright and pellucid, and keep ſound a due time. The wines of France, Spain and the Madeiras poſſeſs more or leſs of theſe properties, in proportion to the heats, which the grapes of theſe countries ſuſtain in their ſeveral ſtages of growth, and ſome wines, which come from the

the Eaſt-Indies can ſcarcely ever be made tranſparent by art, nature having being too laviſh of its heat, at the time of their firſt formation.

The nature of the ſoil proper for the vine might, in another work, be a very uſeful enquiry. It will be ſufficient here barely to hint at the effect, which lixivial ſoils produce in muſts. The Portugueze, when they diſcovered the Iſland of Madeira in 1420, ſet fire to the foreſts, with which it was totally covered. It continued to burn for the ſpace of ſeven years, after which the land was found extremely fruitful, and yielding ſuch wines, as, ſtill at preſent, we have from thence, in greater plenty. It is very difficult to fine theſe wines, and, though the climate of this iſland is more temperate than that of the Canaries, the wines are obliged to be carried to the Indies and the warmer parts of the globe, to be purged, ſhook, and attenuated, before they can arrive to an equal degree of fineneſs with other wines; though, were the Portugueze acquainted with what may be termed the artificial method of exciting periodical fermentation, much or the whole of this trouble might be avoided. Hence we ſee, that ſoils impregnated with alkaline ſalts will produce muſts able to ſupport themſelves longer, and to reſiſt acidity more, than other ſoils, under the ſame degree of heat.

Grapes have the ſame conſtituent parts as other vegetables. The difference between them, as to their taſtes and properties,

properties, conſiſts, in the parts being mixed in different proportions. This ariſes, either from their abſorbent veſſels more readily attracting ſome juices than others, or from their preparing them otherwiſe, under different heats and in different ſoils.

We find, ſays Dr. Hales, by the chemical analyſis of vegetables, that their ſubſtance is compoſed of ſulphur, volatile ſalts, water, and earth, which principles are endued with mutual attracting powers. There enters likewiſe in the compoſition a large portion of air, which has a wonderful property of attracting in a fixed, or of repelling in an elaſtic, ſtate, with a power ſuperior to vaſt compreſſing forces. It is by the infinite combinations, actions and reactions of theſe principles, that all the operations in animal and vegetable bodies are effected.

Boerhaave, who is ſomewhat more particular with regard to the conſtituent parts of vegetables, ſays, that they contain an oil mixed with a ſalt in form of a ſapo, and that a ſaponaceous juice ariſes from the mixture of water with the former.

We have ſeen, from the nature of the compoſition of the grapes, that they have all the neceſſary principles to form a ſapo. They abound with elaſtic air, water, oils, acid and neutral ſalts, and even lixivial and ſaponaceous juices. The air contained in the interſtices of fluids is more in quantity than is commonly apprehended, for Sir Iſaac Newton has proved that water has forty times more pores than ſolid parts; and the proportion is likely not very different in vegetable juices. But their viſcidity prevents the expanſion of this incloſed air, and being enveloped by the covering of the fruit, it lies inactive, till it is moved by ſome foreign cauſe. In this forced ſtate, it cauſes no viſible motion, nor are the principles, thus confined, either ſubjected to any apparent impreſſions of the external atmoſphere, or ſo intimately mixed as when the juices of the fruit are expreſſed. But as a perfect mixture of theſe principles is neceſſary for the formation of a ſapo, it is clear, that a free communication of the external air with that contained in the interſtices of the liquor is required for that purpoſe. By what means this is effected, what alterations it produces, or in general, in what manner the juices of the grapes become wine, muſt be the ſubject of our next enquiry.

The proceſs of a perfect fermentation is undoubtedly the ſame, (where the due proportions of the conſtituent part, forming the muſt are exactly kept,) whatever vegetable juices it is excited in. For this reaſon, we will obſerve the progreſs of this act in beers and ales, theſe being ſubjects we are more accuſtomed to, and where the characters are moſt diſtinct, in order to apply what may be learned from thence to our chief object, the buſineſs of the brewer.

SECT. VII.

SECTION VII.

Of FERMENTATION in general.

FERMENTATION is that act, by which oils, and earth, naturally tenacious, are brought to ſuch a degree of fluidity, as to be equally ſuſpended in an homogeneous, pellucid fluid; which, by a due proportion of the different principles, is preſerved from precipitation and evaporation. According to Boerhaave, a leſs heat than forty degrees leaves the maſs in an inert ſtate, and the particles fall to the bottom in proportion to their gravity; a greater heat than eighty degrees diſperſes them too much, and leaves the reſiduum a rancid, acrimonious, putrid maſs.

It is certainly very difficult, if not totally impoſſible, to diſcover the true and adequate cauſe of fermentation. But, by tracing its ſeveral ſtages, circumſtances and effects, we may perhaps find out the agents and means employed by nature to produce this ſingular change; a degree of knowledge, which, if not ſufficient to ſatisfy philoſophical curioſity, may be ſo to anſwer our practical purpoſes.

The muſt, when juſt preſſed from the grapes, is a liquid compoſed of neutral and lixivial ſalts, oils of different ſpiſſitude, water, earth, and elaſtic air. Theſe are irregularly ranged, and if I may be permitted the expreſſion, compoſe a chaos of wine. Soon after the liquor is ſettled, a number of air bubbles ariſe, and at firſt adhere to the ſides of the containing veſſel: their magnitude encreaſes as they augment in number, till at laſt they cover the whole ſurface of the muſt.

It has been long ſuſpected, and if I miſtake not, demonſtrated, that an acid, of which all others are but ſo many different ſpecies, is univerſally diſperſed through, and continually circulating in the air; and that this is one of nature's principal agents in maturating and reſolving of bodies. Muſts, like other bodies, being porous, the circulating acids very powerfully introduce themſelves therein by the preſſure of the atmoſphere, in proportion as the pores are more or leſs expanded by the heat they are expoſed to. The particles of acids are ſuppoſed by Newton to be endued with a great attractive force, in which their activity conſiſts. By this force, they ruſh towards other bodies, put the fluid in motion, excite heat, and violently ſeparate ſome particles in ſuch manner as to generate or expel air, and conſequently bubbles.

From hence it appears that, as ſoon as the acid particles of the air are admitted into the muſt, they act on the oils, and excite a motion ſomewhat like the efferveſcence generated, when acids and oils come in contact, though in a leſs degree. This motion is the cauſe of a heat, by which the included elaſtic air, being rarefied, occaſions the bubbles to aſcend towards the ſurface. Theſe, by the power of attraction, are drawn to the ſides of the veſſel; at firſt they are ſmall and few, but increaſe, both in number and magnitude,

tude, as the effect of the air encreaſes, till, at laſt, they ſpread over the whole ſurface. The firſt ſtage then of vegetable fermentation ſhews itſelf to be the motion, by which part of the elaſtic air is freed from the muſt. It may, perhaps, be proper to obſerve, that all muſts, which ferment ſpontaneouſly, contain for this purpoſe a large proportion of elaſtic air.

Bubbles ſtill continue to riſe after the muſt is entirely covered with them ; and a body of bladders is formed, called by the brewers, the *head of the drink* ; which, by retaining the internal heat excited by motion, accelerates the fermentation. As the number of bubbles encreaſe, the head riſes in height, but the oils of the muſt being as yet of different ſpiſſitudes, ſuch which are leaſt tenacious emit their air ſoon than the others, and their aerial bubbles, being more ſtrongly rarefied by the fermenting heat, riſe on the ſurface higher than the reſt. From hence, and from the conſtituent parts of the muſt not being intimately mixed, the head takes an uneven and irregular ſhape, and appears like a beautiful piece of rock work. After this, it requires ſome time, and it is by degrees, that the particles diſpoſe themſelves in their due order, which, when effected, the interpoſition of the water keeps not only the ſaline, oily and ſpirituous parts, but alſo the mucilaginous and earthly ones, within their reſpective ſphere of attraction. The head becomes more level, heterogenous bodies, as dirt, ſtraw, corks, &c. are now buoyed on the ſurface, and ſhould be ſkimmed

med of, leſt, when the liquor becomes more light and ſpirituous, they ſhould ſubſide. As the heat increaſes, and the air bubbles grow larger, ſome, not formed of parts ſo ſtrong as the others, which generally are the firſt, burſt and ſtrengthen the reſt; the internal heat is hereby better retained in the fermenting liquor, and fermentation carried on to a farther degree. The particles of the muſt become more pungent and ſpirituous, becauſe more fine and more active; ſome of the moſt volatile ones fly off; hence, that ſubtle and dangerous vapor, called *Gas*, which extinguiſhes flame and ſuffocates animals. Thoſe bubbles, which were formed of oils more tenacious than the reſt, and are rendered more denſe by their admixture with earth, though they ſtrongly envelope much elaſtic air, ſubſide by their weight, and form the lees. The wine, by theſe ſeveral acts, being more and more attenuated, is at laſt unable to ſupport, on it's ſurface, the weight of ſuch a quantity of froth, rendered more denſe by the repeated exploſions of the air bubbles. At this period, leſt the liquor ſhould be fouled by the falling in of the froth, it is put in veſſels having only a ſmall aperture, where it continues to ferment, with a ſlower and leſs perceptible motion, even when the bung hole of the caſk is ſtopped. It is ſufficient for this, that the communication with the atmoſphere be not intirely interrupted. The alteration cauſed in the liquor, by the preſſure of the external air, from the very firſt of it's fermenting, not only occaſions the particles of the muſt, to form themſelves in their

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due order, but alſo, by the weight and action of that element, grinds and reduces them into ſmaller parts. From hence, they more intimately blend with each other, the wine becomes of an equal and even taſte, and if the muſt was perfectly ſaponaceous, it will continue to ferment, until, from the conſtituent parts being diſpoſed and ranged in right lines, a fine and pellucid fluid be produced.

That this operation ſubſiſts, even after the liquor becomes fine, is evident; for every fretting is a continuance of fermentation, though often almoſt imperceptible. Thus, as the component parts of the liquor are continually reduced to a leſs volume, the oils become more attenuated, and leſs capable of retaining elaſtic air. As theſe frettings are often repeated, it is impoſſible to determine, by any rule, the exact ſtate in which wine ſhould be, in order to be perfect for uſe. It would ſeem however, that the more minutely the parts are reduced, the more their pungency will appear, and the eaſier their paſſage be in the human frame. Both wines and beers, when new, poſſeſs more elaſtic air, than when meliorated by age; to be wholeſome, they muſt be poſſeſſed of the whole of the fermentable principles. For theſe reaſons, beers and ales, when ſubſtituted to wines in common, and more eſpecially when given to the ſick, ſhould always be brewed from entire malt: for the laſt extracts, poſſeſſing but the inferior virtues of the grain, have by ſo much leſs the power to become light, ſpirituous and tranſparent.

Wines never totally remain inactive ; fermentation in ſome degree continues, and in time the oils, by being greatly attenuated, volatilize, and fly off. In proportion as this circumſtance takes place, the latent acids of the liquor ſhow themſelves, the wine becomes ſour, and in this ſtate is termed vinegar.

It's laſt ſtage or termination is, when the remaining active principles, which the vinegar poſſeſſed, being evaporated in the air, a pellicle forms itſelf on the ſurface of the liquor, and duſt and ſeeds, which always float in the atmoſphere, depoſiting themſelves thereon, ſtrengthen this film into a cruſt, on which grow moſs, and many other ſmall plants. Theſe vegetables, together with the air, exhauſt the watery parts. No ſigns of fermentable principles then remain ; but, like the reſt of created beings, all the virtues being loſt, what is left is a ſubſtance reſembling common earth.

Upon the whole, then, it appears, that a liquor fit for fermentation ought to be compoſed of water, acids ſmoothed over with oils, or ſaccharine ſalts, and a certain portion of elaſtic air ; that the heat of the air the liquor is fermented in, muſt be in proportion to the denſity of it's oils ; and laſtly that the pores are to be expanded by ſlow degrees, leſt the air, by being admitted too haſtily, or too quickly, ſhould cauſe an effervesſcence rather than a fermentation, and occaſion the whole to become ſour. Wines therefore fermented in countries, where the autumn is hot, require their oils to be more pin-

pinguious, than where the ſeaſon is cooler. For the ſame reaſon, beers are beſt made, when the air is at forty degrees of heat, or below the firſt fermentable point, becauſe the brewer can, in that caſe, put his wort to work, at a heat of his own chuſing, which will not be augmented by that of the air; on the contrary, when, by it's internal motion, the heat is increaſed, it will again be abated and regulated by the cold of the medium.

As the acids are to be blunted by the oils of the muſt, if the firſt are conveyed in a greater proportion, the muſt ought to be charged with a larger quantity of the laſt. On this account ſmall beer brewed in ſummer, when the air and acids more eaſily inſinuate themſelves into the liquor, ought to be enriched with oils obtained by hotter extracts, and in winter the contrary method muſt be perſued.

From this hiſtory of fermentation, we can with propriety account for the many accidents and varieties, that accompany this act; and a comparative review of ſome of them may not be unneceſſary.

A cold air, cloſing the pores of the liquor, always retards and ſometimes ſtops fermentation; heat, on the contrary, conſtantly forwards this act, but, if carried too high, immediately prevents it.

A muſt loaded with oils, will ferment with more difficulty, than one which abounds with acids; it likewiſe is longer, before it becomes perfectly homogeneous and fine, but when once ſo, will be more laſting.

If the quantities of oil are increaſed, they will exceed the power, both of the acids naturally contained in the juice, and of thoſe that are abſorbed in fermenting; the liquor will therefore require a longer time, before it becomes pellucid, unleſs aſſiſted by precipitation: and there may be caſes, where even precipitation cannot fine it.

Theſe conſiderations naturally lead us to a general diviſion of wines in three claſſes, viz. 1. of ſuch, as ſoon grow fine, and ſoon become acid, being the growth of cold countries; 2. of thoſe, which, by a due proportion of heat, both when the grapes germinate, and when they come to maturity, form a perfect ſaponaceous muſt, and not only preſerve themſelves, but in due time, become fine; and 3, of ſuch, as having taken their firſt form under the higheſt degrees of *germination*, (as I termed them,) are replete with oils, diſappoint the cooper, and render the application of menſtruums uſeleſs, unleſs in ſuch quantities, as to change the very nature of the wine.

This remarkable difference of different wines appears to me chiefly to ariſe from the climate; a ſimilar difference may be obſerved in beers, and it has its origin in the different degrees of heat, the malt has been expoſed to both in drying and in extracting.

This will confirm an obſervation we have before mentioned, that wines are neither naturally or uniformly perfect, and conſequently that they muſt be ſubject to many diſeaſes. Sometimes they are vapid and flat, without being ſour. This does not ſo much ariſe, from their imbibing the air of the atmoſphere, as from their fermenting, generating, and caſting off too much air of their own. To prevent this accident, they are beſt preſerved in cool cellars, where their active and invigorating principles are kept within due bounds, and not ſuffered to fly off.

It ſometimes falls out, that a muſt, though overloaded with oils, has ſtill a greater tendency to fermentation than to putrefaction, acids not being wanting, but only enveloped. In this caſe, time will get the better of the diſeaſe. This ſometimes happens in wines of the growth of too hot a ſun; they ſoon become faint and ſick, but recover by heat and air. The ſame thing happens frequently in beers extracted with too hot waters or overcharged with hops; theſe liquors, at a certain period, ſicken, ſmell rancid, and have a diſagreeable taſte, but, by long ſtanding, they begin to fret, and receiving more acids from the air, recover their former health and taſte.

But ſhould the quantity of oils exceed this laſt proportion, eſpecially in wines formed from corn, the muſt, inſtead of fermenting, would putrify, even though, by ſome means, elaſtic air has been driven into them. In that caſe, the over proportion

portion of the oil and its tenacity prevent the entrance of the acids, the muſt receives no enlivening principle from without, and the air, at firſt conveyed into it, is enveloped with oils ſo tenacious as to be incapable of action. Nothing ſo much accelerates putrefaction as heat, moiſture, and a ſtagnating air; and all ſubſtances corrupt, ſooner or later, in proportion to the inactivity of the contained air, to the want of a proper vent, and to the cloſeneſs of their confinement. This ought to convince us of the truth, deduced by Dr. Hales from many experiments; that there is a great plenty of air incorporated in the ſubſtance of vegetables, which, by the action of fermentation, is rouzed into an elaſtic ſtate, and is as much inſtrumental in the production of fermentation, as it is neceſſary to the life and being of animals.

I would here cloſe this ſhort and imperfect account; but as, in the art of brewing, there is no part ſo difficult, and at the ſame time ſo important to be in ſome meaſure underſtood, as the cauſe and effects of fermentation; and as the examination of this act, in all the different lights in which it offers itſelf to our notice, can hardly be thought unintereſting, I beg leave to add ſome detached thoughts thereon.

We have ſeen that all vegetable ſubſtances poſſeſs fermentable principles, though in a diverſity of proportions; but that thoſe juices only, whoſe conſtituent parts approach to the proportion neceſſary to the act of fermentation, can be made into wines. I would not, from what has before been ſaid, be under-

underſtood, as if I thought that vegetables are more or leſs acid, more or leſs ſulphureous, or in general more or leſs fermentable, merely from the heat of the climate they grow in. This, though one of the cauſes of their being ſo, is by no means the only one; the form and conſtitution of the plant is another. In very hot climates, we find acid fruits, ſuch as limes, tamarinds, lemons and oranges; the proportions of fermentable principles in theſe fruits are ſuch, as to render them incapable of making ſound wines, though their juices may, in ſome degree be ſuſceptible of natural fermentation. In thoſe countries, ſo greatly favoured by the ſun, ſome vines and other fruit trees attract the acids from the air, and poſſibly from the earth ſo greedily, that, when the juices are fermented, they ſoon become ſour. On the contrary, in cold climates, we ſee warm aromatic vegetables grow, ſuch as hops, horſe radiſh, camomile, wormwood, &c. whoſe principles cannot, without difficulty, and perhaps not perceptibly, be brought to ferment. But theſe inſtances muſt be accounted the extremes on each ſide; for, in cold, as well as in hot countries, fruits are produced ſuſceptible of a perfect natural fermentation, as apples, ſome ſpecies of which are indued with ſuch auſtere and aromatic qualities, that their expreſſed juices ferment ſpontaneouſly, until they become pellucid, and are capable of remaining in a ſound ſtate many years. From thence it appears, that proper ſubjects, which will naturally ferment for making wines, may be found in almoſt every climate. England, ſays Boerhaave, is on this account remarkably happy: her fruits are capable of of producing a great variety of wines, equal in goodneſs to many imported, were not our taſtes, perhaps, made ſubſervient to our prejudices.

The effect of the act of fermentation on liquors is ſo to attenuate the oils, as to cauſe them to become ſpirituous, and eaſily inflammable. When a wine is diſpoſſeſſed of ſuch oils, which is nearly the caſe in vinegar, far from poſſeſſing a heating or inebriating quality, it refreſhes and becomes a remedy againſt intoxication. The term of fermentation ought, perhaps only, to be applied to that operation, which occaſions the expreſſed juices of vegetables to become wine: but as ſeveral acts paſs under the ſame name, it may not be improper here to inveſtigate them.

Vegetation, one of them, is that operation of nature, wherein more air is attracted than repelled. I believe all that hath been ſaid above concerning the juice of grapes, is a convincing proof thereof.

Fermentation is, where the communication of the external and internal air of a muſt is open, and in a perfect ſtate, when the power of repelling is equal to that of attracting air.

Putrefaction is when, by the power of ſtrong oils, or otherwiſe, the communication between the external and internal air is cut off, ſo that the liquor neither attracts the one or repels the other,

other, but, by an inteſtine motion, the united particles ſeparate and tend to fly off.

Effervescence is when, by the power of attraction, the particles of matter ſo haſtily ruſh into contact, as to generate a heat which expels the incloſed air; and this more or leſs, in proportion to the motion excited.

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SECTION VIII.

Of ARTIFICIAL FERMENTATION.

BY what has been ſaid, it appears, that, though fermentation is brought on by uniform cauſes, and productive of ſimilar effects, it is ſubject to many varieties, both in reſpect to its circumſtances and to its perfection. One difference is obvious, and ſeems to deſerve our attention, as it furniſhes a uſeful diviſion between *natural* and *artificial* fermentation. The firſt riſes ſpontaneouſly, and requires nothing to anſwer all the neceſſary purpoſes, but the perfection of the fruit, and the advantage of a proper climate. The other, at firſt ſight leſs perfect, wants the aſſiſtance of ferments, or ſubſtitutes, without which the act could, either not at all, or very imperfectly, be excited.

There are undoubtedly liquors, which, though they have of themſelves a tendency to fermentation, and are naturally brought to it, yet, from ſome defect in the proportions of their conſtituent parts, either do not acquire a proper tranſparency, or cannot maintain themſelves in a ſound ſtate for a ſufficient time. Theſe diſadvantages inbred with them can hardly ever be intirely removed; and they get very little or nothing from age. Defective at firſt, they ſeldom grow much better, and therefore are really inferior to liquors, which require the aſſiſtance of ſubſtituted ferments, to become real wines.

wines. In ſome artificial fermentations, the ferments are ſo duly adminiſtrated, and ſo intimately blended with the liquors, that in the end they approach very near to, and even vie with, the moſt perfect natural wines. Were I to enter into a more minute detail, it might be ſhewn, that wines, when tranſported from a hot climate to a cold one, are often hurt in their progreſs, and from thence become or remain imperfect, whereas beers may be ſo brewed, as to be adapted either to a hot or a cold region, not only without any diſadvantage, but with a conſiderable improvement.

Hitherto I have conſidered grapes as a moiſt pulpous fruit, ſufficient to furniſh the quantity of water neceſſary for extracting the other parts: but the natives of the countries where this fruit abounds, in order to preſerve them, as near as poſſible in the primitive ſtate, after they are gathered, ſuſpend them in barns, or place them in ovens, to dry. Thus, being, in great meaſure, diveſted of their aqueous particles, theſe grapes remain almoſt inactive, without juices ſufficient to form wines, unleſs water be added to them. This element becomes in this caſe, a ſubſtitute, and conſequently the liquors produced in this manner may be accounted the *firſt* claſs of *artificial* wines.

In all bodies, the various proportions of their conſtituent parts, produce different effects; hence they remain more or leſs in a durable ſtate, and tend either to inaction, fermentation, or putrefaction. Now, by a judicious ſubſtitution of ſuch parts as ſhall be wanting, they may be reſtored to their priſtine nature; as may be proved by the obſervations and experiments communicated to the public by Dr. Pringle. Thus grapes, though dried and exported from their natural climate to another, by the addition of water only, ferment ſpontaneouſly, and form wines very near alike to ſuch, as they would have produced before. It may, with confidence, be ſaid, that, when any conſiderable difference appears, it ariſes from the injudicious manner, in which the water is adminiſtered, from the fruits not being duly maccerated, or from want of ſuch heat being conveyed to the water and fruit, as the juices would have had, if they had been expreſſed out of the grapes when juſt gathered; often from the whimſical mixture of other bodies therewith, and perhaps too, from the quantity of brandy, which is always put to wines abroad, to prevent their fretting on board a-ſhip. Upon the whole, though from what juſt now has been ſaid, ſome ſmall difference muſt take place, it rather proves than contradicts the fact, that, a due quantity of water being applied to dry raiſins, an extract may be formed, which will be impregnated with all the neceſſary conſtituent parts the grapes had in them when ripe upon the vine, and conſequently will ſpontaneouſly ferment, and make a vinous liquor.

Vegetables, in their original ſtate, are diviſible into the pulpous and farinaceous kinds, both poſſeſſing the ſame conſtituent parts, though in different proportions. If from the farinaceous ſuch parts be taken away as they ſuperabound

perabound in, and others be added, of which they are defective, theſe vegetables may, by ſuch means, be brought to reſemble, in the proportion of their parts, more eſpecially in their muſts, the natural wines I have before been treating of: and this being univerſally acknowledged to be the ſtandard of wines, the nearer any fermented liquor approaches thereto, by its lightneſs, tranſparency and taſte, the greater muſt its perfection be.

To enquire which of the pulpous or which of the farinaceous kinds of vegetables are fitteſt for the purpoſe of wine-making, would here be an unneceſſary digreſſion. Experience, the beſt guide, hath on the one ſide, given the preference to the fruit of the vine, and on the other to barley. To make a vinous liquor from barley, having all the properties of that produced from the grape, is a taſk, which can only be compaſſed by rendering the wort of theſe ſimilar to the muſt of the other.

As malt liquors require the addition of other ſubſtitutes, beſides water, to become perfect wines, they can only be ranked in the *ſecond* claſs of *artificial* fermentation. Theſe ſubſtitutes are properly called *ferments*, and deſerve the cloſeſt attention of the brewer.

Ferments, in general, ſuch as yeaſt, flowers or lees of wine, honey, the expreſſed juices of ripe fruits, are ſubjects more or leſs replete with elaſtic air, and conveying the ſame to the muſts, which ſtand in need of it. Boerhaave has ranged theſe, and ſeveral others, in different claſſes, according to their different powers, or rather in proportion to the quantity of air they contain for this purpoſe.

The juice of the grape, when fermented, forms more lees than the decoction of malt. May we not infer from thence, that in the fruit, the elaſtic air is both more abundant, and contained in a greater number of ſtronger, though ſmaller, veſicles, than it is in the malt? The barley, being firſt ſaturated with water, and then dried and parched, has its air in part driven out; for the heat, which performs the operation of malting, much exceeds the limits of fermentation. The expulſion of air from the worts of beers and ales is ſtill farther effected by the long boiling which the extracts of malt undergo. Hence the neceſſity of replacing the loſt elaſtic air, in order that theſe extracts may become fermentable. This is effected by means of the yeaſt, which, conſiſting of a collection of ſmall bubbles, filled with air, and ready to burſt by a ſufficient heat, becomes the ferment, which facilitates the change of the wort into a vinous liquor.

The muſts of malt generally produce two gallons of yeaſt from one quarter of the grain, whereas, in the coldeſt fermentable weather, one gallon of yeaſt is ſufficient to work that quantity of malt. Much elaſtic air ſtill remains in beer, or wine from corn, after the firſt act of fermentation is

over,

over, and the liquor is ſeparated from the yeaſt above mentioned, as it is then neither flat, vapid, or ſour. If then we ſay that malts, by their being dried, and having their extracts boiled, looſe one part in three of their air, we ſhall not perhaps be very far from truth.

As the loſt air, juſt mentioned, is replaced chiefly by means of the yeaſt, it muſt be obſerved that the aerial veſicles of yeaſt, the lees or flowers of malt liquor, are of a weaker texture, and more equal in ſize than thoſe of grapes; and conſequently that the air in the bubbles is not ſo much compreſſed. This probably ariſes from the oils of the malt being leſs tenacious than thoſe of the grapes, from their firſt fermentation being completed in a much ſhorter time, and from the greater heat in the fermentation which produced the flowers. Their effect is therefore more ſpeedy, inſomuch that, were the air bubbles produced from malt, and applied to a muſt, equal in number to thoſe produced from the ſame quantity of the unfermented juice of grapes, their quick exploſion could ſcarcely be termed a fermentation, the ſpirituous parts would fly off, the liquor ſoon ſicken, and be void of every enlivening principle.

Hops, which have the quality to check the proneneſs that malts have to ferment, are therefore neceſſary to beers intended to be kept long; and, on this account alſo, all artificial fermentations ſhould be carried on in the cooleſt and ſloweſt manner poſſible. This ſhows likewiſe, that beers, but more eſpecially ales, ought not to be racked from their lees, as it is frequently practiſed for natural wines, unleſs, on account of ſome defect, they are to be blended with freſh worts under a new fermentation.

As all ferments, as well as hops, are liable to be tainted, great care ought to be taken in the choice of them, every imperfection in the ferment being readily communicated to the muſt. It would not therefore be an improper queſtion to be determined by phyſicians, whether, in a time of ſickneſs the uſe of thoſe, which have been made in infected places ought to be permitted, and whether, at all times, a drink fermented in a pure and wholeſome air is not preferable to that which is made among fogs, ſmoke, and nauſeous ſtenches *.

Wines from corn are diſtinguiſhed by two appellations, viz. thoſe of ale and beer. As each of theſe liquors has ſuffered in its character, either from prejudice or want of a ſufficient enquiry, it may be proper to levy the objections made againſt their uſe, before we enquire into the means of their formation. The moſt certain ſign of the wholeſomeneſs of wines, is tranſparency and lightneſs; yet ſome which are rich, more eſpecially ales, tho' perfectly fine, have been ſaid to be viſcid. Tranſparency ap-

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* By Dr. Hales's experiments made for diſcovering the proportion of air generated from different bodies, it appears that raiſin wine, abſorbed, in fermenting, a quantity of air equal to nearly one third part of its volume; and ale, under the like circumſtances, abſorbed one fifth.

pears indeed in many wines, before the oils are attenuated to their higheſt perfection, as we have before remarked, and ſome viſcidity may therefore be conſiſtent with ſome degree of pellucidity. Where the powers of the oils and the ſalts are equal, which is denoted by the brightneſs of the liquor, viſcidity can only ariſe from the want of age: in this caſe the fault is not in the defect, but in the miſapplication of the liquor, which has been uſed too ſoon.

That beers retain igneous or fiery particles, ſeems equally a miſtake. Malts dried to keep have undoubtedly their particles removed by fire, beyond their ſphere of attraction: elſe they would not be in a fit ſtate to preſerve themſelves ſound. For this reaſon, when they firſt come in contact with the water, which is to extract them, they cauſe an effervescent heat, which adds to the extracting power, and ſhould be looked on by the brewer as an auxiliary help; but it is impoſſible that the malt or the muſt, ſhould ever incloſe and confine the fire employed in their formation. It is of ſo ſubtile a nature, that its particles, when contained in a body, continually tend to fly off, and mix with the ſurrounding air; ſo that only an equal degree, with what is in the atmoſphere, can be continued in the grain, or any liquor whatever; after it has been, for ſome time, expoſed thereto. Brown beers made from malt more dried than any other are, from experience, found to be leſs heating than liquors brewed from pale malt; which probably ariſes from hence, that brown beers contain a leſs quantity of elaſtic air than pale beers, as pale malt liquors contain leſs than wines, produced from vegetables in their natural ſtate: and as malt liquors contain their elaſtic air in bubbles of a weaker conſiſtence than thoſe made from the juices of the grape, the effect of beer, when taken in an over-abundant quantity, is neither of ſo long a continuance, nor ſo powerful as that of wine, ſuppoſing the quality and quantity of each to be equal. This may appear to ſome perſons to be the effect of prejudice, yet it is but a juſtice due to the produce of my country, to add, that ſome phyſicians have given it as their opinion, that ſtrong drinks from malt are leſs pernicious than thoſe produced from grapes. As far as theſe gentlemen, I hope I may advance, without being thought guilty of aſſuming too much, or countenancing debauch, by pointing out the wines that occaſion the feweſt diſorders.

SECTION IX.

Of the NATURE *of* BARLEY.

BARLEY is a ſpicated, oblong, ventricoſe ſeed, pointed at each end, and marked with a longitudinal furrow. The eſſential conſtitution of the parts in all plants, ſays Dr. Grew, is the ſame: thus this ſeed, like all plants which have lobes, is furniſhed with radical veſſels, which having a correſpondence with the whole body of the corn, are always ready, when moiſtened, to adminiſter ſupport to the plume of the embryo, or what is uſually called the *acroſpire*. Theſe radical veſſels, at firſt, receive their nouriſhment from a great number of glandules diſperſed almoſt every where in the grain, whoſe pulpous parts ſtrain and refine this food ſo as to fit it to enter the capillary veſſels; and ſuch an abundant proviſion is made for this nouriſhing of the plume, that the ſame author ſays, theſe glandules take up more than nine tenths of the ſeed.

It is ſown about March, ſooner or later, according to the ſoil that is to receive it, and generally houſed from ten to twenty weeks time after. Moſt plants, which ſo haſtily perform the office of vegetation, are remarkable for having their veſſels proportionably larger; and that theſe may be thus formed, the ſeed muſt contain a greater quantity of tenacious oils, in proportion, than thoſe ſeeds, whoſe veſſels being ſmaller, require more time to perform their growth, and come to maturity. Barley alſo, as may be obſerved, grows and ripens with the lower degrees of natural heat; from whence and from the largeneſs of the ſize of its abſorbent veſſels, it muſt receive a large portion of acid parts. It is ſaid to be viſcid, though at the ſame time a great cooler, water boiled with it being often drank as ſuch; and however it be prepared, it never heats the body when unfermented.

From theſe circumſtances, of its being viſcous and replete with acids, it would at firſt appear to be a moſt unfit vegetable, from which vinous liquors, to be long kept, ſhould be made; and indeed the extracts from it in its original ſtate are not only clammy, but ſoon become ſour.

When the grain is at full maturity, its conſtituent parts ſeem to be differently diſpoſed, than when in a ſtate of vegetation. By germination alone all its principles are put in action; the fibrous parts poſſeſs themſelves of a great quantity of tenacious oils, leaving the glandules and finer veſſels replete with water, ſalts and the pureſt ſulphur. If, in this ſtate, the corn is placed in ſuch a ſituation, that, by heat, the acid and watery parts may be evaporated, the more ſuch heat is ſuffered to affect it, the more dry, and leſs acid will the corn become; its parts will be divided, its viſcidity removed; its taſte become ſaccharine, by the acids being ſheathed or covered over with oils; and theſe laſt be rendered more tenacious in proportion to the greater quantity of heat they have received. This proceſs regularly carried on is what is termed *malting*, and will hereafter be explained at large.

But before we enter thereon, it is neceſſary to conſider the ſtate of the grain as it comes from the field. When mowed, though upon the whole it may be ſaid to be ripe, yet every individual part, or every corn cannot be ſo. In ſome ſeaſons, this inequality is ſo remarkable, as to be diſtinguiſhed by the eye. The difference in the ſituation, the ſoil, and the weather, the changes of the winds, the ſhelter ſome parts of the field have had from ſuch winds, are ſufficient to account for this, and indeed a much greater variety. When the greater part of the corn is ſuppoſed to have come to maturity, it is cut and ſtacked; the ripeſt parts have the leaſt moiſture, and the feweſt acids; and the greeneſt abound in both. In this ſtate, the unripe grains of the corn communicate, to ſuch as are more dry, their moiſture and acid parts, which coming in contact with their oils, an agitation enſues, more or leſs gentle, in proportion to the power of the acids and water; and from this ariſes a heat, the degree whereof can hardly be determined.

When this ſweating in the mow is kept within its proper limits, the whole heap of the corn, after the fermentation is over, becomes of one equable dryneſs, and is not diſcoloured; but if the grain be put together too wet or too green, the heat occaſioned thereby will produce ſuch a violent inteſtine motion, as to charr and blacken the greateſt part thereof, nay often make it burſt into actual flame.

The effect, which a moderate and gentle ferment has on the corn, is that of driving the oils towards the external parts of its veſſels, and ſkin; by this means, it becomes more capable of preſerving itſelf againſt the injuries of the weather. The more it is in this ſtate, the backwarder will it be to germinate, when uſed to this purpoſe; and if this act is carried too far, as we have before ſeen, the plume and root of the encloſed embryo muſt be quite ſcorched, and the corn become inert and incapable of vegetation. This effect is produced, by a motion ſufficient to remove the particles of the grain from each other beyond their ſphere of attraction; and the heat, by which this motion is excited, has been found by experience to be at about 120 degrees.

It is likely, that vegetables, in general, are ſuſceptible of a large latitude in this reſpect, according to their different textures. The degree of heat juſt now mentioned may, perhaps, be applicable only to barley: the ſeeds of ſome grapes endure 124 degrees of heat, and may be capable of being impreſſed with more, and yet vegetate. But if the oils of the corn become ſo tenacious as to be diſcoloured, the ſeed can ſcarcely be revived; and this may happen ſooner or later, by heat, in proportion to the coheſion and weight of the parts. This is a point properly to be judged of by the color of the grain, and is more immediately the buſineſs of the farmer and maltſter than that of the brewer.

Thus, though it may be diſadvantageous to the maltſter, to ſteep grain which has not ſweated in the mow, as, from this reaſon, it will not equally imbibe the water; ſo barley that is overheated, or *mow burnt*, cannot be fit for his purpoſe. It is in fact ſcarcely poſſible, that any large quantity of barley, from the ſame ſtack, ſhould make equally perfect malt, as, on its being put together, the heat generated is always greateſt in the center of the rick, and conſiderably more ſo there, than in its exterior parts.

SECTION X.

Of MALTING.

THIS proceſs is intended to furniſh proper means, for ſetting the conſtituent principles of the grain in motion: ſo that the oils, which before ſerved to defend the ſeveral parts, may be enabled to take their proper ſtations. This is effected by ſteeping the barley in water, where it ſtrongly attracts moiſture, as all dry bodies do; but it requires ſome time before the grain is fully ſaturated therewith. Two or three days, more or leſs, are neceſſary, in proportion to the heat of the air: for vegetables receive the water only, by its ſtraining through the outward ſkin, and abſorbent veſſels, and their pores are ſo very fine, that they require this element to be reduced almoſt to a vapor, before it can gain admittance. Heat hath not only the property of expanding theſe pores, but perhaps alſo that of rendering water more fit to make its way into them.

By the water gaining admittance into the corn, a great quantity of air is expelled from it, as appears from the number of bubbles which ariſe on the ſurface of the water; yet ſtill much remains therein. A judgment is formed that the corn is fully ſaturated with water, ſo as not to be able to imbibe any more of it, from its turgidity, and pulpouſneſs, which occaſions it readily to give way to an iron rod dropped perpendicularly therein. Then is the water let go, or drawn off, the grain taken out of the ciſtern, and laid in a regular heap. As hay, or any other moiſt vegetable, when ſtacked together, grows hot, ſo doth this heap of barley. The heat, aſſiſted by the moiſture, puts in motion the acids, oils, and elaſtic air remaining in the corn, and theſe, with united power, force the juices from the glandular parts into the roots, which are thereby diſpoſed to ſeek and receive nouriſhment for the embryo or acroſpire, and the plume is ſoftened by its proximity to the body of the grain. The root having received ſome power (before it expands its fibres) by the heated elaſtic air, preſſes the oils towards the acroſpire. The corn in the heap is however not ſuffered to acquire too great a degree of heat, and carry on the germination too faſt, by which not only the finer but alſo the coarſer oils, would be raiſed and entangled together, and the malt when made become bitter and ill taſted; it is therefore, at a due temperature, diſperſed in beds on the floor of the malt houſe, and gradually ſpread thinner and thinner. Care is taken to turn it frequently from time to time, in proportion as it is more or leſs ſlow in growth, ſo that it may come tolerably dry to the kiln, in ſuch a ſtate as its fibrous roots ſhall be ſpread, and the ſpire be near coming through the outward ſkin of the barley. By theſe ſigns the maltſter is ſatisfied, that every part of the grain has been put in motion, and ſeparated. The corn, thus prepared for drying, is, in this lively and active condition, ſpread on the kiln; where meeting with a heat ſuperior to that requiſite for vegetation, its farther growth is ſtopped: though in all probability, from the gentleneſs of the firſt fire it ought to be expoſed to, none of the finer veſſels are, by this ſudden change, rent or torn, but, by drying, only ſhrivelled up, rendered inactive, and put in a preſervative ſtate. Now let it be obſerved, that thoſe oils which fill the roots, being with them puſhed out from the body of the grain, and dried by heat, are loſt to any future wort, not being ſoluble in water; which is likewiſe true of thoſe parts which are contained in the ſhoot or plume: ſo that the internal parts of the malt have remaining in them a greater proportion of ſalts to the oils then before, and conſequently are leſs viſcid, more ſaccharine, and eaſier to be extracted.

In this proceſs, the acid parts of the grain, though they are the moſt ponderous, yet being very attractive of water, become weaker, and, by the continued heat of the kiln, are volatilized and evaporated with the aqueous ſteam of the malt. Thus, by malting, the grain acquires new properties, and theſe vary at the different ſtages of dryneſs; in the firſt it reſembles the fruits ripened by a weaker ſun, and in the laſt thoſe which are the growth of the hotteſt climates.

When the whiteneſs of the barley has not been greatly changed by the heat it has been kept in, it is called pale malt, from its having retained its original color; but when the fire in the

the kiln has been made more vehement, and kept up a longer time, it affects both the oils and the ſalts of the grain, in proportion both to the degree of the heat, and to the time it has been maintained, and thus occaſions a conſiderable alteration in the color. Actual blackneſs ſeldom is, and ought never to be, ſuffered in malts, but in proportion to the intenſeneſs of the fire they have been expoſed to, they nearer and nearer come to that tinge, and from the different brown they ſhow, receive their ſeveral denominations.

The condition the barley was gathered in, whether green or ripe, is alſo clearly diſcernible when it is malted. If gathered green, it rather loſes than gains in quantity; for the ſtock of oils of unripe corn being ſmall, the whole is ſpent in germination, the malt becomes of a ſmaller body, appears ſhrivelled, and is often unkindly hardened. That, on the contrary, which hath come to full maturity, encreaſes by malting, and if properly carried through the proceſs, appears plump, bright and clean, and, on being cracked, readily yields the fine mealy parts, ſo much deſired by the brewer.

The malts, when dried to the pitch intended by the maker, are removed from the kiln into a heap. There their heat gradually diminiſhes, and from the known properties of fire, flies off, and diſperſes itſelf in the ambient air, ſooner or later as the heap is more or leſs voluminous, perhaps too in ſome proportion to the weight of the malt, and as the fire has cauſed it to be more or leſs tenacious. Nor can it be ſuppoſed, that any of its parts are capable to retain the fire in ſuch a manner, as not to ſuffer it to get away. So ſubtile an element cannot be confined, and much leſs be kept in a ſtate of inactivity, and imperceptible to our ſenſes. Bars of iron or braſs, even of a conſiderable ſize, when heated red hot, cool and loſe their fire, though their texture is undoubtedly much cloſer than that of malt or barley. The experiments made by Dr. Martin, on the heating and cooling of ſeveral bodies, leave no room to doubt of this fact, I ſhould not be ſo particular about it, was it not to explain the technical phraſe uſed by brewers, when they ſay, *malts are full of fire, or want fire.* Hence a prejudice hath by ſome been conceived againſt drinks made from brown malts, tho' they have been many months of the kiln, and have no more heat in them, either whole or ground, than the air they are kept in. The truth of the matter is, that in proportion as malts are dried, their particles are more or leſs ſeparated from one another beyond their ſphere of attraction, and coming in contact with another body, ſuch as water, ſtrongly attract from it the uniting particles they want. The more violent this inteſtine motion is, the greater is the heat juſt then generated, and no ways durable. An effect ſomewhat ſimilar to what happens on malt being united with water, muſt occur on the grain being maſticated; and the impreſſion made on the palate moſt probably gave riſe to the technical expreſſion juſt taken notice of.

The minute circumſtances of the proceſs of malting will be more readily conceived from what will hereafter be ſaid. The effects that fire will have, at ſeveral degrees, on what from having been barley is now become malt, are moſt particularly the concern of the brewer; and that they are various, both as to the color and properties of the malt, is certain. A determinate degree of heat produces, on every body, a certain alteration, and hence, as the action of fire is ſtronger or weaker, the effect will be different from what it would have been in any other degree.

Barlies may, at a medium, be ſaid to loſe, by malting, one fourth part of their weight, including what is ſeparated from them by the roots being ſkreened off: but this proportion varies, according as they are more or leſs dried.

As the acroſpire, and both the outward and inward ſkins of the grain are not diſſoluble in water, the glandular or mealy ſubſtance is certainly very inconſiderable in volume and in weight; but as this alone poſſeſſes the fermentable principles of the grain, it deſerves our utmoſt attention.

We have before ſeen, that wines, beers and ales, after the firſt fermentation, are meliorated through age, by the more refined and gentle agitations they undergo, and which often are not perceptible to our ſenſes. To ſecure this favorable effect we muſt form worts capable of maintaining themſelves, for ſome time, in a ſound ſtate. This quality, however, if not originally

originally in the malt, is not to be expected in the liquor. Some objections have been raiſed againſt this method of arguing, and theſe aided by prejudices often more powerful than the objections themſelves. It is therefore neceſſary, as malting may be eſteemed the foundation of all our future ſucceſs, to enquire after the beſt and propereſt methods of ſucceeding in this proceſs. Let us, for this purpoſe, re-aſſume the conſideration of the grain, as it comes from the mow, trace it to the kiln, and obſerve every change it undergoes by the action of the fire, from the time that it receives the firſt degree of preſervation to that, when it is utterly altered and nearly deſtroyed.

Barley in the mow, though it ſcarcely ſupports a heat much greater than of 100 degrees, may be extracted or brewed without malting. This the diſtiller's practice daily evinces; but then the extracts, made from this unchanged corn, are immediately put in the ſtill after the firſt fermentation, elſe they would not long remain in a ſound ſtate. Nor is this method even practicable in ſummer time, as the extracts would turn ſour, before they were ſufficiently cooled to ferment. It is true indeed, that, by this means, all the charge of the malt duty is ſaved; but our ſpirits are thereby made greatly inferior to thoſe of the French. Boerhaave recommends the practice of that nation, which is to let the wines ferment, ſubſide, and be drawn off fine from the lees, before they are diſtilled. Was this rule obſerved in England, diſtillation would only be attempted from malted grain, and the difference in the ſpirit would ſoon ſhew, how uſeful, nay how neceſſary it is to give

give wines, (either from grapes or corn,) time to be ſoftened, before they are uſed for any purpoſe whatever.

But might not barleys be dried without being germinated? Undoubtedly they might; but as they abound with many acids and ſtrong oils, they would require a heat more intenſe than malt doth, before they were ſufficiently penetrated, and then the oleaginous parts would become ſo compact, and ſo reſinous, as nearly to acquire the conſiſtence of a varniſh, ſcarcely to be mollified by the hotteſt water, and hardly ever to be intirely diſſolved by that element.

Barley then ungerminated, either in its natural ſtate or when dried, is not fit for the purpoſe of making wines; but when, by germination, the coarſer oils are expelled, and the mealy parts of the grain, become ſaccharine, might not that ſuffice, and where is the neceſſity of the grain being dried by fire? I ſhall not dwell on the difficulty of ſtopping germination at a proper degree without fire, ſo that ſufficient quantities of the grain thus prepared, may always be provided for the purpoſes of brewing; nor even inſiſt upon the difficulty, and perhaps impoſſibility of grinding ſuch grain, as it would then be ſpungy and tough. I think it ſufficient to mention ſolely the unfitneſs of this imperfect malt, for the purpoſe it is to be applied to, that of forming beers and ales capable of preſerving themſelves for ſome time. We ſhould find ſo many acids blended with the water ſtill remaining in the grain, that, in the moſt favorable ſeaſons for brewing, they would often

often render all our endeavours abortive, and in ſummer time make it impracticable to brew the extracts from ſuch grain in any manner whatever.

I have heard of a project of germinating grain, and drying it by the heat of the ſun in ſummer time, in order, by this means, to ſave the expence of fuel: but, tho' the hotteſt days in England may be thought ſufficient for this act, as well as for making hay, yet as barley and graſs are not of equal denſities, the effects would not be the ſame. This however is not the only objection to this ſcheme. As the grain is to be grown to a certain degree before it is ſtopped, this very hot ſeaſon, favorable in appearance to one part of the proceſs, would be directly contrary to the other; for the barley, by this heat, would ſhoot and come forward ſo faſt as to entangle too much the conſtituent principles of the grain with one another, and drive the coarſer ill taſted oils among the finer ſweet mealy parts, which alone, in their utmoſt purity, are the ſubject required for ſuch as would obtain good drinks.

Here I cannot help obſerving the general diſpoſition of mankind to wiſh for the gifts of providence, in a different manner than they have been vouchſafed to us. Theſe various ſchemes, if I miſtake not, have ſprung from the deſire of having beers and ales of the ſame appearances with white wines. But as they are naturally more yellow or brown, all ſuch projects, by which we endeavour to force ſome ſubjects to be of a like color with others, are but ſo many attempts againſt nature, and the

the proſecution of them muſt commonly be attended with diſappointments. It is true, that, though malts be dried ſlack, yet if they be made in winter, ſpeedily uſed, and brewed in the moſt proper ſeaſon, they may make a tolerable drink, which will preſerve itſelf ſound for ſome time: but as the proportion, which ſhould be kept between the heat which dried the malt, and that which extracts it, cannot in this caſe take place, and as the grain will be more replete with air, water and acids, than it ought to be, the drink, even by ſuppoſing the moſt fortunate ſucceſs, and that it doth not ſoon turn acid, will ſtill be frothy, produce exploſions, and be therefore greatly wanting in ſalubrity; for an exceſs in any of the fermentable principles is always hurtful.

Barley then, to be made fit for the purpoſe of brewing, muſt be malted; that is, it muſt be made to ſprout or germinate with degrees of heat nearly equal to thoſe which the ſeed ſhould be impreſſed with when ſown in the ground; and it muſt be dried with a heat ſuperior to that of vegetation, and capable of checking it. How far germination ſhould be carried on, we have already ſeen; the law ſeems to be fixed univerſally, as to the extent of the acroſpire: the degree of dryneſs admits of a larger latitude, and to what extent it may be properly puſhed ſhall be the ſubject of our next enquiry.

Malt dried in ſo low a degree, as that the vegetative power is not intirely deſtroyed, will, on laying together in a heap, generate a new, tho' ſmall, heat, germinate afreſh, and ſend forth its plumes and acroſpires quite green. The ultimate parts of the nouriſhing principles are then within each other's power of acting, elſe this regermination could not take place; and ſuch grain cannot be ſaid to be malted, or in a preſervative ſtate. Bodies, whoſe particles are removed, by heat, beyond their ſphere of attraction, can no more germinate; but coming in contact with other bodies, as malt with water, they effervеſce. The grain, we are now ſpeaking of, firſt ſhews this act of effervеſcence, when it has been thoroughly impreſſed with a heat of 120 degrees, when alſo its color, from a white, begins to incline to the yellow. Such are the malts, which are cured in a manner to be able to maintain themſelves ſound, though in this ſtate they ſtill poſſeſs as much air, and as many acid and watery particles as they are capable of. This therefore may be termed the firſt or loweſt degree of drying this grain for malt.

To diſcover the laſt or greateſt degree of heat it is capable of enduring, we have no circumſtance to direct us, with the ſame certainty as effervеſcence helped us to the firſt. We muſt therefore have recourſe to the obſervation of that heat, which wholly deprives the grain of its principal virtues. Now, to uſe Dr. Shaw's words, *alcohol is one of the moſt eſſential parts of wine*; when abſent, the wine looſes its nature, and when properly diffuſed, it is a certain remedy for moſt diſeaſes incident to wines, and keeps them ſound and free from corruption; from whence was derived the method of preſerving vegetable and animal ſubſtances from corruption. The ſame excel-

lent

lent author had before this obſerved, that *no ſubjects but thoſe of the vegetable kingdom are found to produce this preſerving ſpirit.* Is alcohol then a new body created by fermentation and diſtillation, or did it originally, though latently, reſide in the vegetable? *I have, for a good while, been ſatisfied, by experiments,* (ſays Boerhaave,) *that all other inflammable bodies are ſo only as they contain alcohol in them, or, at leaſt, ſomething that, on account of its fineneſs, is exceedingly like it, the groſſer parts thereof, that are left behind, after the ſeparation of this ſubtil one, being no longer combuſtible.*

Now as the ſame author has clearly proved *, that fire, by burning combuſtible bodies, as well as by diſtilling them, ſeparates their different inflammable principles, according to their various degrees of ſubtility, the alcohol reſiding in the barley, when expoſed to ſuch a degree of heat as would cauſe it to boil, i. e. 175 degrees, muſt make great efforts to diſengage itſelf from the grain. Is it not therefore moſt natural to conclude, that, in a body like malt, prepared for fermentation, or the making a vinous liquor, this event will probably happen at the ſame time that malt charrs? and if this is true, may not charring be termed the laſt degree of dryneſs, as, when it takes place, the acid parts and fineſt oils, which are neceſſary for forming a fermentable muſt, fly off, and cannot be recovered. Charring ſeems to be a criſis in ſolid bodies, ſomewhat analogous to ebullition

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* Boerhaave Elem. of Chem. Vol. I. p. 195-199. Exp. 8, 9, 10, 11, 12, and 13.

in

in fluids. Both are thereby perfectly ſaturated with fire, their volatile and ſpirituous parts diſſipated, but their fixed principles not entirely deſtroyed. Now, as liquors boil with a greater or leſs heat, in proportion to their tenacity and gravity, ſolid bodies may likewiſe be charred with different proportions of heat. The whole body of the barley cannot, at the ſame inſtant, become black, nor, where any quantity of the grain is otherwiſe in ſimilar circumſtances, if not equally germinated, can the whole charr with the ſame degree of heat.

To the ſeveral reflections, before made, I thought proper to add the ſurer help of experience. I therefore made the following trial, with all the care I was capable of. If the effects of it appear, as I hope they will, ſatisfactory, by gaining two limited and diſtant degrees, we may determine and fix the properties of the intermediate ſpaces, in proportion to their expanſion.

In an earthen pan, of about two feet diameter, and three inches deep, I put as much of the paleſt malt, unequally grown, as filled it on a level to the brim. This I placed over a little charcoal lighted in a ſmall ſtove, and kept continually ſtirring it from bottom to top.

At firſt it did not feel ſo damp as it did about half an hour after. In about an hour more it began to look of a bright orange color on the outſide, and appeared more ſwelled than before.

before. Every one is ſenſible, that a long-continued cuſtom makes us ſufficient judges of colors, and this ſenſe in a brewer is ſufficiently exerciſed. Then I maſticated ſome of the grain, and found them to be nearly ſuch as are termed brown malts. On ſtirring and making a heap of them towards the middle, I placed therein, at about half depth, the bulb of my thermometer, and found that it roſe to 140 degrees: the malt felt very damp, and had but little ſmell.

At 165 degrees I examined it in the ſame manner as before, and could perceive no damp; the malt was very brown, and on being chewed, ſome few black ſpecks appeared.

Many corns, neareſt the bottom, were now become black and burnt; I placed my thermometer nearly there, and it roſe to 175 degrees: but as the particles of fire aſcending from the ſtove act on the thermometer in proportion to the diſtance of the ſituation it is placed in, through the whole experiment an abatement of five degrees ſhould be allowed, as near as I could eſtimate. Putting a little after my thermometer in the ſame poſition, where about half the corns were black, it ſhewed 180 degrees. I now judged, that the water was nearly all evaporated, and I obſerved, that the heap grew black apace.

Again, in the center of the heap raiſed in the middle of the pan, I found the thermometer at 180 degrees; the corn taſted burnt, the ſurface appeared, about one half part a full brown, and the reſt black. On being maſticated ſtill ſome

ſome white ſpecks appeared, which I obſerved to proceed from thoſe barley-corns, which had not been thoroughly germinated, and whoſe parts cohering more cloſely together, the fire, at this degree, had not penetrated. Their taſte was inſipid, the malt brittle, the ſkin ready to part. The thermometer was now more various, as it was nearer to, or farther from the bottom; and in my opinion all the true malt was charred.

I, nevertheleſs, continued the experiment, and at 190 degrees, ſtill found ſome white ſpecks on chewing the grain, the acroſpire always appearing of a deeper black or brown than the outward ſkin; the corn, at this juncture, fried at the bottom of the pan.

I ſtill encreaſed the fire; and the thermometer, placed in the middle between the bottom of the pan and the upper edge of the corn, ſhewed 210 degrees. The malt hiſſed, fried and ſmoaked abundantly. Though, during the whole proceſs, the grain had been kept ſtirring, yet on examination, the whole was not equally affected by the fire. I found a great part thereof reduced to perfect cinders, eaſily crumbling to duſt between the fingers, ſome of a very black hue, without gloſs, ſome very black, with oil ſhining on the outſide. Upon the whole, two thirds of the corn were perfectly black, and the reſt of a deep brown, but more or leſs ſo, as the grains were hard, ſteely, or imperfectly germinated. This was eaſily diſcovered by the length of the ſhoot: moſt of the grains ſeemed to have loſt their coheſion, and had a taſte reſembling that of high-roaſted coffee.

In the laſt ſtage of charring the malt, I placed over it a wine glaſs inverted, into which aroſe a pinguious oily matter, which taſted very ſalt. It may, perhaps, not be unneceſſary to ſay, that the length of time this experiment took up, was four hours, and that the effect it had, both on myſelf, and on the perſon who attended me, was ſuch as greatly reſembled that of inebriation.

Though, from the reſult of this experiment, ſome doubt may remain about the exact degree of heat in which malt charrs, which poſſibly it is equally difficult and unneceſſary to fix with the utmoſt preciſion, yet we ſee that black ſpecks appeared, when the thermometer was at 165 degrees; that ſome of the corns were entirely black at 175, and at 180; that the grains thus affected were ſuch as had been perfectly germinated, and that thoſe, which bore a greater heat, were defective in this reſpect. May we not, from thence, conclude, with an exactneſs, ſurely ſufficient for the purpoſes of brewing, that true germinated malts are charred in heats, between 175 and 180 degrees? as theſe correſpond to the degrees, in which pure alcohol, or the fineſt ſpirit of the grain itſelf boils at, does not that etherial enlivening principle diſengage itſelf from malted barley, by that heat? and are we not hereby inſtructed of one reaſon, why this grain is the fitteſt for the purpoſes of brewing?

SECTION XI.

Of the different PROPERTIES of MALT.

THE conſequences, reſulting from the before-mentioned experiment, have already been hinted at. But it is neceſſary to trace them farther, and to ſhew how much they may tend to the information and uſe of the brewer.

Germinated barleys, ſo little dried, as that their particles remain within their ſphere of attraction, are not in a preſervative ſtate, and cannot properly be termed malts.

The firſt degree of dryneſs, which conſtitutes them ſuch, is, as we have ſeen before, that which occaſions them to cauſe ſome effervеſcence. This cannot be effected, when they are dried with leſs than 120 degrees of heat, the higheſt that leaves them white. When urged by a fire of 175 degrees, they charr and turn black. Now this difference in heat, being 55 degrees, and producing, in the grain, ſo great an alteration, as from white to black, the different ſhades or colors belonging to the intermediate degrees of heat, cannot, with a little practice, eaſily be miſtaken.

White, we know from Sir Iſaac Newton's experiments, is a compoſition of all colors, as black is owing to the abſence of them. Theſe two terms indicate the extremes of the dryneſs of malt. The color, which a middling heat impreſſes upon it, is brown, which being compounded of yellow and red, the four tinges, which ſhade malt differently, may be ſaid to be white, yellow, red and black. The following table, conſtructed on theſe principles, will, on chewing the grain, readily inform the practitioner of the degree, to which his malts have been dried.

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A TABLE of the different degrees of the dryneſs of malt, with the changes of color occaſioned by each increaſe of the degrees.

Degrees.		
119	White	White
124	W, W, Yellow	white turning to a light yellow.
129	W, W, Y, Y,	light yellow inclining to amber.
134	W, W, Y, Y, Red,	Amber
138	W, W, Y, Y, R. R,	high amber, or firſt brown.
143	W, Y, Y, R, R,	Brown.
148	Y, Y, R, R,	middling brown.
152	Y, R, R,	high brown.
157	Y, R, R, Black	brown inclining to black.
162	Y, R, R, B, B,	high brown ſpeckled with black.
167	R, R, B, B,	blackiſh brown with black ſpecks.
171	R, B, B,	Coffee color.
176	Black	Black.

N. B. The ſeveral letters againſt each degree, it is apprehended, will help in practice to fix the color.

The

The foregoing table not only enables us to judge of the dryneſs of the malt by its color, but alſo, when a griſt is compoſed of ſeveral ſorts of malt, to foreſee the effect of the whole when blended together by extraction. Some ſmall error may poſſibly occur in judgments thus formed upon the report of our ſenſes; but as malts occupy different volumes in proportion to their dryneſs, if, in the practice of brewing, upon mixing the water with the malt, the expected degree is obſerved, ſuch parcel of malt may be ſaid to have been judged of rightly, in regard to its dryneſs. So that the firſt trial either confirms or corrects our opinion thereof.

Though malts, dried to 120 degrees, are in a preſervative ſtate, yet they are the leaſt ſo as malts. They ſtill poſſeſs the whole of their acids; which occaſions their fermentation and frettings often to return of themſelves, and with much violence: hence wines, formed from ſuch malts, are not of long duration, and ſoon become ſour. If the heat, which is made uſe of in the extraction of theſe malts, is kept up in proportion to that which dried them, even ſhould the fermentation be very cooly carried on, and the ales and beers be brewed in the moſt favorable ſeaſon, they will arrive at a ſtate of ripeneſs, in ſo ſmall a ſpace of time as two weeks. We may therefore conſider this, as the firſt fixed term, for obtaining a fermentable liquor, and ſuch a one indeed, which in the leaſt time will be fit for uſe.

When malts charr and become black, their parts are ultimately divided, they can ſcarcely poſſeſs any acids, nor conſequently remain ſuſceptible of fermentation; for fermentation is a diviſion of parts, and that cannot admit of a proper diviſion that is already too much divided. The degree of heat then, prior to that which produces this effect, is the laſt, which ſtill retains part of the fermentable properties. In malts thus highly impreſſed by fire, fermentation would proceed with ſo ſlow and reluctant a pace, that, in this caſe, the liquor might be ſaid to be in the utmoſt ſtate of preſervation. No term can be fixed for its duration. A liquor of this ſort, brewed with a heat ſimilar to that which dried the malt, might keep many years, and thus become rather more accommodated to the temperature of the place it was depoſited in, than to its own conſtituent parts. Experience has ſhewn, that two years are the limitted ſpace for drinks made from malts dried with 162 degrees of heat, before they be in a drinkable ſtate; and at this degree of heat, we have ſeen that the grains were of a very high brown and ſpeckled with black, and conſequently had many of their finer parts charred. From theſe two extremes, and on ſuch principles, the following table is formed, exhibiting the length of time that drinks made from malts of each reſpective degree of dryneſs properly brewed, and in the moſt favorable ſeaſon, will require, before they come to their due perfection to be uſed.

A TABLE, ſhewing the age beers will require, when properly brewed from malts of different degrees of dryneſs.

Degrees.		
119	White	2 Weeks.
124	W, W, yellow	1 Month.
129	W, W, Y, Y,	2 Months.
134	W, W, Y, Y, Red	4 Months.
138	W, W, Y, Y, R, R,	3 Months *.
143	W, Y, Y, R, R,	4 Months.
148	Y, Y, R, R	6 Months.
152	Y, R, R	12 Months.
157	Y, R, R, black	18 Months.
162	Y, R, R, B, B	2 Years.
167	R, R, B, B,	
171	R, B, B	
176	Black.	

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* When the medium heat of the dryneſs of the malt, and of the heat of the extracts are ſo high as to require the liquors to be forced or precipitated, in order to become pellucid, part of the oils, which ſupported them ſound, being carried down by the precipitant, they will be leſs capable of preſerving themſelves, after having been precipitated, than they were before.

It muſt be obſerved, that the foregoing table is conſtructed on the ſuppoſition, that theſe different ſorts of malt be brewed and fermented with the utmoſt care, and have a proper addition of hops; an ingredient which ſhall be conſidered in its proper place. What is meant by the *extracts being in proportion to the dryneſs of the malt*, may merit ſome explanation.

Grapes, when ripe, carry with them the water they have received, both during their growing ſtate, and that of their maturity. This quantity is ſufficient to form their muſts with. To dried grapes or raiſins, water is applied, to ſupply what they have loſt; and for the ſame reaſon it is requiſite in regard to malt: but as grapes ſtood in no need of artificial fire, to give to their fermentative principles a due proportion, ſo what they produced by themſelves, or by cold water added to them, when dry, is a ſufficient menſtruum. But barleys, wanting the aſſiſtance of a great heat to bring their parts to the neceſſary proportion, require alſo a ſimilar or rather a greater heat to reſolve them. Without that, the flour of the grain would come away undiſſolved, and thus conſiderably impoveriſh the griſt. Should, on the other hand, too great a heat be applied, an equal loſs would be ſuſtained, from ſome of the finer parts being coagulated or diſperſed. The proportioning therefore the heat of the water to the dryneſs of the malt, more eſpecially in reſpect to the ſtrength of the drink, is of real neceſſity.

It is certainly true, that we often ſee liquors brewed from very palemalts, preſerve themſelves for, and become fit to be drank

drank only in, a long time, and ſome brown malts ſo managed, as to give beers which ſoon will become ſtale. The firſt of theſe caſes happens, when the extracts are made with very hot water, and the latter, when the water is too cold for the purpoſe. Too much being extracted in one caſe, and too little in the other, the time, which improves the firſt drink, muſt neceſſarily ſpoil the latter. Our table indicates the medium, both of the dryneſs of the malt and of the heat of the extracts, and upon the ſuppoſition of an equality, always deſirable, between them, ſhews the ſpace of time, which the liquor may keep, before it is full ripe.

Well-brewed drinks ſhould not only preſerve themſelves ſound their due ſpace, in order to be meliorated by time; they ſhould likewiſe be fine and tranſparent. This may be eſteemed the moſt certain ſign of the artiſt's ſkill and care, as well as of the ſalubrity of the drink, and is at once the ſureſt mark and proof of a well-formed muſt, and of a perfect fermentation. If then the rules for obtaining theſe ends can be deduced from the foregoing principles, and experiments, we may flatter ourſelves with poſſeſſing a theory, which will anſwer our expectations in practice.

According to the laws of nature diſcovered by Sir Iſaac Newton, the ſpaces between the parts of opake bodies are filled with mediums of different denſities, and the diſcontinuity of parts, each in themſelves tranſparent, is the principal cauſe of their opacity. Salts in powder, or infuſed in in an improper medium, will intercept the light; gums make a muddy compound, when joined to ſpirits; and oils, unaſſiſted by ſalts, refuſe to be incorporated with water. Muſts therefore, which are not ſaponaceous, or in other words, whoſe conſtituent parts are not capable of being diſſolved by water into one homogeneous body, are not fit, either for a perfect fermentation or a pellucid drink.

When extracts are made with an improper degree of heat, that is, when either the malts are not ſufficiently dried, or the water is not powerful enough in heat, the oils of the malt do not mix perfectly with the water, and the liquor muſt be deficient in tranſparency.

On the other hand, extracts made with waters ſo hot, that the conſtituent parts are removed beyond their ſphere of attraction, or the oils coagulated ſo as to form a body ſeparate from the water, muſt needs be opake. Worts or muſts can never, in either of theſe caſes, yield a tranſparent wine; whereas with a due or mean heat, between theſe two, they muſt perfectly become ſo; and as they recede from this medium, they will be more or leſs valuable.

Length of time, which improves beers and wines, often rectifies our errors in this reſpect; for the oils being, by various frettings, more attenuated, and more intimately mixed, the liquor is frequently reſtored, and becomes of itſelf pellucid. Yet I never found this to ſucceed, where the error on the whole

whole of the dryneſs of the malt, and the heat of the extracts, exceeded the medium by 14 degrees.

Art has alſo, in ſome meaſure, concurred with nature, to remedy this defect. When beers or wines have been ſuffered to ſtand, till they are rather in an attracting than in a repelling ſtate, that is, when their fermentations and frettings have had their courſe; then, if they do not become ſpontaneouſly fine, they may be precipitated, by mixing with them a more ponderous fluid. The floating particles, that occaſioned the foulneſs, are, by this means, made to ſubſide to the bottom, and leave a limpid wine: but the power of diſſolved iſinglaſs, the ingredient generally uſed for this purpoſe, ſeldom takes effect, when the error exceeds the medium, as before, by more than 14 degrees.

Other ingredients, indeed, have been uſed, which carry this power near 10 degrees farther. It is not my province to determine, whether ſuch be ſalutary: undoubtedly it would be better if there were no occaſion for them. Beyond theſe limits, precipitation has no effect; the liquor, which cannot be fined thereby, if attempted, by increaſing the quantity of the precipitants, will be overpowered by the menſtruum, and injured in its taſte. How frequent this laſt caſe of *cloudineſs* is, would anſwer no purpoſe in this place to enquire. The uſe of doubtful ingredients, and ſuch errors as have been mentioned, need no longer blemiſh the art, when a conſtant and happy practice will be both the effect and the proof of a ſolid and experimental theory.

Beers which become bright of themſelves, or by time alone, as well as thoſe precipitated either by diſſolved iſinglaſs, or by more powerful means, each poſſeſs their reſpective properties in a certain latitude or number of degrees; and as theſe effects ariſe wholly from the heats employed in drying the malts, and in forming the extracts, the following table will be of uſe to point out the limits, within which each drink may be obtained.

A TABLE ſhewing the tendency beers have to become fine, when properly brewed from malts of different degrees of dryneſs.

Degrees.		
119	White	Latitude of pale malts, which, when properly brewed, ſoon become ſpontaneouſly fine, or where, as in pale ales, the fermentations are periodically repeated.
124	white, turning to a light yellow	
129	light yellow inclining to amber	
134	amber	
138	high amber or firſt brown	
143	brown	by precipitation theſe grow bright in a ſhort time.
148	middling brown	with precipitation theſe require from 6 to 12 months to be bright
152	high brown	
157	brown inclining to black	theſe may be fined by precipitation, but never will be bright
162	high brown ſpeckled with black	
167	blackiſh brown with black ſpecks	Theſe with difficulty can be brewed, without the goods being ſet, but will by no means become bright, not even with the help of the ſtrongeſt acid menſtruum.
171	coffee color	
176	black,	

Before this ſection is concluded, permit me to draw one inference more from the foregoing experiment. As malts charr and become black with the ſame degree of heat, at which alcohol boils, and as the effect the vapours riſing from them had on the perſons attending the experiment was a ſlight inebriation, it appears, that this ſpirit was reſident therein, and parted therefrom, when the heat was carried to the degree of ebullition. Hence, if dry and moiſt heats are equally capable of putting the grain into a ſtate of preſervation, malt ought not, when in poſſeſſion of the whole of its properties be made to indure ſuch moiſt heats as are equal to 175? Will not the extracts, by ſuch a degree, be, at leaſt in part, deprived of the ſpirit its moſt preſervative principle? and, as in fermentable muſts this ſpirit is not to appear diveſted of the other principles of the grain, ought it not to be intimately mixed with ſuch as are neceſſary, in order to ſoften, ſheath and retain it the deſired time?

Thus does the ſucceſs of this art depend on the inſtrument ſo often mentioned, which, by indicating the expanſions cauſed by different heats, becomes a ſure guide in our operations. I ſhall now cloſe this account of malt, as I did that of fermentation, by comparing with the principles here laid down the defects, which we, but too often, meet with in barley when malted.

SECTION XII.

OBSERVATIONS *on defective* MALTS.

IN the preceding enquiry, ſome of the defects of malts have been occaſionally mentioned: but as a perfect knowledge of the grain, eſpecially when it has undergone this proceſs, is a matter of no ſmall concern to the brewer, I ſhall now bring ſuch defects into diſtinct view, both to compare them with the foregoing principles, and that the knowledge of them may be more at hand, on every occaſion, when wanted.

Every different degree of heat acting on bodies cauſes a different effect: and this varies alſo, as ſuch heat is more or leſs haſtily applied. The growth of vegetables is in general ſubmitted to theſe laws; but yet I conceive there is ſome difference between germination and vegetation, which I beg leave to point out. The former ſeems to be the act cauſed by heat and moiſture, while the plume or acroſpire is ſtill enveloped within the teguments of the parent corn, and it is moſt perfectly performed by the gentleſt action, and conſequently by the leaſt heat, that is capable of moving the different principles in their due order. Vegetation, again, is that act which takes place, when the plant iſſues forth, and, being rendered ſtronger by the impreſſions of the air, becomes capable of reſiſting its inclemencies, or the warmth of the ſun-ſhine. Germination is the only act neceſſary for malting, the intention being ſolely to put in motion the principles of the grain, and not to puſh up the embryo to a plant. Now, as this begins in barley at the degree where the water firſt becomes fluid, or nearly ſo, the cold ſeaſon, when the thermometer ſhews from about 32 to 40 degrees, would ſeem the moſt proper for this purpoſe. How far its latitude may with propriety be extended, experience alone can determine. Maltſters continue to work ſo long as they think the ſeaſon permits, and leave off generally in may, when the heat of the water extends at a medium from 50 to 55 degrees. But the nearer they come to this medium, with the greater diſadvantage muſt they malt: as, by ſuch warmth, the veſſels of the corn are much diſtended, the motion of the fluids violent, and the finer parts too apt to fly off. Thus the coarſer oils, gaining admittance, the glandular parts become filled with an impure and leſs delicate ſulphur, which, inſtead of a ſweet, inclines to a bitter, taſte. This is ſo manifeſt, and ſo univerſally experienced, that in general brewers carefully avoid purchaſing what is termed *latter-made malts.*

Malt, which has not had a ſufficient time to ſhoot, ſo that its plume may have reached to the extent of the inward ſkin of the barley, remains overburthened with too large a quantity of earth and oils, which otherwiſe would have been expended in the acroſpire and radical veſſels. All thoſe parts of the corn, which have not been ſeparated, and put in a motion by the act of germination, will, when laid on the kiln to dry, harden and glutinize; no greater part thereof will

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be ſoluble in water, then ſo far as the ſtem or ſpire of the barley riſes to, or very little farther, and as much as is wanting thereof, will be loſt to the ſtrength of the drink.

When malts are ſuffered to grow too much, or until the ſpire is ſhot through the ſkin of the barley, which indeed is not often the caſe, though all that is left be malt, that is containing ſalts diſſoluble in water, yet as too large a portion of oils has been expended out of the grain, ſuch malts cannot be fit to brew drinks for long keeping. There is beſides a real loſs of the ſubſtance of the corn occaſioned by its being overgrown.

Malts, which have been but juſt enough grown, and have been duly worked upon the floors, if not ſufficiently dried on the kiln, even though the fire be excited to a proper heat, retain many watery parts. The corn, when laid together, will be apt to germinate afreſh, perhaps ſo to heat as to take fire, and ſhould it continue long in this ſtate, muſt at leaſt grow mouldy, and have but an ill flavor.

Malts well grown, and worked as before, but over dried, though with a proper degree of heat, will become of ſo tenacious a nature, as to require a long time, before they can admit of the outward impreſſions of the air to relax or mellow them, that is, before they be fit to be brewed with all the advantages they otherwiſe would have.

Malts dried on a kiln not ſufficiently heated muſt require proportionably a longer time to receive the proper effect of the fire; the want of which will bring them in the ſame ſtate as malts not thoroughly dried.

If too quick or fierce a fire be employed, inſtead of gently evaporating the watery parts of the corn, it torrifies the outward ſkin, divides it from the body of the grain, and ſo rarefies the incloſed air as to burſt the veſſels. Such are called *blown malts*, and, by the internal expanſion, occupy a larger ſpace than they ought. If ſuch a fire be continued, it even vitrifies, or at leaſt changes into a brittle ſubſtance, ſome parts of the grain, from whence the malts are ſaid to be *glaſſy*. Thoſe, which, from their being thus hardened and rendered of a ſteely nature, will not diſſolve, or but in a ſmall proportion, are very troubleſome and dangerous in brewing, as they frequently occaſion a total want of extraction, which is termed, *ſetting the griſt*.

Malts, juſt, or but lately, taken from the kiln, remain warm for a conſiderable time. Until they become equally cool with the ſurrounding air, they cannot be ſaid to be mellow, or in a fit ſtate to be brewed; for as their parts will be harſh and brittle, the whole of their ſubſtance cannot be reſolved, and the proper heat of the water, which ſhould be applied to them for that purpoſe, is therefore more difficult to be aſcertained.

The practice of thoſe maltſters, who ſprinkle water on malts newly removed from the kiln, to make them appear as having been made a proper ſpace of time, or, as they term it, to *plump* them, is a deceit which ought to be diſcouraged. By this practice, the circumſtance of the heat, and harſhneſs of the malt, is only externally and in appearance removed, and the purchaſer groſly impoſed on. The grain, by being thus heated, occupies a greater volume, and if not ſpeedily uſed, ſoon grows mouldy, heats, and is greatly damaged.

The direct contrary is the caſe of high dried malts, which have been made a long time: the dampneſs of the air has relaxed them, and ſo much moiſture has inſinuated itſelf into the grain, that ſome doubt muſt ariſe how much hotter the maſh ſhould, for this reaſon, be. Yet ſuppoſing no diſtemper, ſuch as being mouldy, heated, or damaged by vermin, is obſerved, malts, in this caſe, may more certainly be helped in brewing, than thoſe juſt abovementioned.

From what has been ſaid, it appears, how neceſſary it is to procure malts, which have been wetted and germinated to their true pitch, dried by a heat raiſed to a moderate, yet true, degree, ſo that the moiſture of the corn be duly evaporated, then cured in a manner to preſerve themſelves a due time, without being blown, vitrified, or burnt by too hot or haſty fires. I need not ſay how eaſy it is to regulate this proceſs in the ciſtern, on the floors, and on the kiln, when the maltſter uſes no artifice to ſave his exciſe. But with what certainty and eaſe the whole might be carried on by the help of the thermometer, I leave ſuch to determine, who are modeſt enough to think, that the art may be brought to more accurate rules than thoſe of the bare report of our unaſſiſted ſenſes. As ſuch rules may eaſily be deduced from the principles here laid down, I ſhall not be more particular in ſhewing their application, that not being my immediate purpoſe, nor my buſineſs as a brewer. I have neither leiſure, nor the conveniency of a malt-houſe, to make experiments of this ſort; yet I may with truth ſay, that ſuch as would not be diſappointed in their brewing, muſt take care not to be deceived in their malts. This, however, being but too frequently the caſe, it is undoubtedly uſeful to be aware of their faults, and know how to correct them. If they are treated in the ſame manner as if they were perfect, the well-malted parts alone will be digeſted. If they be too ſlack dried, they may be corrected by an addition of heat, and if overdried, or injured by fire, they may be proportionably helped. By applying the thermometer to the firſt extract, the brewer will, to a ſufficient degree of exactneſs, be informed of the defects he can mend, and hardly be ever at a loſs for the propereſt means he can ſafely employ.

I flatter myſelf, ſome ſatisfaction muſt ariſe from ſeeing both what is perfect, and what is defective in the principal proceſſes of this art, agreeing ſo well with its theory, and af-

affording ſo many proofs of its certainty; and though there be ſeveral incidents, (as yet unmentioned,) inſeparable from the practice, ſuch will only ſerve to confirm this truth, that, as our taſk is to imitate *nature*, it is our duty to inform ourſelves of, and induſtriouſly to be ſteady to, her laws.

Part II.

THE PRACTICE OF BREWING.

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BREWING.

BEFORE I enter upon the practical, and indeed moſt important, part of this work, it will, I think, not be improper to give a diſtinct, though general, view of the different parts it is to conſiſt of. Thus is a general map prefixed before any book of geography, to point out the countries deſcribed in it, and their connexion one with another.

To extract from malt a liquor, which, by the help of fermentation, may acquire the properties of wines, is the general object of the brewer, and the rules of that art are the ſubject of theſe ſheets.

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An art truly very ſimple, if, according to vulgar opinion, it conſiſted in nothing elſe than applying warm-water to malt, maſhing theſe together, multiplying the taps at diſcretion, boiling the extracts with a few hops, ſuffering the liquor to cool, adding yeaſt to make it ferment, and truſting to time, cellars, and noſtrums, for its taſte, brightneſs and preſervation!

This might be ſufficient, were the place and conſtitution of the air always the ſame, the materials and veſſels employed intirely ſimilar, and laſtly the malt drinks intended for the ſame uſe and time; but, as every one of theſe particulars is liable to variations, the rules, by which the artiſt is to govern himſelf, would only ſerve to deceive him, if he applied them indiſcriminately, or truſted to indefinite ſigns, and inſufficient maxims, in his deviation from them.

A more certain foundation has been laid down in our firſt part, and the principles there eſtabliſhed will, it is hoped, in all caſes, anſwer our ends, provided we make uſe of the proper means to ſettle their application. In order to effect this, nothing ſeems more proper than to follow, as much as poſſible, that plan, which the rational brewer would, in every particular circumſtance, ſketch to himſelf, before he proceeded to buſineſs. His firſt attention ought to be directed not only to the actual heat of the weather, but alſo to that which may be expected in the ſeaſon of the year he is in. The grinding of his malt muſt be his next object, and as the difference of the drinks greatly depends upon that of the extracts, he can but chuſe to have diſtinct ideas of what may be expected from each of them. Hops, which are added as a preſervative to the extracts, become too important a part of them, to be employed without a ſufficient knowledge of their power. The ſtrength of our malt liquors depending principally on their quantity or lengths, it is neceſſary to aſcertain the heights in the copper, which anſwer to theſe lengths. The differences in the boiling, with regard to different drinks or ſeaſons, the loſs of water by evaporation, the proper diviſion of it according to the different degrees of heat to be given, the means to aſcertain theſe degrees by determining what quantity of cold water is to be added to that, which is at the point of ebullition, as well as to a certain volume of griſt, come afterwards under the conſideration of the artiſt. He will next employ himſelf in aſcertaining the manner and time of maſhing, and as many unexpected incidents may have produced ſome ſmall variations between the actual and the calculated heat of his worts, it will be incumbent upon him to make a proper eſtimation and allowance for them. To diſpoſe theſe worts in ſuch forms and depths, as may render the influence of the ambient air the eaſieſt and moſt efficacious upon them, and then, by the addition of yeaſt, to ſupply the part of that internal and moſt powerful agent, which was loſt in boiling, are the next requiſites. The fermentation, which follows, and which the brewer retards or forwards according to his intentions, compleats the whole of his proceſs, and it muſt be an additional ſatisfaction to him, if, upon comparing his operations with thoſe of the moſt approved practitioners in his art, he finds himſelf able to account for thoſe ſigns and eſtabliſhed cuſtoms, which before were looſely deſcribed, authoratively dictated, and never ſufficiently determined or explained. An object of ſtill greater importance to him, is to know the proper ſtock of beer he ought to keep in order to have at all times a ſufficient quantity fit for uſe. As precipitation is requiſite in certain caſes, the common methods for effecting it ſhould be known, and likewiſe the means practiſed among coopers to correct the real or imagined errors of the brewer, and to render his drinks agreeable to the palate of the conſumers. This will naturally, and laſtly, lead him to conſider what true taſte is, and by employing the means, by which it may ſafely be obtained and improved, he will have done all what was in his power, to anſwer his cuſtomer's expectation, and to ſecure his ſucceſs.

This arrangement, which appears the moſt ſimple, is that, which the reader will find obſerved in the following ſections. The proper illuſtrations of tables and examples have not been omitted, and from the complete plans for brewing, under two forms of the moſt diſſimilar kind, which have been propoſed, it will be found that the rules are adapted to all circumſtances, and applicable to every purpoſe.

If, notwithſtanding my endeavours, ſome things ſhould appear out of their places, and ſome others in more than one, if redundancies, chiefly occaſioned by the natural temptation of accounting for particular appearances, have not always been avoid-

avoided, if, laſtly, inaccuracies ſhould now and then have eſcaped me, let it be remembered, (by the good-natured it certainly will,) that, in new and intricate ſubjects, digreſſions and repetitions are in ſome meaſure allowable, that an overfulneſs is preferable to an affected and too often obſcure brevity, and laſtly, that the improvement of the art, rather than the talent of writing, muſt be the brewer's merit, and was my only aim.

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SECTION I.

Of the heat of the air, as it relates to the practical part of brewing.

IN and about the city of London, the greateſt cold, that has been obſerved, is 16 degrees, and the greateſt heat has made the thermometer riſe to 87. Within theſe limits are comprehended all the fermentable degrees, and conſequently thoſe neceſſary for carrying on the proceſs of brewing. If the loweſt degree proper for fermentation be 40, and the higheſt 80, the medium of theſe two would, at firſt ſight, appear to be the fitteſt for this peculiar purpoſe. The internal motion, neceſſary to bring on fermentation, excites a heat ſuperior to the original ſtate of the muſt by 10 degrees. Hence if 60 degrees be the higheſt eligible heat a fermenting muſt ſhould ariſe to, 50 ſhould be the higheſt for a wort to be let down at to ferment. This can only be obtained, when the degree of heat in the air is equal thereto, and it denotes the higheſt natural heat for beers and ales to be properly fermented. With regard to the other extreme or the loweſt heat, however cold the air may be, as the worts, which form both beers and ales, gain by boiling, a degree greatly ſuperior to any degree allowed of in fermentation, it is conſtantly in the artiſt's power to adapt his worts to a proper ſtate. The brewing ſeaſon, then, may juſtly be eſteemed all that part of the year, in which the medium heat

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of the day is at, or below, 50 degrees, that is in our climate, from the beginning of October to the middle of May, or 32 weeks.

As the extractions are made by heats far ſuperior to any natural ones, though the actual temperature of the air neither adds to, or diminiſhes from, their ſtrength, yet it is to be known for the following reaſon. The proper heat is given to the maſh, by means of cold added to boiling water, and cold water generally is of no other heat than that of the air itſelf. Indeed, when the cold is ſo intenſe, as to occaſion a froſt, and to change water into ice, that which is then uſed for brewing, being moſtly drawn from deep wells or places, where froſt never takes place, may be eſteemed at 35 degrees, and this will be ſufficiently exact.

The following table ſhews the temperature of the air for every ſeaſon in the year, and confirms what I have juſt now ſaid concerning the time proper for brewing, and the actual heat of the water. It was deduced from many years obſervations made with very accurate inſtruments, at 8 o'clock in the morning, the time in which the heat is ſuppoſed to be the medium of that of the whole day.

A TABLE, ſhewing the medium-heat, for every ſeaſon of the year, in and about *London*, deduced from obſervations made from 1753 to 1759, at eight o'clock each morning.

	Degrees.		Degrees.
January 1 to . . . 15	36′ 38	July . . 1 to . . 15	60′ 52
to . . . 31	34′ 97	to . . 31	60′ 29
February 1 to . . 14	35′ 51	Auguſt 1 to . . 15	59′ 89
to . . 28	38′ 11	to . . 31	58′ 48
March 1 to . . 15	37′ 99	Septem. 1 to . . 15	55′ 17
to . . 31	39′ 72	to . . 30	54′ 13
April . 1 to . . 15	43′ 13	October 1 to . . 15	48′ 66
to . . 30	46′ 04	to . . 31	46′ 72
May . 1 to . . 15	49′ 05	Novem. 1 to . . 15	42′ 26
to . . 31	53′ 67	to . . 30	39′ 40
June . 1 to . . 15	57′ 20	Decem. 1 to . . 15	38′ 61
to . . 30	59′ 14	to . . 31	37′ 54

To

To aſcertain the authority of this table, and to make it uſeful to ſeveral purpoſes, I have carried to decimals the mean numbers reſulting from my obſervations. But ſuch an exactneſs has been found, in the practice of brewing, to be more troubleſome than neceſſary. I have therefore conſtructed another table ſimilar to the former, but where the fractions are omitted, and the whole numbers carried on from five to five. The heat, in the latter end of October and beginning of November, has been ſet down rather higher than it really is; as, at this time of the year, the hops fit to brew with are old and weak, and I could not deviſe any means more eaſy to allow for their want of ſtrength.

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A Table, ſhewing the medium-heat of the air, in and about *London*, for every ſeaſon of the year, applicable to practice.

	Degrees.		Degrees.
January 1		July . . 1	
to . . 15	35	to . . 15	60
to . . 31	35	to . . 31	60
February 1		Auguſt 1	
to . . 14	35	to . . 15	60
to . . 28	40	to . . 31	60
March 1		Septem. 1	
to . . 15	40	to . . 15	60
to . . 31	40	to . . 30	55
April 1		October 1	
to . . 15	45	to . . 15	50
to . . 30	45	to . . 31	50
May . 1		Novem. 1	
to . . 15	50	to . . 15	45
to . . 31	55	to . . 30	40
June . 1		Decem. 1	
to . . 15	55	to . . 15	40
to . . 30	60	to . . 31	35

As nothing is ſo inconſtant as the weather, we are not to be ſurprized when it deviates from the progreſſion ſpecified in the table. The flowing water uſed in the brewery, at the coldeſt ſeaſons, we have fixed at 35 degrees, and the higheſt heat to carry on the proceſs for beers brewed for long keeping at 50°. The length proper to be drawn, or the quantity of beer to be made from each quarter of malt being fixed, the brewer, at any time, has it in his power to make calculations for brewings, at 35, at 40, at 45, at 50, and even at any degree of heat whatever, ſo as never to be unprovided againſt any ſeaſon, which may happen. Water, being a body more denſe than air, requires ſome time to receive the impreſſions either of heat or cold, for which reaſon the medium heat of the ſhade of the preceding day will moſt conveniently govern this part of the proceſs, unleſs ſome very extraordinary change ſhould happen in the atmoſphere. This muſt make the buſineſs of the artiſt, in this reſpect, very eaſy, for he has only to correct the little changes that occaſional incidents give riſe to, and the calculations will anſwer all his purpoſes ſo long as the lengths of beer to be brewed from the ſame quantity of malt remain unaltered, or that the coppers he employs are the ſame.

The beſt method, to know the true heat of cold water, would be to keep a very accurate and diſtinct thermometer, in the liquor back, but as this, in every place, is not to be expected, and inaccuracies muſt ariſe from a change in the air, to prevent their conſequences in practice, we muſt have recourſe to experience. This has taught us that a difference of 8 degrees, between the actual heat of the water, and that from, which the brewing was computed, will produce in the firſt extract, a difference of 4 degrees.

Moſt brewers coppers, though they vary in their dimenſions, are generally made in proportions nearly uniform; the effect of one inch of cold water more or leſs will therefore nearly anſwer alike, that is, it will alter the heat of the tap by 4 degrees. But this will only hold good in ſuch caſes, where the water is in the ſame proportion to the volume of the griſt. In brewing brown beers or porter, three worts are generally made, and the extracts therefore muſt be of different lengths from what they are in beers brewed at two worts only. In this caſe, the water of the firſt extract, neceſſary to wet all the malt, being more in quantity than it otherwiſe would be, occaſions the ſecond to be proportionably leſs; and as it is of great conſequence, if the firſt tap doth not anſwer to its proper degree, that the ſecond ſhould be brought to ſuch a heat, as to make up the medium of the firſt and ſecond extracts, the ſecond or piece liquor, by reaſon of its ſhortneſs, is more conveniently and exactly tempered in the little copper; and one inch cooling is then found, both by calculation and experience, to occaſion a difference of one degree of heat.

One of the principal attentions, in forming beers and ales of any ſort whatever, is that they may come to their moſt perfect ſtate, at the time they are intended to be uſed. Common ſmall beer requires from one to four weeks, and as it is impoſſible to prejudge the accidental variations, as to heat and cold, that may happen in any one ſeaſon of the year, it is rational to act up to what experience has ſhewn is to be expected, and to mix ſuch quantity of cold water with that, which is made to come to ebullition, as to bring the extract to the degree fixed for each particular ſeaſon, let the heat, at the time of brewing, vary therefrom, in any degree whatever.

In treating on the ſubject of air in the former part of this work, I obſerved the effect it had in penetrating the parts of the malt, or in the technical term uſed by brewers, in ſlacking them. If this is the caſe, when the grain is entire and whole, it is more ſo when ground, and experience teaches us, that, when malt has been about 24 hours from the mill, the dampneſs it has imbibed is equal to half an inch more of cold water applied to the firſt liquor, and produces therefore a diminution of 4 degrees in the heat *.

An effect, ſomewhat reſembling to this, is cauſed by the impreſſion of the air on the utenſils of a brewhouſe, which are not daily uſed; the heat received from a foregoing proceſs has expanded their pores, and rendered them more ſuſceptible of cold and moiſture. From this circumſtance, the heat of the firſt maſh, will be affected in a proportion equal to half an inch cooling, or in the ſpace of 24 hours, to 4 degrees of heat.

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* I choſe this manner of expreſſing the quantity of moiſture received in ground malt from the air, as it is the moſt eaſy for the direction of the firſt extract.

The time of the day, in which this firſt extract is made, becomes another conſideration; for as 8 o'clock in the morning is the time of the medium heat in the whole 24 hours, the other hours will give different proportions. When a firſt maſh is made about 4 o'clock in the morning, the following table ſhews the difference between the heat at 4 and at 8; that of the other hours, in the like caſe, may be learned by obſervation. It has been obſerved, that, in the cold months, from the ſun's power being leſs, the heat of the day and night are more uniform, and alſo that the coldeſt part of the 24 hours is about half an hour, or an hour before ſun-riſing. I have judged it convenient, to place, in the ſame table, the ſeveral incidents affecting the firſt extract.

INCIDENTS occaſioned by the air affecting the heat of the firſt extract, to be noticed more particularly, when ſmall beer is brewed, as the quantity of water is then greateſt, and the maſh more ſuſceptible of its impreſſions.

Morning at 4	Colder by ſo many degrees than at 8 o'clock in the morning.
January	0
February	0
March	2
April	4
May	6
June	8
July	10
Auguſt	8
September	6
October	4
November	2
December	0

Utenſils, for want of being uſed, in 24 hours looſe 4 degrees of heat, equal to half an inch of cold water.

Malt, which has been ground 24 hours, imbibes moiſture equivalent to half an inch, which leſſens the heat by 4 degrees.

The difference between the actual heat of the air, and that naturally expected is to be allowed in proportion of 8 degrees to one inch.

Malts, from having been long kept, or old, become conſiderably ſlacked.

Before we quit this ſubject, it may not be improper to obſerve, that, in the hotteſt ſeaſon, and in the hotteſt part of the day, the difference between the heat of the air in the ſhade, and that in the ſun's beams, is about 16 degrees, and alſo that the cellars or repoſitories for beers are in winter generally hotter by ten degrees, than the external air, and in ſummer colder by five.

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SECTION

SECTION II.

Of GRINDING.

MALT muſt be ground, in order to facilitate the action of the water on the grain, which otherwiſe would be obſtructed by the outward ſkins. Every corn ſhould be cut for this purpoſe, but not reduced to a flower or meal, for, in this laſt ſtate, the griſt would not be eaſily penetrable. It is therefore ſufficient that every grain be divided into two or three parts, nor can there be any neceſſity for varying this, in one ſort of drink more than in another. The intention of grinding is the ſame, in every brewing, and the tranſparency of the liquor, mentioned by ſome people on this occaſion, depends, by no means, on the cut of the corn.

It has been a queſtion, whether the motion of the mill did not communicate ſome heat to the malt; but, if this ſhould be the caſe, it can be but in a very ſmall degree; and that muſt again be loſt by ſhooting the grain out of the ſacks, or uncaſing the griſt into the maſh ton.

We have before obſerved, that malt, by being ground and expoſed for ſome time to the air, more readily imbibes moiſture than when whole, and that the dampneſs, thus abſorbed by the grain, being in reality ſo much cold water, a griſt, that has been long ground, is capable of being impreſſed with hotter waters than otherwiſe it would require. In country places, where the

the people are ignorant, that a certain heat is neceſſary to form a proper extract with, and where, inſtead of the determinate degree, boiling water is indifferently applied, the effects of this error are in ſome meaſure prevented, by grinding the malts a conſiderable time, as a month or ſix weeks before the brewing. This method, from the inconſtant ſtate of the air, muſt be more uncertain than any other, and few or no arguments are neceſſary to explode it. The truth is, the merit of country ales ſo often mentioned, proceeds from the people not being obliged to tap their drink, but when it is in the fitteſt ſtate for uſe. Thus does time not only correct the errors of the operators, but alſo give them, in the eyes of the ignorant, the credit of an extraordinary knowledge and unmerited ability.

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SECTION III.

Of EXTRACTION.

EXTRACTION is a ſolution of part, or the whole, of a body, made by means of a menſtruum. In brewing, it is chiefly the mealy part of the grain that is required to be reſolved, and fire and water combined are ſufficient to perform this act. Water properly is the receptacle of the parts diſſolved, and fire the power, which conveys into the vehicle more or leſs of theſe parts.

When all the parts neceſſary to form a vinous liquor are not employed, or when more than are required for this purpoſe are extracted, the liquors muſt vary in their conſtituent parts, and conſequently be different in their effects. This difference ariſes either from heat alone, or from the manner of applying it; and the properties of beers and ales, will admit of as many varieties as may be ſuppoſed in the quantity of the heat, and in its application. But as the uſeful differences are alone neceſſary to the brewer, they may all be reduced to the four following modes of extraction.

Firſt, that which is moſt perfect, and for which the malt is choſen of ſuch dryneſs, and the extracts made with ſuch heats, as to give the beer an opportunity to be improved by time, and to become of itſelf fine and tranſparent.

Secondly, that, which occaſions the liquor to become tranſparent, but, for want of a ſufficiency of fire, does not allow it the advantages, which age procures to the firſt.

Thirdly, that, which, in order to obtain every advantage of time, produces ſuch extracts, as cannot become pellucid of themſelves, but do require precipitation.

Fourthly, that, which, by conveying a greater heat to the firſt extract, than is done in any of the preceding caſes, gives to the liquors the ſweet and ſoft taſte of wines formed from grapes ripened by the hotteſt ſun.

Theſe four modes of reſolving the grain, being the fundamental principles, on which almoſt every ſpecies of drink is brewed, I muſt be allowed to treat of them ſeparately, but firſt will ſet down a few general principles applicable to all.

As grapes, in their original ſtate, are acid, from having been formed under the lower degrees of heat, the firſt maſh or extract, in any kind of liquor, muſt be the leaſt in heat of the whole brewing: and as the acids of the grapes become saccharine by the encreaſed power of the ſun, the laſt maſh of every brewing muſt be ſo far raiſed by heat, as to extract a ſufficient quantity of oils, to ſmooth over the acids produced in the firſt extract, and cauſe the wort to become ſweet. Theſe oils, raiſed in different proportions, conſtitute what, in the muſt or wort, may be called the *degrees of ſaponaceouſneſs*.

In

In the table * ſhewing the different effects produced in the grain by the different degrees of heat, the numbers, with reſpect to worts, expreſs, not only the degrees of dryneſs in the malt, but alſo thoſe of heat in the extracting liquor to the medium of which the degree of power in the hops is likewiſe to be added. The heat of the firſt extracting water ought to be, at leaſt equal, if not ſuperior, to the heat which dried the grain, to give it a ſufficient power to open it, and not let fall any of its parts undiſſolved.

Fermentation, either in grape or barley wines, is kept back or accelerated, in proportion to the quantity of oils the muſt contains, and theſe are raiſed by heat alone. Nature points out, in what part of the proceſs of brewing this encreaſed heat ſhould be placed, as thoſe wines preſerve themſelves longeſt, whoſe grapes, every other circumſtance being the ſame, are germinated under a hotter ſun; it is therefore in the drying of the malts, and in the firſt part of the proceſs, that the heat ſhould be raiſed.

A muſt or wort, to be perfect, ſhould be formed ſo, as that its ſaponaceous properties keep an even pace with the fermentable ones. The properties of a true ſapo muſt then, as has before been ſaid, be eſtimated by the ſame ſcale as the degrees of fermentation, although their reſpective number be different. Thoſe of ſaponaceouſneſs are comprehended between the degree of heat, by which germinated barley is firſt changed into

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* Part I. Sect. XI. page 103.

malt, and the laſt degree of dryneſs, in which the malt preſerves the whole of its conſtituent parts. The firſt of theſe degrees is 119, and the laſt, by which the grain firſt begins to charr, 157. The difference is 38 *, which number, being deducted from the higheſt degree of heat applied to malt for any intended purpoſe, the remainder will be the loweſt. The extracts of all beers and ales, intended to become of themſelves tranſparent, muſt be formed on calculations, comprehending all the ſaponaceous or 38 degrees, and ſince perfect opacity is the effect of the total want of ſaponaceouſneſs, the intermediate ſtates may be expreſſed by the following table.

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* It might be ſuppoſed, that the real number of the ſaponaceous degrees of malt extends from 119 to 176, when it appears quite black and charred. But, malt, by ſo much as it turns to blackneſs, becomes defective, and improper for the true vegetable ſapo *fit for fermentation*, and therefore we are to ſtop, where that change firſt takes place, viz. at 157.

A TABLE, ſhewing the effects of the ſeveral ſaponaceous degrees.

38 Degrees——ſpontaneouſly bright.
33———by precipitation, bright from 6 to 9 months.
28———by precipitation, fine from 12 to 18 months.
24———by precipitation, fine in 24 months.
19——— cloudy
14———
9——— Different degrees of cloudineſs.
5———
0————opake.

Whenever opacity takes place, even in ſo ſmall a proportion as 32 degrees, precipitation muſt be uſed. When at 19 the powers of tranſparency and opacity being equal, an effect expreſſive of both will enſue, and a color properly belonging to neither be obſerved. The drinks will, in one light, appear tranſparent, and in another, opake; and this ſeems to be the true character of cloudy beers.

Though beers and ales are divided into ſtrong and ſmall, this diviſion regards only the proportion of the vehicle, and not that of the conſtituent parts. The ſame means, as to the heat of the extracts, muſt be employed, to form ſmall beers, capable of preſerving themſelves ſound for ſome time, as are uſed to make ſtrong and durable drinks: for though a ſmall liquor poſſeſſes more aqueous parts, the oils and ſalts of the malt are only more diluted,

diluted, but not altered in their proportions, and this cauſes but a very ſmall difference in the duration of the liquor.

It now remains to apply theſe rules, deduced from the theory, to the ſeveral ſorts of malt liquors, which anſwer to the four modes of extraction juſt before laid down.

The firſt and moſt perfect is, when the malt is choſen of ſuch dryneſs, and the extracts made with ſuch heats, as give the beers an opportunity of being improved by time, and of becoming ſpontaneouſly bright and tranſparent. Under this head, may be comprehended all *pale keeping ſtrong*, and all *pale keeping ſmall* beers.

From its name, regard muſt be had to the color of the malt, and ſuch only uſed, as is dried the leaſt, or by 119 degrees of heat.

The hops * ſhould likewiſe be pale, and their quantity uſed in proportion to the time the drink is intended to be kept; ſuppoſe in this caſe it is 10 months, 10lb of fine hops will be required.

The higheſt degree of heat, or rather the medium of the higheſt dryneſs in malt, with the mean heat of the ſeveral extractions to admit of ſpontaneous pellucidity, we have ſeen in the foregoing table (page 103) to be 138 degrees, and this me-

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* Though the conſideration of hops is the particular ſubject of the next ſection, I am under a neceſſity of anticipating here ſome parts of it. In all complicated ſubjects, this muſt neceſſarily be the caſe.

dium is choſen as it anſwers not only to the intent of long keeping, but of brightneſs alſo: and for this reaſon the whole number of ſaponaceous degrees muſt be employed in the calculation.

Method of determining the malt's dryneſs, the heat of the firſt and laſt extracts, and the value in degrees of the quantity of hops to be uſed, for brewing pale ſtrong or pale ſmall beers, intended to be kept about ten months, before they are uſed.

119 degrees, dryneſs of the malt

157 the higheſt medium of the extracting heats, becauſe, with the dryneſs of the malt, it makes a mean anſwerable, to the intent of duration and tranſparency, or 138 degrees.

276

138 as abovementioned

157 from above, is the mean of the extracts, as would occaſion pellucidity to be in its loweſt degree, but the preſervative quality in the higheſt, and therefore the greateſt heat, the firſt extract could bear for this purpoſe

38 the whole number of ſaponaceous degrees to be deducted

119 this then the loweſt ſaponaceous extract

157 this the higheſt ſaponaceous extract

276

276

276	
* 138	the middle ſapo, or heat of the firſt maſh or extract
164	the heat of the laſt maſh or higheſt degree of maturation, becauſe it is the only number, that will anſwer the following purpoſes
302	
151	the mean heat of the extracts, or of all the maſhes,
119	the malt's dryneſs
270	
135	medium of malt's dryneſs, and heat of the extracts
3	value of the virtue of the hops
138	the medium firſt intended.

The elements for forming pale ſtrong or pale ſmall beers, intended to be kept, are therefore the following,

Malt's dryneſs;	value of hops;	whole medium;	firſt maſh;	laſt maſh.
119	3	138	138 2	164 2

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* The middle ſaponaceous heat is made uſe of inſtead of the loweſt 119, becauſe preſervation, as well as tranſparency, is intended. This part of brewing is of the greateſt conſequence, and bears a remarkable analogy to the growth of grapes; for in the vine, the juices raiſed by the preceding autumnal ſun, reſiding ſtill in the ſtem and branches of the plant, mix with thoſe drawn up by the vernal heat, ſo that the grapes, though acid at their firſt forming, are at the ſame time, auſtere, and of a middle nature.

It is neceſſary to add two degrees to the heat of every maſh, ſuch being the mean of 4 degrees conſtantly loſt in every extract, at the time they are ſeparated from the griſt, and expoſed to the impreſſions of the air.

The ſecond mode of extraction is that, which makes a tranſparent, but not a durable liquor. Under this head are comprehended *common ſmall* beer, *brown* ales, and all malt liquors, becoming of themſelves fine, and ſoon fit for uſe.

Common ſmall beer is ſuppoſed to be ready for uſe, in winter, from two to ſix weeks, and in the heat of ſummer, from one week to three. Its ſtrength is regulated by the different prices of malt and of hops; its chief intent is to quench thirſt, and its moſt eſſential properties are, that in the winter it ſhould be fine, and in the ſummer ſound. This liquor is chiefly uſed in and about great cities, ſuch as London, where, for want of a ſufficient quantity of cellar room, drinks cannot be ſtowed, which, by long and ſlow fermentations, would come to a greater degree of perfection. The duration of this kind of liquor being ſhort, and there being a neceſſity of brewing it in every ſeaſon of the year, the incidents attending its compoſition, and the methods for carrying on the proceſs muſt be more various and complicated, than thoſe of any other liquor made from malt.

Beers intended for long keeping, are generally brewed, when they have the advantage of being ſet to ferment with a heat not exceeding 50 degrees, and as, in the coldeſt ſeaſons, the temperature of the cellars is in general at 45 degrees, and in the hotteſt at 65, the continued ſtate of liquors long kept is nearly at 55 degrees.

Common ſmall beer may, in winter, be impreſſed by ſuch a heat, but in ſummer, from the ſhortneſs of the duration of the liquor, this advantage can, but in part, be obtained. In proportion as it is brewed, in a hot or in a cold ſeaſon, we muſt employ every means, either to repel or to attract the acids circulating in the air; for this purpoſe, the degrees of dryneſs in the malt, and the quantity of hops muſt vary as ſuch ſeaſons do, as likewiſe the heat of the extracts, and the degree of temperature the wort is ſuffered to ferment with. The ſucceſs, in brewing common ſmall beer, greatly depends on its fermentation being retarded or accelerated as the ſeaſons require. Expanſion being the principal effect of heat, was a wort of this ſort ſuffered, in winter, to be ſo cold as 40 degrees, the air would, with difficulty, if at all, penetrate into the muſt, and put it in action. This ſlow fermentation would not permit the beer to be ready at the time required. For theſe reaſons, brewers let down their worts, in that ſeaſon, at 60 degrees, whereas in ſummer the air of the night is made uſe of to get them as cold as poſſible, by which means a part of them may be 12 degrees colder than the medium of the heat of the day, and the whole of the worts, nearly 5, in the ſpace of 24 hours.

The choice of the malt, as to its dryneſs and color, for brewing this liquor, is more arbitrary in the cold ſeaſon than moſt other

other circumſtances; the dryneſs forming only one part of the medium, which may be rectified by the heat given to the extracts. In the height of ſummer, malt dried to 130 degrees ſeems to be the beſt, as it unites the properties of ſpeedy readineſs, preſervation, and tranſparency, and theſe ſeveral characters are, at that time, requiſite in this liquor.

Was ſmall beer to be uſed, in winter, immediately after being brewed, malts dried to their firſt degree or to 119, would be moſt fit for that ſeaſon; but the intention is, that the drink be kept ſome ſmall time, and yet be readily fermented. Malt dried between the proper degree for the hotteſt time, or 130, and 119, which is the loweſt, anſwers this character. Suppoſing therefore, that, when the heat of the air is at 40, malt of 124 degrees of dryneſs be the propereſt, and when the medium heat is at 60, that malt of 130 degrees of dryneſs is fixed, the following table will, from the proportion of theſe two extremes, ſhew the proper color of the grain, for every fermentable heat.

Heat in the air.	Malts dryneſs.	Value of hops in degrees.
35	122	1
40	124	1
45	124	1
50	127	1
55	129	1
60	130	1
65	131	2
70	133	2
75	135	2
80	136	2

What has been ſaid for determining the dryneſs of the malt to brew ſmall beer with, according to the different ſeaſons, may, in ſome meaſure, be applied to the diſcovery of the heat, which is to be given to the extracting water. Dry and moiſt heats, are ſimilar as to their preſervative effects; to accelerate fermentation, in a cold ſeaſon, a leſſer heat is to be given to the extracts, than when, from the heat of the air, we are obliged to retard this operation. If no regard was to be had to the incidents attending the uſe of common ſmall beer, ſuch a dryneſs in the grain, and ſuch a medium heat in the extract, as would barely place it in a preſervative ſtate, or 119 degrees in both, would be ſufficient. In the higheſt fermentable heat, it would require that quantity of fire, by which the properties of the grain are ſtill preſerved, but, upon the leaſt increaſe, would begin to be diſperſed. The joint medium would then be 157 degrees. Though we know, that this is not exactly the caſe, with regard to ſmall beer, a table founded on this ſuppoſition will aſſiſt us, when we have found the mean of all the incidents attending this liquor.

Heat of the air.	Medium of the dryneſs of the malt and of the heat of the extracts.
40	119
45	124
50	130
55	134
60	138
65	143
70	148
75	153
80	157

It would be very deſirable, if it was poſſible, to fix a conſtant term for the duration of this liquor ; but this will vary in each different ſeaſon, and according to the primitive heat the wort is made to ferment under.

All muſts and worts contract heat, by the motion excited in the fermentable act ; the nearer this heat comes to 80 degrees, the leſs will the liquor keep ſound ; and in proportion as the heat approaches 40, the more reluctantly will the wort be brought to ferment. Sixty degrees, being the mean between theſe two extremes, ſeems, therefore, the higheſt heat a firſt regular

gular fermentation ſhould ariſe to. Beers, long to be kept, require more time to be under this act, and are not immediately brought to this heat; whereas, in common ſmall beer, where diſpatch is required, eſpecially in winter, the worts are at once ſet to ferment at a heat of 60 degrees, and ſoon after conveyed to cellars generally 50 degrees hot. The mean between theſe two, or 55 is therefore the degree of heat, which ſmall beer endures, when the air is at the firſt fermentable degree of heat, or 40 degrees. This, according to the foregoing table, (page 145) ſhews that the medium of the dryneſs of the malt and of the heat of the extracts is to be 134 degrees, upon the ſuppoſition that the drink is uſed immediately, or at leaſt as ſoon as ſettled after the firſt fermentation is over. But we have already obſerved, that, in this ſeaſon, ſmall beer is expected to keep from 4 to 6 weeks, and to find out what addition is to be made on that account to the medium of 134 degrees, we muſt compare this liquor, under a fermenting heat of 60 degrees, to ſome other drink of a longer duration, nearly alike in quality, and make a proper allowance for their difference in heat, under the firſt fermentation.

The firſt mode of extraction, or that of pale ſmall beer intended to be kept long, furniſhes us with a liquor fit for this compariſon. It is generally brewed when the heat of the air is at 40 degrees; the heat it is put at firſt to ferment with is 50, and when riſen to its higheſt pitch, it comes to 60: the medium of the dryneſs of the malt and of the heat of the extracts for keeping ſmall beer, abſtracted from the value of the hops, we have fixed at 135 degrees in the account of its conſtituent parts, page 140. Such a drink, with 10 wt. of hops for every quarter of malt, will keep as many months. Was the medium of the degrees of dryneſs in malt, and of the extracting heat of common ſmall beer, when the temperature of the air is at 40, to be 135 degrees, the wort ſet to ferment at firſt with a heat of 50 degrees, together with 3 wt. of hops to every quarter of malt, would preſerve itſelf ſound for three months. But, as we have obſerved, common ſmall beer, in winter, is made immediately to ferment, at a heat of 60 degrees; the difference between 60° and 50°, being 10°, will produce in the effects, a difference of 8° in the numbers of the table, page 145; and ſince theſe 8 degrees are equal to 3 months keeping, 4° will anſwer to 6 weeks. The medium of theſe 4° only muſt be added to the medium before found, or 55°, and will bring it to 57°; conſequently the number 136, or rather, on account of the hops, 137° ought to take place in the proceſs of common ſmall beer, when the heat of the air is at 40 degrees.

This governing number for the firſt fermentable degree of heat in the air being diſcovered, it is neceſſary to ſeek the governing number of the other fermentable extreme, but this, being attended with a variety of circumſtances, can only be fixed, by making, from experience, proper allowances for them.

In cold weather, as the temperature of the air is nearly uniform, during the term of the natural day, worts cool almoſt as faſt at one time as at another; but the caſe is quite different in ſummer, the evenings and nights are employed to obtain the greateſt cold; fermentation, at this ſeaſon, is likewiſe carried on with more violence, being rather forwarded than checked by the exterior air. This internal agitation is often increaſed by the beers being conveyed from place to place, in the midſt of the day, and in the ſun-ſhine. Large cities are generally more hot in ſummer-time, than country places, where the buildings are leſs crowded, and as our obſervations, for the medium heats of the natural day, were made at Hampſtead, an allowance muſt be made on this account. The difference in the heat of the cellars, at this time, need but little regard, and will at moſt produce an abatement of one degree, as thoſe, which are allotted for common ſmall beer, are none of the beſt, and the exterior air is ſuffered to have a free acceſs to them.

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When 60 degrees are the mean heat of the day, a firſt wort, by being expoſed to the air until evening, may be let down at	60 degrees.
A laſt wort, by receiving the benefit of the evening's and night's cold	48
	108
The mean heat	54
Heat gained by fermentation	10
Allowance for the preſervative quality, as before	2
Heat gained, by the drink being conveyed in the ſun	3
Difference of heat between London and Hampſtead	2
	71
Deduction for the cold received in the cellars	1
	70 degrees.

Now this number anſwers in the table, (page 145) to that of 148 for the dryneſs of the malt and the heat of the extracts, to which one degree more is to be added for the value of the hops. The two extremes being thus fixed, the intermediate ſpace for every degree of heat in the air, in which common ſmall beer is to be brewed, is eaſily determined. The heat of the firſt and laſt extracts, for any particular caſe, will be ſettled by the ſame rules, as were employed for pale ſtrong and pale ſmall beers long to be kept. One example, ſhewing how this method holds good throughout the whole, will be ſufficient, and ſhew the means, by which the following table was formed.

When the air is at 40, the degree of dryneſs fixed for malts to be uſed for common ſmall beer is 124, and the medium of their dryneſs and the heat of the extracts, together with the value of the hops added thereto, is 137 degrees.

◆

124	Malt's dryneſs
150	the higheſt medium of the extracting heats
274	
137	the medium intended
150	higheſt extracting medium as before
38	whole number of ſaponaceous degrees
112	loweſt ſaponaceous heat for this purpoſe
150	higheſt extracting heat, the 1ſt maſh could bear for this purpoſe
262	
131	heat of the firſt maſh
165	heat of the laſt maſh
296	
148	medium of the extracting heats
124	dryneſs of malt
272	
136	medium of malt's dryneſs and heat of extracts
1	value of hops
137	medium ſought for, and directed as above

The medium of the heat loſt in the maſh tun, amounting to two degrees, is added to the heat of the firſt and laſt maſh in the following table. In the hotteſt ſeaſon, the laſt extracts for common ſmall beer are made to exceed 175 degrees, a heat which alcohol boils at, but this is at a time when the malts are far from poſſeſſing the whole of their properties, and if ſuch a heat was not uſed at that time, the number of degrees of ſaponaceouſneſs could not take place to regulate the heat of the firſt maſh, and the liquor would not retain a ſufficient quantity of acids to be capable of fermentation, or become tolerably clear. Theſe two circumſtances experience ſhews to be preferable to ſome increaſe in the duration and ſtrength of the drink.

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A TABLE *of the elements for forming common ſmall beer, at every degree of heat in the air, with the allowance of two degrees of heat, in the firſt and laſt extractions.*

Heat of air.	malt's dryneſs.	value of hops.	medium of the heat of the extracts and malt's dryneſs.	heat of firſt maſh.	heat of laſt maſh.
35	122	1	135	131	165
40	124	1	137	133	167
45	125	1	140	138	172
50	127	1	143	142	176
55	129	1	146	146	180
60	130	1½	149	151	183

From a due obſervation of this table, it appears, how neceſſary it is for brewers to be acquainted, not only with the daily temperature of the air, but alſo with the medium heat of ſuch ſpaces of time, wherein a drink like this is expected to preſerve itſelf. This I have eſtimated for every 14 days; but as the event may not always exactly correſpond with our expectations, an abſolute perfection in this drink, as to its tranſparency, is not to be expected. It greatly depends on the care and attention given to it, and on the temperature and quieſcent ſtate of the cellars it is placed in. The firſt of theſe circumſtances is often ne-

neglected, and the other hardly ever obtained, as the places, where common ſmall beer is kept, are generally the worſe of the kind. When the heat of the air is ſo hot as 60 degrees, ſuch diſadvantages muſt naturally accompany the brewing of this liquor, that all, what can be expected from art at this time, is to make it anſwer ſomewhat near to the properties required in it.

The third mode of extraction is that, which, in order to gain every advantage of time, produces ſuch drinks, as cannot become ſpontaneouſly pellucid, but require the help of precipitation.

The improvement, which every fermented liquor gains by long ſtanding, is very conſiderable; the parts of the grain, which give ſpirit to the wine, being, by repeated fermentations, more and more attenuated, not only become more light and pungent, but alſo more wholeſome. If, in order to give to beers this preſervative quality, more oils are extracted, in proportion to the ſalts, tranſparency cannot take place; but, when the heat employed for this purpoſe does not exceed certain limits, this defect may eaſily be remedied, and the drink be fined by precipitation; and as time enables it to take up part of the very oils, which at firſt prevented its tranſparency, it will, by long ſtanding, become both brighter and ſtronger.

Where the demand for a liquor is conſtant and conſiderable, but the quantity required not abſolutely certain, it ought to be brewed in a manner that time may increaſe its merit, and precipitacipitation render it almoſt immediately ready for uſe. Theſe circumſtances diſtinguiſh this claſs of extraction, and juſtify the preference given to *porter* or *brown* beer, which come under that mode.

It appears, by the table (page 103.) that drinks brewed from malts, affected by heats, whoſe medium is 148 degrees, require from 8 to 12 months with precipitation to become bright; and as this is the age generally appointed for brown beers to be drank at, 148 degrees will give the medium of the heat of the extracts, and of the dryneſs of the malt.

The quantity of hops, neceſſary for the preſerving of pale beers, has been obſerved to be one pound weight to every quarter of malt, for every month the liquor is intended to be kept; but hops employed for theſe pale ſtrong drinks are ſuppoſed to be new, and ſtrong, whereas, in porter, where the price does not keep an equal pace with the value of the commodity, hops, rather leſs in quality, are thought to be ſufficient. Their quantity is, on this account, encreaſed from 12 to 14 pound, *per* quarter, and their value eſtimated in the calculation to 3° 75 which, being deducted from 148, ſeem to indicate malts of 144 degrees; but, as the dryneſs of the malt muſt conſtantly be leſs than the heat it is impreſſed with, was grain uſed of this degree of dryneſs, this neceſſary circumſtance could not take place. Therefore the higheſt dried of the pale kind, or the firſt degree of the brown, has been fixed upon as more eligible, eſpecially as it conduces to a more ſucceſsful precipitation.

In

In the drinks before examined, the whole number of ſaponaceous degrees or 38 has been conſtantly employed, they being intended to become ſpontaneouſly bright; but, as this quality is in the preſent caſe only required with the aſſiſtance of precipitation, the numbers 32 or 33, in the table ſhewing the effects of the ſeveral ſaponaceous degrees (page 137) ſeem the propereſt to anſwer our purpoſe, as they correſpond nearly to the time this liquor is in general made uſe of. Theſe conditions being premiſed, the proper degrees of the firſt and laſt extract for porter will be found by the ſame rules as were uſed before.

138 Malt's dryneſs
158 higheſt mean of extracting heats

296

148 the medium of the malt's dryneſs and heat of extracts, with the value of the hops required

158 as above
32 number of ſaponaceous degrees employed in this proceſs

126 loweſt ſaponaceous heat for this brewing
158 higheſt ſaponaceous heat

284

142 heat of the firſt maſh
160 heat of the laſt maſh

302

151

151 true medium of the extracts
138 dryneſs of the malt

289

144½ medium heat of malt's dryneſs, and heat of extracts
3¾ value of the effect of the hops

148¼ medium ſought for and directed as above.

* * *

The elements, for brewing brown ſtrong beer, with two degrees added to the firſt and laſt extracts, for what is loſt in their parting from the malt.

Malt's dryneſs;	value of hops;	whole medium;	firſt maſh;	laſt maſh.
138	3¾	148	144	162

It may be obſerved, that 3¾ degrees are charged for the quantity of hops uſed; as this number correſponds to the quantity proper to form beer of this denomination. A greater or a leſs proportion of hops is indeed ſometimes allowed to this drink, on account of its better or inferior quality, of the neceſſity there may be to render it fit for uſe in a ſhorter time than that which is commonly allowed, viz. from 8 to 12 months, and laſtly of old, ſtale, or otherwiſe defective drinks blended with new guiles. In theſe caſes, which cannot be too rare, the errors ſhould be corrected only by the addition of hops, and no alteration be made, either in the dryneſs of the malts, or in the heat of the extracts.

The fourth mode of extraction is that, which, by conveying a greater heat to the firſt maſh, than is done in the preceding caſes, gives to the liquors, commonly known by the names of *pale ale, amber or twopenny*, the ſofteſt and richeſt taſte malt can poſſibly yield, and makes them reſemble wines formed from grapes ripened by the hotteſt ſun.

As wines have, in general, been named from the town or city, in the neighbourhood of which the grapes, from which they are made, are found growing, this has, though with leſs reaſon, been in ſome meaſure the caſe, with our numerous claſs of ſoft beers and ales. Theſe topical denominations can indeed conſtitute no real or at leaſt no conſiderable difference, ſince the birth place of any drink is the leaſt of all diſtinctions, where the method of practice, the materials employed, and the heat of the climate are ſo nearly alike.

The ale, we have now under conſideration, is to be pale; the dryneſs of the malts ſhould therefore be from 119 the firſt degree to 130, when the color begins to change to amber. As this drink is expected to be rich with the grain, this laſt dryneſs is not to be exceeded, the ſtrength of the extract enhancing the color. The liquors of this ſort, generally brewed in and about London, are from malts of 124 degrees in dryneſs, or what are termed pale.

Ales are not required to keep a long time; ſo the hops beſtowed upon them, though they ſhould always be of the fineſt color and beſt quality, are proportinably fewer in the winter,

than

than in the ſummer The reaſon is, that the conſumption made of this liquor in cold weather is generally for purl,* whereas in ſummer, as it is longer on draught, it requires a more preſervative quality.

Where pungency in taſte and length of preſervation are intended, the heats of the firſt extracts ought to be the mean between the higheſt and loweſt; but, where a muſt, as in this caſe, is required to lay long expoſed, and to reſiſt to, the acid particles floating in the air, ſuch an extraordinary power muſt be given to the oils, as is equal to the time it is to be expoſed to the air, which is at leaſt three times more than what is required for common ſmall beer. As fermentation acts more powerfully on worts, in proportion to the heat of the air, the extracts for ale worts being always uniform, are, in the hot ſeaſon, inriched with oils, from the increaſed quantity of hops, which checks and retards the violent agitation theſe worts would otherwiſe be liable to. The following calculation, where the firſt extract is impreſſed with a degree of heat, determined by this rule, has been found by experience conducive to ſucceſs; but tranſparency being one of the neceſſary properties of this drink, the whole medium ought never to exceed 138 degrees, and in proportion as the heat is raiſed in the firſt extract, it muſt be depreſſed in the laſt.

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[*] *Purl*, is pale ale, in which bitter aromatics, ſuch as wormwood, orange peel, &c. are infuſed, uſed by the labouring people, chiefly in cold mornings, and a much better and wholeſomer relief to them than ſpirituous liquors.

124 malt's dryneſs
152 higheſt heat.

276

138 medium of malts dryneſs and heat of extracts

152 higheſt extracting heat, the firſt maſh could bear
38 whole number of ſaponaceous degrees; as pellucidity is expected,

114 loweſt ſaponaceous heat

152 from above, this multiplied by 3 for the reaſons juſt given

456
114

number of the higheſt and loweſt ſaponaceous heats. 4 [570

143 heat of the firſt extract
155 heat of the laſt extract

298

149 mean heat of the extracts
124 malts dryneſs

273

136½ medium of dryneſs of malt and heat of extracts
1½ medium of the value of hops uſed in every ſeaſon

138

138 medium of the whole required.

The elements, for brewing pale ale or amber, with the allowance of 2 degrees for the heat left in the extracts.

malts dryneſs	value of hops	medium of the whole	heat of firſt maſh	heat of laſt maſh
124	1½	138	145	157

The time, this liquor is intended to be kept, ſhould entirely be governed by the quantity of hops uſed therein; for this ale being required to become ſpontaceouſly fine, the medium of the whole or 138 degrees cannot be exceeded. In and about London, and in ſome countries in England, theſe ales, by periodical fermentations, are made to become fine, ſooner than naturally they would do, and often in a ſhorter time than one week. The means of doing this, by beating the yeaſt into the drink, as it is termed, has by ſome people been greatly blamed, and thought to be an ill practice. An opinion of the yeaſt being unwholeſome has prevailed; and ſome brewers, erroneouſly led by this, and yet willing that their commodity ſhould appear of equal ſtrength with ſuch as had undergone repeated fermentations, have been induced to add ingredients, to their worts, if not of the moſt deſtructive nature, at leaſt very unwholeſome. The plain truth is, that, by returning the elaſtic air in the fermenting ale, the effects of long keeping are greatly imitated,

tated, though with leſs advantage as to flavor and to ſtrength; but as this caſe relates to fermentation, we ſhall have hereafter an opportunity of farther explaining it.

It is under this claſs, that the famous *Burton ale* may be ranked, and if I dont miſtake, it will be found, that its qualities and intrinſic value will be the ſame, when judiciouſly brewed in London or elſewhere, from whence it may be exported at much cheaper rates to Ruſſia and other parts, than where it is increaſed in price by a long and chargeable land-carriage.

We ſhould now put an end to this ſection, but as other drinks are brewed beſides thoſe here particularly treated of, I ſhall juſt mention them, to ſhew, how their different proceſſes are reducible to the rules juſt laid down.

Brown ale is a liquor, whoſe length is generally two barrels from one quarter of malt, and which is not intended for preſervation. It is heavy, thick, foggy, and therefore juſtly grown in diſuſe. The hops uſed in this liquor differ in proportion to the heats of the ſeaſon it is brewed in, but are generally nearly half the quantity of what is employed, at the ſame times, for common ſmall beer. The ſyſtem, it ought to be brewed upon, is not different from that of this laſt liquor, the medium of the malt's dryneſs and heat of the extracts are the ſame for each degree of heat in the air, and it requires the ſame management when under fermentation. But though common pale ſmall beer and brown ale are ſo much alike in their theory, yet, from the difference of the dryneſs of the malt which, for brown ale, is conſtantly ſo high as 138 degrees, the practice will appear greatly

greatly different. Small beer is made after this ale, by the ſame rules as that made after pale ale or amber; the malts muſt, in that caſe, be valued according to their original dryneſs, and eſtimated at the medium, as if no extract had been taken from them. No ſmall beer brewed after ales can ever be equal in goodneſs to ſuch as are brewed from entire griſts; but that which is made after brown ale, from the grain being ſo highly dried and nearly exhauſted in the firſt proceſs, is neither nouriſhing or fit to quench thirſt.

Brown ſtout is brewed with brown malt, as amber is with pale; the ſyſtem for brewing theſe liquors is the ſame, allowing for the difference in the dryneſs of the malt. The overſtrength of this drink has been the reaſon of its being diſcontinued, eſpecially ſince porter or brown beer has been brought to a greater perfection. That, which is brewed, with an intent of being long kept, ſhould be hopped, in proportion to the time propoſed, or the climate it is to be conveyed to.

Old hock requires the ſame proportion of hops, as are uſed in keeping pale ſtrong or keeping pale ſmall beer; but more or leſs according to the time it is intended to be kept before it becomes fit for uſe. The length is about two barrels, from a quarter of the paleſt and beſt malt. As ſpontaneous pellucidity is required, its whole medium muſt not exceed 138 degrees, for the drying and extracting heat. The management of it, when fermenting, is under the ſame rules with the liquor juſt now mentioned, or thoſe which are allowed a due time to become of themſelves pellucid.

Dorcheſter

Dorcheſter beers, both ſtrong and ſmall, range under the ſame head. They are brewed from barlies well germinated, but not dried to the denomination of malt. The rule of the whole 138 degrees for the medium, muſt, even with this grain, be obſerved to form theſe drinks; but, from the ſlackneſs of the malt and the quantities of ſalt and wheaten flour mixed with the liquor, when under fermentation, proceed its peculiar taſte, its mantling, and its frothy property.

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SECTION IV.

Of the NATURE *and* PROPERTIES *of* HOPS.

THE conſtituent parts of malt, like thoſe of all vegetable ſweets, are ſo inclined to fermentation, that, when once put in motion, it is difficult to retard their progreſs, retain their preſervative qualities, and prevent their becoming acid. Among the many means put in practice, to check this forwardneſs of the malt, none promiſed ſo much ſucceſs as blending with the extracts the juices of ſuch vegetables, which, of themſelves, are not eaſily brought to fermentation. Hops were ſelected for this purpoſe, and experience has confirmed their wholeſomeneſs and efficacy.

Hops are an aromatic, grateful bitter, endued with an auſtere and aſtringent quality, and guarded by a ſtrong reſinous oil. The aromatic parts are volatile, and diſengage themſelves from the plant with a ſmall heat. To preſerve them, in the preceſſes of brewing, the hops ſhould be put into the copper, as ſoon as poſſible, and be thoroughly wetted with the firſt extract, while the heat of the wort is at the leaſt, and the fire under the copper has little or no effect thereon. Whoever will be at the trouble to ſee this performed, by the means of rakes or otherwiſe, will be made ſenſible, that the flavor is retained, which, when the wort comes to boil, is conſtantly diſſipated in the air.

The bitter is of a middle nature, or ſemivolatile; it requires more fire to extract it, than the aromatic part, but not ſo much as the auſtere or aſtringent. Hence it is plain, that the principal virtues of this plant are beſt obtained by decoction, and that the auſtere parts do not exhibit themſelves, but when urged by ſo violent and long continued boiling, as is ſeldom, or never practiſed in the brewery. It would be greatly ſatisfactory to fix, from experiments, the degrees of heat, that firſt diſperſe the aromatic, next the bitter, and laſtly the auſtere parts: and it is likely that, by this means, a more eaſy and certain method of judging of the true value and condition of hops, than any yet known, might be diſcovered.

This vegetable is ſo far from being, by itſelf, capable of a regular and perfect fermentation, that, on the contrary, its reſinous parts retard the aptneſs which malt has to this act. Hops, in this manner, keep barley-wines ſound a longer ſpace of time, and by repeated and ſlow frettings, give an opportunity to the particles of the liquor to be more ſeparated and comminuted. Fermented liquors acquire thus a greater pungency, ſo that, even if they did receive no additional ſtrength from this mixture, the direct contrary of which might eaſily be made to appear, ſtill would hops, from the circumſtance juſt mentioned, be the occaſion of an improvement of taſte and an increaſe of ſtrength.

Dr. Grew ſeems to think, that the bitter of the hops may be increaſed by a greater degree of dryneſs; but perhaps this is only one of the means of retaining longer this quality, which undoubtedly decreaſes through age, in a proportion which, as near as can be gueſſed, is from ten to 15 *per cent* yearly.

The varieties in the ſoil, and in the ſeaſons, in which hops are planted, may alſo have ſome ſhare in their inequality. They ſeem to be much benefitted by the ſea air. Whoever will try ſimilar proceſſes with the Worceſterſhire and Kentiſh hops, will ſoon perceive the difference, and the general opinion ſtrengthens this aſſertion, as the county of Kent alone produces nearly half the quantity of hops uſed in this kingdom.

The ſooner and the tighter hops are ſtrained after having been bagged, the better will they preſerve themſelves. The opinion that they increaſe in weight, if not ſtrained until after Chriſtmas, may be true, but will not recommend the practice; the hops imbibe the moiſture of the winter air, which, when the weather grows drier, is loſt again, together with ſome of the more ſpirituous parts. Nor is this the greateſt damage occaſioned by this delay, as hops, by being kept ſlack bagged in a damp ſeaſon, too often become mouldy.

Hops may be divided into ordinary and ſtrong, and into old and new. The denomination of old is firſt given to them, one year after they have been bagged. New ordinary hops, when of equal dryneſs, are ſuppoſed to be alike in quality, with old ſtrong ones.

The different teints, with which hops are affected in brewing, afford the beſt rule for adapting their color to that of the malt; in general the fineſt hops are the leaſt, but the moſt carefully, dried.

To extract the reſinous parts of the hops, it is neceſſary they ſhould be boiled. The method of diſpoſing them is generally to put the whole quantity, in the firſt wort, which being, always made with waters leſs hot than the ſucceeding extracts, poſſeſſes the greateſt ſhare of acids, and is in want of the largeſt proportion of reſins and bitters to defend it. The virtue of the hops is not entirely loſt by once boiling, and there remains ſtill enough to bitter and preſerve the ſecond wort. But where the firſt is ſhort of itſelf, and a large quantity of hops are required for the whole, it is needleſs and waſteful to put more in at once than the firſt muſt can abſorb, which appears by a thin bitter pellicle floating on the wort. No particular rules can be given to avoid this inconveniency, as the nature and quantity of the worts on one ſide, and the ſtrength of the hops on the other, muſt occaſion a difference in the management eaſily determinable by experience.

Hops carry with them into the wort large quantities of air, the more of which a wort poſſeſſes the more it is inclinable to ferment: and, as fire expels air, the more hops a wort contains, the longer a liquor is intended to be kept, or the hotter the ſeaſon is in which it is brewed, the longer boiling it requires.

When

When waters, not ſufficiently hot, have been uſed, the worts, for want of the proper quantity of oils, readily admit of the external impreſſions of the air, and are eaſily excited to a ſtrong and tumultuous fermentation, which diſperſes the bitter particles, and diminiſhes the effects of the hops. The virtue of this plant is therefore retained in the drinks, in proportion to the heat of the extracts, and the ſlowneſs of the fermentation.

Hops ſhould be uſed in proportion to the time that the liquors are to be kept, and the heat of the air in which they are fermented. As the medium heat which dried the malt is added to that of the extracts, the value of the oils, raiſed by the drying of the hops, is likewiſe to be added to the medium of the malt's drying and of the heat of the extracts.

The quantity requiſite to preſerve any drink a twelve month being known, and how much is neceſſary to keep beers or ales four weeks, when the air is at 40 degrees, tables may be formed aſcertaining the proper quantities to be uſed in all caſes.

Experience has ſhewn that 12 pounds of hops of a good quality, joined to one quarter of malt, are a ſufficient preſervative for one twelve month. * It has likewiſe been found that 15 pounds produce upon the worts the ſame effect, as if 5

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* This rule only takes place for ſuch climates, as are of the ſame heat with ours; for when drinks are brewed to be expended in more ſouthern countries, or to undergo long voyages, twenty pounds of hops to one quarter of malt have been uſed with ſucceſs.

degrees more of heat had been added to that of the extracts. The calculations to prove this would be long and unneceſſary, and the effect of hops as well as that of the malt may be judged of by the color of the extract. I would only add that hops, after they have been boiled for one purpoſe, are ſometimes and eſpecially in ſmall beer brewed after pale ales, uſed for another, and may then be ſuppoſed to have loſt three fourths of their virtue.

After having premiſed theſe obſervations, the conſtruction as well as utility of the following tables will be obvious.

◆ ◆ ◆

A TABLE of the value of the hops expreſſed in degrees, to be added to the medium of the dryneſs of the malt, and of the heat of the extracts.

Hops	new or ſtrong	pale, low dried, old
15 ℔ equal	5	3¾
12	3¾	3
8	2½	2
4	1¼	1

A TABLE

A TABLE of the quantity of hops requiſite for every quarter of malt brewed for porter, ſuppoſed to be fit for uſe from eight to twelve month.

	℔
Old ordinary hops ſtarted over old beer -	14 *per* quarter
d° neat guiles - - - -	12½
Strong good old hops when ſtarted over old beer	12½
d° neat guiles - - -	12
New ſtrong hops when ſtarted over old beer	12
ditto neat guiles - - - -	11½
New ordinary hops ſtarted over old beer -	12½
ditto neat guiles - - -	12

N. B. The quantity of old beer to be blended with new is here ſuppoſed never to exceed one eight part of the whole quantity.

A TABLE of the quantity of hops requiſite for common ſmall beer, for each quarter of malt, in every ſeaſon.

Heat in the air	new hops		old hops	
	℔	oz.	℔	oz.
35°	2	8	2	8
40	3	0	3	0
45	3	8	3	8
50	4	4	4	8
55	5	0	5	8
60	6	0	6	8
65	6	12		
70	7	8		
75	8	4		
80	9	0		

The medium heat of the hotteſt days in England, ſeldom at any time, exceeds 60 degrees, but I continued the table proportionably, as the quantities are here ſet down from repeated experiments. It appears, that, as, at the loweſt fermentable degree of heat, 3 pounds of hops are required for each quarter of malt, at the higheſt, 9 pound of hops ſhould be allowed for each quarter.

A TABLE of the quantity of hops neceſſary to each quarter of malt in brewing amber or two-penny.

Heat of the air	℔	oz.
35°	1	6
40	2	0
45	3	0
50	4	0
55	5	0
60	6	0

Amber is a liquor, which, by repeated periodical fermentations, is ſo attenuated, as to be ſoon fit for uſe, and by its ſtrength is ſuppoſed to reſiſt longer the impreſſions of the air than other liquors, eſpecially in winter; for this reaſon, though ſoon fit for uſe in this ſeaſon, it requires fewer hops than common ſmall beer, and wants only the ſame quantity in the ſummer, from its fermentations being quick and violent.

A TABLE of the quantity of hops neceſſary for each quarter of malt, in brewing Burton ale.

This liquor requires fewer hops than ſuch ales, which are more diluted by water: as it is always brewed in the winter, the quantities here ſet down are for the number of months it is ſuppoſed to be kept, before it is drank or bottled.

Months	℔	oz.
1	1	0
2	1	8
3	2	0
4	2	8
5	3	0
6	3	8
7	4	0
8	4	8
9	5	0
10	5	8
11	6	0
12	6	8

Though common amber, keeping amber and Burton ales require the ſame degree of heat in their extracts, yet ſome ſmall exception muſt be made to this rule, on account of the different quantity of hops uſed.

Beſides

Beſides the uſe of hops for keeping the muſts of malt, they may be alſo employed to ſtrengthen the extract, or at leaſt to give it a power to reſiſt infection or acidity. One or two pounds in a net ſuſpended in the water the extract is to be made with, are ſufficient for that purpoſe.

Though the purchaſing the materials, uſed in any manufacture, does not immediately relate to its practical part, yet as, in this caſe, it is of great importance to the brewer to know what ſtock it is prudent for him to keep of an ingredient equally neceſſary and variable in its value, I hope the attempt of a calculation on this ſubject will eaſily be pardoned.

The amount of the duty upon hops, for 13 years, from 1733 to 1745, was £. 704198, which ſum, eſtimating the duty at 21*s.* *per* bag, gives 670665 bags uſed in that time. At the beginning and expiration of this interval, hops ſold at that high price, at which no ſtock in hand is ſuppoſed to remain, viz. from £. 8 to £. 10. *per* hundred. If, therefore, to the aforeſaid quantity of 670665 bags, which may be ſuppoſed to have ſerved for the whole conſumption during this period, we add what may have eſcaped paying duty, and ſomewhat for the greater demand for this commodity at this time than it was twenty years ago, the annual conſumption of hops may be eſtimated at 65000 bags. From theſe premiſes, the following table was conſtructed, which, though not capable of abſolute certainty, may be of ſome ſervice to the brewers, in informing them of the quantities, that probably remain in hands at any time, and the ſtock which prudence will ſuggeſt them to lay in.

A TABLE ſhewing the medium price, hops ſhould bear, and determining the quantity to be purchaſed, in proportion to the ſtock in hand.

Prices of hops at a medium *	ſtock of new and old hops in the whole kingdom, after the harveſt	quantity of hops equal to as many weeks conſumption.
30 Shill.	130000 bags	70
35	125000	65
40	120000	61
45	115000	57
50	110000	53
55	105000	47
60	100000	44
70	95000	40
80	90000	36
90	85000	32
100	80000	28
110	75000	24
120	75000	20
130	70000	16
140	67000	12
150	65000	8
160	62000	4
170	60000	
180	57000	
190	55000	
200	52000	

---

* Forty ſhillings *per* hundred weight are ſuppoſed to be the mean difference between new and old hops, and ought to be eſtimated in proportion to the quantity of old left in hand, and that of new hops grown, in order to aſcertain the value of the laſt.

SECTION V.

Of the LENGTHS *neceſſary to form* MALT-LIQUORS *of the ſeveral denominations.*

BY length, in the brewery, is underſtood the quantity of drink made from one quarter of malt. Beers and ales differ in this reſpect; and the particular ſtrength allowed to every ſort of drink varies alſo ſomewhat, according to the prices of the materials. This increaſe or abatement is however never ſuch as to make the profits certain or uniform; for the value of the grain being ſometimes double of what it is at other times, a proportionable diminution in ſtrength can by no means take place.

It might be expected to find here tables determining the differences in ſtrength and quality of each drink, in proportion to their prices and the expences of the brewer. But this, on many accounts, would be inconvenient, and in ſome reſpects impracticable. He, who chuſes to be at this trouble, ought not only to take in his account the prices of malt and hops, and the duties paid on each commodity, but the hazards in the manufacturing of them, thoſe of leakage, of bad cellars, and of careleſs management, the frequent returns attended with many loſſes, the wearing out of utenſils and eſpecially of caſks, which laſt article engroſſes at leaſt one fifth of the brewer's capital, the charges of ſervants, horſes, and carriages for the delivery

delivery of the drinks, the duties paid immediately to the government without any ſecurity for the reinburſement, at leaſt in point of time, the large ſtock and credit neceſſary to carry on this trade, and many other incidents hardly to be eſtimated with a ſufficient accuracy, and never alike to every brewer. In general it appears, that the expences of malt and hops are ſeldom more than equal to the charge attending the manufacture, or about half the value of the drinks. Hence this concluſion, ſenſibly felt by every honeſt trader, muſt reſult, that, from change of circumſtances, the reputation of the profits has outlived the reality of them, and that a trade, perhaps the moſt uſeful to the landed intereſt and to the government, of any, ſeems diſtinguiſhed from all, by greater hazards and leſs encouragement.

But, in a treatiſe like this, where only the rules, upon which true brewing is founded, are laid down, I would avoid any thing, that might, though undeſignedly, give handle to invidious reflections, and ill-timed controverſies. I therefore content myſelf, with ſetting down the latitudes of lengths generally allowed to drinks of every denomination.

◆

Lengths of common ſmall beer.

$4\frac{1}{4}$ Barrels to $5\frac{1}{4}$

Lengths of keeping ſmall beer.

$4\frac{3}{4}$ Barrels to $5\frac{1}{2}$

Lengths of amber or pale ale.

$1\frac{1}{2}$ Barrel to $1\frac{3}{4}$

Lengths of brown ſtrong or porter.

$2\frac{1}{4}$ Barrels to $2\frac{3}{4}$

Lengths of Burton ale.

1 Barrel to $1\frac{1}{4}$

} from one quarter of malt.

SECTION VI.

METHOD *of* CALCULATING *the* HEIGHT *in the* COPPER *at which Worts are to go out.*

THE expected quantities or lengths of beer and ale can only be found by determining what height of the copper the worts muſt be at.

Brewers have ſeveral methods of expreſſing to what part they would have the worts reduced by boiling. *Braſs*, is the technical appellation for the upper rim of the copper; it is a fixed point, from which the eſtimation generally takes place, either by inches, or by the nails, which rivet the parts of the copper together. Theſe laſt are not very equal, either in the breadth of their heads, or their diſtances from each other. Inches then, though not ſpecified on the copper, but determined by the application of a gauge, on which they are marked, claim the preference. The neceſſity of coppers being gauged, and the contents of what they contain on every inch, both above and below braſs, known, muſt appear in a ſtronger light, the nearer we bring the art to exactneſs. The following tables will ſhew the moſt uſeful manner, in which I conceive this gauging ſhould be ſpecified.

Gauges

Gauges of coppers.

Great copper ſet up November 30. 1750.

		* B.	F.	G.	
	17 - -	15	3	4	Full
	16 - -	15	2	1	
	15 - -	15	0	5	
	14 - -	14	2	8	
	13 - -	14	1	4	
	12 - -	13	3	7	
	11 - -	13	2	3	
	10 - -	13	0	6	
Inches above Braſs.	9 - -	12	3	2	
	8 - -	12	1	5	Current of Great Copper allowed.
	7 - -	12	0	1	
	6 - -	11	2	4	
	5 - -	11	0	8	
	4 - -	10	3	3	
	3 - -	10	1	7	
	2 - -	10	0	2	
	1 - -	9	2	6	
	Braſs -	9	1	1	
	1 - -	8	3	8	
	2 - -	8	2	6	
	3 - -	8	1	4	
Inches below Braſs	4 - -	8	0	2	
	5 - -	7	2	8	
	6 - -	7	1	6	
	7 - -	7	0	4	
	8 - -	6	3	3	
	9 - -	6	2	2	

Little copper ſet up Auguſt 3. 1753.

		B.	F.	G.	
	15 - -	11	2	7	
	14 - -	11	1	5	
	13 - -	11	0	3	
	12 - -	10	3	1	
	11 - -	10	1	7	
	10 - -	10	0	6	
	9 - -	9	3	4	
Inches above Braſs.	8 - -	9	2	2	
	7 - -	9	0	8	
	6 - -	8	3	6	
	5 - -	8	2	5	
	4 - -	8	1	3	Current of Little Copper allowed.
	3 - -	8	0	1	
	2 - -	7	2	7	
	1 - -	7	1	5	
	Braſs -	7	0	5	
	1 - -	6	3	5	
	2 - -	6	2	5	
	3 - -	6	1	5	
	4 - -	6	0	5	
Inches below Braſs.	5 - -	5	3	5	
	6 - -	5	2	5	
	7 - -	5	1	5	
	8 - -	5	0	5	
	9 - -	4	3	4	
	10 - -	4	2	5	
	11 - -	4	1	6	

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* B. ſtands for barrels, F. for firkins, G. for gallons.

By the foregoing table, it is ſeen that my great copper holds nearly 9 barrels of water to braſs, and as the difference of the volume between boiling worts of moſt denominations and cold water, is nearly as 7 to 9, the quantity it will yield of boiling worts will be but 7 barrels. The diameter of this copper juſt above braſs, is 68 inches, at a medium, and at that mean it holds 12 gallons 7 pints of cold water or nearly 11 gallons of boiling worts, upon an inch.

Hops macerated, by being twice boiled, take up for every 6 pound weight a volume, in the copper, equal to 4 gallons and $\frac{1}{2}$ of water or a *pin.*

In a copper, the gauges of which have juſt been ſet down, it is required to know, what number of inches a length of 24 barrels muſt go out at, with 15 pounds of hops, the guile of beer to be brewed at 2 worts.

24 barrels, length of beer.
14 barrels, for two full braſs,

10
34 numbers of gallons to a barrel accounted by the exciſe, out of the bills of mortality

40 hops twice put in 15 lb. is 30
30
6 lb. [30
340
gallons of 22 5
boiling wort equal to gallons 4 ½
upon an inch 11 [362
22

33 inches above braſs, the 2 worts to go out together.

When 3 worts are boiled, the amount of three full braſſes muſt be deducted from the length; and as the hops go into the copper three times, they become more macerated, and take up much leſs room. The proportion is then nearly of 18 pounds of hops for each 4 gallons ½.

Thus in coppers, which have never been tried or uſed, we are able, by the gauges alone, to determine our lengths; but as their circumferences are not always exact, and the worts are of very different ſtrengths, we ſhould never neglect ſuch tryals, as may bring us nearer to accuracy and truth.

SECTION VII.

Of BOILING.

IT has been a queſtion, whether boiling is neceſſary to a wort; but as hops are of ſo reſinous a quality, that the whole of their virtues is not yielded by extraction, decoction or boiling is as needful as the plant itſelf, and is, together with fermentation, productive of that uniformity of taſte in the compound, which conſtitutes good beer.

Worts are compoſed of oils, ſalts, water, and perhaps ſome ſmall portion of earth, from both the malt and hops. Oils are capable of receiving a degree of heat much ſuperior to ſalts, and theſe again ſurpaſs in this reſpect the power of water. Before a wort can be ſuppoſed to have received the whole of the fire it can admit of, ſuch a degree of heat muſt ariſe, as will be in a proportion to the quantity of the oils, the ſalts and the water. When this happens, the wort may be ſaid to be intimately mixed, and to have but one taſte. The fire, made fiercer, would not increaſe the heat, or more exactly blend together the conſtituent parts; this purpoſe once obtained, the boiling of the worts is completed.

It follows from thence, that ſome worts will boil ſooner than others, receive their heat in a leſs time, and be ſaturated with leſs fire; but, as it is impoſſible and indeed unneceſſary to eſtimate exactly the quantities of oils, ſalts and water contained in each different wort, it is out of our power to fix, for any one, the degree of heat it is capable of. This renders the thermometer in this caſe uſeleſs, and obliges us to depend entirely on experiment, and to obſerve the ſigns, which accompany the act of ebullition.

Fire, as before has been mentioned, when acting upon bodies, endeavours to make its way through them in right lines. A wort ſet to boil, makes a reſiſtance to the effort of fire, in proportion to the different parts it is compoſed of. The watery particles are, it is imagined, the firſt, which are ſaturated with fire, and, becoming lighter in this manner, endeavour to riſe above the whole. The ſalts are next, and laſt of all the oils. From this ſtruggle, proceeds the noiſe heard, when the worts firſt boil, which proves how violently they are agitated, before the different principles are blent one with an other. While this vehement ebullition laſts, we may be ſure that the worts are not intimately mixed, but when the fire has penetrated and united the different parts, the noice abates, the worts boil ſmoother, the ſteam, inſtead of clouding promiſcuouſly as it did at firſt round the top of the copper, riſes more upright, in conſequence of the fire paſſing freely in direct lines through the drink, and when the fierceneſs of the fire drives any part of the drink from the body of the wort, the part ſo ſeparated aſcends perpendicularly. Such are the ſigns, by which we may be ſatisfied that the firſt wort, or the ſtrongeſt part of the extracts, has been ſo affected by the fire as to become nearly of one taſte. If, at this time, it is turned

out

out of the copper, it appears pellucid, and forms no conſiderable ſediment.

The proper time, for the boiling of the worts, has hitherto been determined, without any regard to theſe circumſtances; hence the variety of opinions, on this ſubject, greater perhaps than on any other part of the proceſs. While ſome brewers would confine boiling to ſo ſhort a ſpace as five minutes, there are others, who believe two hours abſolutely requiſite. The firſt alledge, that the ſtrength of the wort is loſt by long boiling; but this argument will not hold good againſt the experiment of boiling worts in a ſtill, and examining the collected ſteam, which appears little elſe than mere water. Thoſe, who continue boiling the firſt wort a long time, do it in order to be ſatisfied, that the fire has had its due effect, and that the hops have yielded the whole of their virtue. They judge of this, by the worts curdling, and throwing out flakes like ſnow. If a quantity of this ſediment is collected, it will be found to the taſte both ſweet and bitter, and if boiled again in water, the decoction, when cold, will ferment and yield a vinous liquor. Theſe flakes, therefore, contain part of the ſtrength of the wort; they conſiſt of the firſt and choiceſt principles of the malt and hops, and by their ſubſiding, become of little or no uſe.

It appears from theſe circumſtances, that boiling a firſt wort too ſhort or too long a time is equally detrimental, that different worts require different times, and that theſe times can only be fixed by obſervation.

The

The firſt wort having received, by the aſſiſtance of the fire, a ſufficient proportion of bitter from the hops, is ſeparated therefrom. The hops being deprived of their virtues, are, on the other hand, inriched with ſome of the glutinous particles of the malt. They are afterwards a ſecond and ſometimes a third time boiled with the following extractions, and thereby diveſted, not only of what they had thus obtained, but alſo of the remaining part of their preſervative qualities. The thinneſs and fluidity of theſe laſt worts render them extremely proper for this purpoſe. Their heat is never ſo intenſe as that of the firſt wort when boiling; becauſe they conſiſt of fewer oils and are incapable of receiving ſo great a degree of heat. This deficiency can only be made up by doubling or tripling the ſpace of time the firſt wort boiled, ſo that what is wanted in the intenſeneſs of the heat be ſupplied by its continuance.

The following table is conſtructed from obſervations made according to the foregoing rules.

◆

A TABLE ſhewing the time each wort requires to boil for the ſeveral ſorts of beer, in every ſeaſon.

Degrees of heat in the air.	Brown beer, keeping pale ſtrong and keeping ſmall beer.			Small beer.			amber	Burton	ſmall after amber	keeping ſmall after amber
	hours	hours	hours.	hours	hours	hours.	hours	hours	hours	hours.
35°	1	2	4	½	1	2	½	½	1	2
40	1	2	4	½	1	2	½	½	1	2
45	1	2	4	½	1	2	½	½	1	2
50	1	2	4	½	1	2	½	½	1	2
55	1	2	4	1½	3		¾	¾	1	2
60	2	4	0	1½	3		¾	1	1½	2
	1 wort	2 wort *	3 wort	1 wort	2 wort	3 wort.				

It may, perhaps, be objected, that, by a long boiling of the laſt worts, the rough and auſtere part of the hops may be extracted, and give a diſagreeable taſte to the liquor; but let it be obſerved, that, this only happens, either in beers long to be kept, or in ſuch as are brewed in very hot weather. In the firſt caſe, the roughneſs wears of by age, and grows into ſtrength, and in the laſt, it is a check to the proneſs muſts have in ſuch ſeaſons to ferment.

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* When there are but two worts in brown ſtrong, keeping ſtrong, keeping pale ſmall, or common ſmall, the boiling is to be obſerved as marked for the ſecond and third worts.

One obſervation more is neceſſary under this head; moſt coppers, eſpecially ſuch which are made in London, and ſet by proper workmen, waſte or ſteam away, by boiling, about three or four inches of the contained liquor, in each hour. The quantity waſted being found on tryal, and knowing how much water the copper holds upon an inch, the quantity loſt by boiling in each brewing may eaſily be eſtimated.

SECTION VIII.

Of the QUANTITY *of* WATER *waſted; and of the application of the preceding rules to two different proceſſes of brewing.*

WASTE water, in brewing, is termed that, which, though of ſervice in the proceſs, yet does not remain in the beers or ales when made. Under that head is comprehended the water ſteemed away in the boiling of the worts; that which is loſt by heating for the extracts; that which the utencils imbibe when dry; that which neceſſarily remains in the pumps and underback; and more than all the water which is retained in the griſt. The fixing to a minute exactneſs how much is thus expended, is both impoſſible and unneceſſary. Every one of the articles juſt now mentioned varies in proportion to the griſt, to the lengths made, to the conſtruction and order of the utencils, and to the time employed in making the beer. To theſe different cauſes of the ſteam being leſſened or increaſed, might moreover be added every change in the atmoſphere. However, as, upon the whole, the quantity of water loſt varies from no reaſon ſo much as from the age and dryneſs of the malt, experience is in this caſe, our ſole and ſureſt guide. I have, in the following table, placed under every mode of brewing, how much I have found neceſſary to allow for this waſte.

Brown ſtrong and pale ſtrong beers.

	Barrels	pins.	
For old malts allow - - - - - - -	1	5	*per* quarter
For new * malts - - - - - - - - -	2	0	*per* quarte
Keeping ſmall and common ſmall beers.			
For either new or old malt allow - -	2	4	*per* quarter
Amber or pale ales.			
For either new or old malt allow - -	1	4	*per* quarter
Keeping ſmall or common ſmall after amber.			
Allow for waſte. - - - - - - - -	0	2	*per* quarter

It is now time to begin the account of two brewings, which admit of the greateſt variety, both in themſelves, and in the ſeaſon of the year. The ſame proceſſes will be carried on, in the ſequel of this work, until they be completed.

On the 10th of July a brewing for common ſmall beer is to be made with 6 quarters of malt.

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* By new malt, I underſtand ſuch, as has not loſt the whole of the heat received on the kiln, and by old ſuch, as is of equal heat with the air, by having laid more than a ſufficient time to be thoroughly impreſſed therewith.

By page 123 the medium heat of the air at this time is - - - - - - - - - -	60 degrees
By page 144 the malt to be be uſed for this purpoſe ſhould be in dryneſs at. - -	130 degrees

By page 172 the proper quantity of new hops is 6 pounds *per* quarter. The length, according to the exciſe gauge without the bills of mortality, may be rated at 5 barrels $\frac{1}{8}$ *per* quarter, or from the whole griſt at 30 barrels $\frac{3}{4}$.

By page 183, the inches required in the copper, to bring out this length, at 2 worts, will be, for coppers as gauged page 181, 56 inches in the 2 worts above braſs.

The ſtate of this part of the brewing is therefore;

Six quarters of malt dried to 130 degrees, 36 pounds of hops for 30 barrels $\frac{3}{4}$ to go out at 56 inches above braſs.

30 $\frac{3}{4}$	Length
	Boiling by page 188 1 wort 1 hour $\frac{1}{2}$ or 5 inches
5 $\frac{1}{4}$	2 wort 3 hours or 9 inches
15	waſte water page 191
51	barrels; whole quantity of water to be uſed.

And by page 153 we find the heat of the firſt extract to be 151 degrees, and the heat of the laſt 183 degrees.

The

The other brewing, of which I purpoſe to lay down the proceſs in this treatiſe, is one for brown beer or porter of 11 quarters of malt, to be brewed on the 20th of February.

By page 123 the medium heat of the air at this time is - - - - - - - - - } 40 degrees

By page 155 the malt for this purpoſe ſhould be at } 138 degrees

By page 171 the quantity of hops is 12 pounds *per* quarter. The length I would fix for this liquor, according to the exciſe gauge without the bills of mortality, is 2 barrels and 4 pins from a quarter, or from the whole griſt 27 barrels ½.

By page 183 the inches required, in a copper, ſuch as I have ſpecified page 181, to bring out this length at 3 worts, are 29 above braſs.

The ſtate of this brewing, ſo far as we have conſidered it, is therefore 11 quarters malt dried to 138 degrees, 132 pounds of hops for 27 barrels ½ to go out at 29 inches above braſs.

27 ½ barrels the length
boiling by page 188
{ 1 wort 1 hour or 4 inches
2 wort 2 hours or 6 inches
8 ¼ 3 wort 4 hours or 12 inches
18 waſte water page 191 old malt
1 ⅝ *per* quarter
——
54 barrels, whole quantity of water to be uſed

[illegible] page 157 we find the heat of the firſt extract to be [illegible] and the heat of the laſt extract 162.

SECTION

SECTION IX.

Of the DIVISION of the WATER for the reſpective WORTS, and MASHES, and of that of the heat adequate to each of theſe.

THAT the whole quantity of water, as well as that of heat, required in any brewing, ought not to be applied at once to the griſt, is obvious, both from reaſon, and from the example of nature, who, in forming the juice of the grape, divides the proceſs, and increaſing ſucceſſively both the moiſture and the heat, gives time to each degree to have its complete effect. A diviſion of the water and heat applied to the griſt is equally neceſſary, but previous to this diviſion the following general rules may be laid down.

The griſt is, if poſſible, at no time, to be left with leſs water than what will cover the malt, and put all its parts in action. In the firſt maſhes for ſtrong beer, an allowance is to be made for as much water as the griſt will imbibe; and laſtly the whole quantity of water, uſed in brewing, ſhould be divided, according to ſome proportion analogous to that of the degrees of heat.

Proceſſes for brewing are carried on, either with one copper, or with two. Though the firſt of theſe methods is almoſt

moſt out of uſe, it may be neceſſary to give an example or two of the diviſion of the water uſed in this caſe.

In brewing with one copper, ſcarcely more than three maſhes can be made; otherwiſe the time taken up in boiling the worts and preparing the ſubſequent waters for extraction would be ſo long, as to cauſe the griſt to loſe great part of its heat, and perhaps become ſour. The whole water required might naturally be divided into three equal parts, was it not for the quantity imbibed in the firſt maſh; but, as in this way of brewing, the beſt management is to make the firſt wort of one maſh and the ſecond wort of the other two, it will be found neceſſary to allow, for the firſt extracting water, four parts out of ſeven of the whole quantity required, and to divide the remainder equally for the other two maſhes. Thus if the whole quantity of water required was 51 barrels, the lengths of the extracting waters would be as follows;

$$\underset{\text{1 Wort}}{\overset{\text{1 Liquor}}{29}} \text{ ——————— } \underbrace{\overset{\text{2 liquor}}{11} \text{ ——————— } \overset{\text{3 liquor.}}{11}}_{\text{2 Wort.}} \text{ barrels.}$$

The water imbibed and retained by the malt is allowed for in this conputation, which will be found juſt to every purpoſe, for ſmall beer brewed in one copper only.

But in ſtrong beers and ales, with three maſhes, whether brewed at one, two or three worts, the caſe will be ſomewhat different, as care ſhould always be taken to reſerve for every maſh

maſh a ſufficient quantity of water to apply to the griſt. For this reaſon, no greater proportion ought to be uſed in the firſt maſh than that of three parts out of ſeven, as the volume of the malt is in a greater proportion to the quantity of water than in the preceding caſe. If, therefore, the whole quantity of water uſed was 35 barrels, the length of the liquors would be;

1 Liquor	2 liquor	3 liquor.
15 ————	10 ————	10 barrels.

In general employing only one copper, is allowed to be bad management, as, in ſome part or other, however the proceſs is well contrived, the buſineſs muſt ſtand ſtill, and conſequently the extracts be injured by the air, continually affecting them. The beſt and moſt uſual practice is, on this account, to brew with two coppers. Other rules are here neceſſary to be obſerved, and I ſhall be more particular in the explanation of them.

When a brewing is to be boiled off in one entire wort, as in fine ales, no other diviſion of the quantity of water uſed is required than into two equal parts; but, when beers are intended to be made, as they commonly are, at two worts, the water muſt firſt be proportioned to theſe, and each of the parts be equally divided for the ſeveral maſhes, which are to form the worts. Experience has ſhewn, that four ſevenths of the whole water ſhould be applied to the firſt wort, and the remainder three ſevenths to the ſecond. This will conſtantly be found to anſwer our purpoſe, and ought alſo to direct us in the diviſion

ſion of the extracting heat. Thus, if, as in the beforementioned guile of ſmall beer (page 192,) 51 barrels be the whole quantity of water uſed,

51
4
7 [204

29 barrels will be the length of the firſt wort, and 22 barrels that of the ſecond.

The laſt extracting heat for this proceſs being - 183 degrees
and the firſt - - - - - - - - - - - - - 151 degrees

their difference - - - 32 degrees
muſt be proportioned in the ſame manner - - 4
7 [128

18 degrees

therefore ought to be added to the heat of the firſt wort, and 14 degrees the remainder of the difference is to be added to the heat of the laſt. As both the water for the maſhes and the increaſed heat are to be equally divided, the length and heat of each extract will be as follows:

Heat	151°	169°	176°	183°
*length	14 ½	14 ½	11	11
liquor	1	2	3	4
	1 wort		2 wort.	

* By giving to the firſt wort, one ſeventh part more of the water than to the laſt wort, a proper allowance is made for what is imbibed by the malt uſed as it is on quality of the extract only that the juſtneſs of the proceſs depends ſo is it right to add tour ſevenths of the heat to the ſecond maſh the firſt extract being fixed on principles before recited.

This rule conſtantly takes place, when there are but two worts either of ſtrong or of ſmall beer; but if the benefit of the drink, or the ſmallneſs of the utencils, obliges us to carry on the proceſs with three worts, theſe proportions muſt neceſſarily be altered, and the following have in that caſe been found moſt advantageous.

The firſt and ſecond wort ought to have two thirds of the water; the firſt wort two thirds of this quantity, the ſecond the remainder of this, and the third wort one third part of the whole.

Porter or brown beer is the ſort of drink, in which this diviſion is moſt commonly obſerved. Let the whole quantity of water to be uſed be that of the brewing, of which the elements have been laid down, (page 193.) or 54 barrels.

54
2
3 [108
36
2
3 [72
24 barrels of water for the firſt wort
12 barrels for the ſecond wort
18 barrels for the third wort.
54

The laſt extracting degree for this drink is 162
the firſt - - - - - - - - - - - - - 144

18 their difference
2

3 [36

12
2

3 [24

8 degrees to be added to the firſt extracting heat, to make up that of the ſecond maſh.
4 degrees for the ſecond wort.
6 degrees for the third wort.

18

A griſt of 11 quarters of malt is too large, to admit of the water allowed for the firſt wort to be equally divided between the firſt and ſecond maſh, and the extraction could not properly be formed, if the firſt heat of 144 degrees was not allowed to take place; therefore, rather than uſe the whole 24 barrels in one maſh, with the additional 8 degrees of heat, a ſufficient quantity only muſt be applied to the firſt maſh, both to work it and to get as much of the extract to come down as will ſave the bottom of the copper, it is to be pumped into. By this management, there will be enough left to form the ſecond extract with, or what by the brewers is termed *the piece liquor*. The exact quantity of water the firſt maſh ſhould have, might be referred to the following ſection, but the order we have laid down will excuſe our anticipating thereon.

It has been found, and will hereafter be proved, that a volume of 11 quarters of malt, dried to 138 degrees, is equal to 6, 11 barrels of liquid, that malt will require twice its volume of water to wet it, and that this quantity is retained after every tap is ſpent.

* * *

6,11 Barrels, volume of the 11 quarters of malt

3

18,33

6,11

12,22 barrels of water imbibed by the griſt

24,30 whole quantity of water allowed for the firſt wort

3 [11,78 extract, which will be yielded from the firſt and ſecond maſh length of the firſt piece, which is ſufficient to ſave the copper

3,92

3,92

12,22 quantity imbibed as above

16,14 quantity of water for the firſt maſh

7,86 quantity of water for the ſecond maſh.

24,00

The ſeveral lengths of the water for each maſh, and the heats proportioned to them will conſequently be as follows:

heat	144°	152°	156°	159°	162°
length	16*	8	12	9	9
liquor	1	2	3	4	5
	1 wort		2 wort	3 wort.	

Thus having ſhewn how to aſcertain the quantities of the malt, the hops, the water and the heat to be uſed, and to

* Here, and in many other places, ſmall fractions have been neglected.

propor-

proportion them to each other, as the good or bad properties of beers ariſe, from the extracts, and fire is the governing agent, we muſt now ſeek the means to adminiſter the right portion of heat, and ſo to temper the water that is to form the extracts, as not to be diſappointed of our intentions. In the calculations made for this purpoſe, not only the water in the copper but the value and effect of the griſt, as to heat and cold, muſt be conſidered. The proof of our ſucceſs can be aſcertained by no other means, than by obſervations made with the thermometer placed in the extract, in the neareſt part it is to, and as it comes from, the malt, viz. at the cock fixed in the maſh tun, to convey the liquor to the underback, in order to its being pumped up into the copper, and there joined to the hops.

* * *

SECTION X.

An enquiry into the Volume of MALT, *in order to reduce the* GRIST *to a common meaſure.*

THE gallon, by which malt is meaſured, is exactly of the ſame capacity with that, which is uſed for beer or water. The quarter of malt contains 64 gallons of this meaſure, and the barrel, within the bills of mortality, according to the gauges uſed by the exciſe, contains 36 gallons, but without the bills, 34; though the firſt quantity is the meaſure for ſale throughout the kingdom. Hence it would appear, that proportioning the grain to the barrel of water would be no difficult undertaking. This however is ſo far from being the caſe, that, after having made uſe of ſeveral calculations to help us to the true proportions, we ſhall find, that they want the corroborating proofs of actual experience, before they can be intirely depended upon.

The ultimate parts of water are ſo very ſmall, as to make this, as well as all other liquids, appear to the eye one continued uniform body, without any interſtices. This cannot be ſaid of malt laying together, either whole or ground; there are numbers of vacancies between the corns, when whole, and between the particles when ground, ſo that the real volume occupied by any quantity of malt is properly no more, then the ſpace

which

which would be occupied by every individual corn, either whole or cut aſunder, were they cloſely joined together.

To determine the quantity of cold water to be added to that, which is brought to the boiling point, (an act by the brewers called *cooling in*,) it is neceſſary to know, what proportion a quarter of malt bears to the meaſure of a barrel of water. Several operations will be found requiſite to come to this knowledge; viz. to take ſeveral gauges of different brewings, more eſpecially in the firſt part of the proceſs; to be well acquainted with the degree of dryneſs of the malt uſed, the heat of the firſt extract, and the quantity of liquor the maſh tun holds upon every inch; to find out what degrees of expanſion are produced by the different degrees of heat in the firſt maſh, how much leſs water the maſh tun holds upon an inch when hot, than it does when cold, what quantity of water is loſt by evaporation, and in what proportion at the ſeveral terms of the proceſs. In order to put this in practice, the gauges of the following brewing were taken.

5 quarters of malt dried to 125 degrees.

	B.*	F.	G.
The quantity of water uſed for the firſt maſh was	12	2	3
The maſh and water gauged together in the maſh tun juſt before the tap was ſet. -	25, 00 inches		

---

* B. ſtands for barrels, F. for firkins, G. for gallons, and the numbers paſt the comma, where the inches are expreſſed, for decimals; 34 gallons are here allowed to the barrel, in compliance to the exciſe gauging, as theſe calculations were made without the bills.

Allow-

Allowance for the ſpace under the falſe bottom boards of the maſh tun, as near as could be computed -	0, 66 inches
The goods gauged in the maſh tun, after the firſt tap was ſpent. - - - - - - - - - -	15, 41 inches
	B. F. G.
Firſt piece gauged in the copper - - - - -	8 0 2

	B. F. G.
The water employed for the ſecond maſh was	12 2 3
The griſt gauged with this water juſt before the tap was ſet - - - - - - - - -	30, 62 inches
And juſt after the tap was ſpent - - - -	15, 63 inches
	B. F. G.
The firſt wort conſiſting of theſe two pieces gauged in the copper - - - - - - -	21 2 0

	B. F. G.
The water uſed for the third maſh was - -	8 3 6
Juſt before the tap was ſet the griſt with this gauged in the maſh tun - - - - -	24, 60 inches
And juſt after the tap was ſpent - - - - -	15, 20 inches

	B. F. G.
The water uſed for the fourth maſh was - -	8 3 6
The maſh gauged juſt before the tap was ſet	24, 60 inches
And juſt after the tap was ſpent - - - - -	15, 16 inches

The heat of the firſt extract was 136 degrees, to which adding two degrees, for what is loſt by the tap ſpending, the true heat of the maſh is 138 degrees.

The firſt extract, before it is blended with hops, may be eſtimated to be nearly equally ſtrong with a firſt wort of common ſmall beer. This, when under a ſtrong ebullition, raiſed the thermometer to 216 degrees, and ſeven barrels of ſuch a wort, when boiling, occupied an equal ſpace with nine barrels of cold water, at the mean temperature of 60 degrees. Now, if the degrees of expanſion follow the proportion of thoſe of heat, the following table conſtructed upon this ſuppoſition will ſhew how many barrels of cold water would be neceſſary to occupy the ſame ſpace with ſeven barrels of wort of different heat.

Degrees of heat	barrels of cold water	barrels of wort.
216	9,00	7
206	8,87	7
196	8,75	7
186	8,62	7
177	8,50	7
167	8,37	7
158	8,25	7
148	8,12	7
138	8,00	7
127	7,87	7
119	7,75	7

The quantity of water evaporated in a brewing is more conſiderable than it is generally apprehended to be; after repeated trials, I have found that what was loſt in this manner amounted nearly to one fifth.

Now ſince the heat of the firſt tap was 138 degrees, and my maſh tun holds 20, 25 gallons upon an inch, the following proportion may be deduced from the preceding table.

If 8 —— 7 —— 20, 5

7,00

8,00 [14175,00

17,71 gallons, and this is the true quantity contained in one inch, at a heat of 138 degrees.

B. F. G.

The quantity of water uſed for the firſt maſh was 12 2 3, or 428 gallons, of which one fifth is ſuppoſed to be ſteamed away, when the firſt liquor is gone through the whole proceſs of the extraction: but as the gauges of the malt and water together are taken before the tap is ſet, the whole evaporation ought not to be deduced, and one ſixth ſeems to be a ſufficient allowance on this account. We may therefore ſuppoſe 357 gallons to be in the maſh tun at the time of gauging, which number being divided by 17,71 will ſhew how many inches are taken up by the water at that heat,

17,71 [357,0000 [20,15

3542

2800

1771

10290

8855

1435

The maſh gauged juſt before the tap was ſet	25, 00 inches
Allowed for the ſpace under falſe bottoms -	0, 66
	25, 66
Deduct the inches taken up by the water - -	20, 15
Remainder for the five quarters of malt, - -	5, 51 inches

or 1,10 inch for one quarter. This number being multiplied by 17,71 the quantity of gallons contained upon one inch at this heat, will give for 19,48 gallons one quarter of this malt. There now remains nothing but to bring a barrel of water of 34 gallons under like circumſtances, as to expanſion and evaporation, with theſe 19,48 gallons, with this difference only that, as the proportion required is at the time the water and malt firſt come in contact, and not after the maſh has been worked, a leſs allowance for ſteaming will be ſufficient, and may well be fixed at one ſeventh.

If 7,00 —— 8,00 —— 34
34
3200
2400
7,00 [272,00
38,85
5,55 loſt by ſteam
33,30 the barrel of water reduced; and as 19,48 gallons, under the ſame circumſtances, were

found equal to one quarter of malt, the following diviſion will ſhew the proportion between them.

```
19,48 [ 33,3000 ] 1,70
        1948
        ----
        13820
        13636
        -----
          184
```

Thus in malt dried to 125 degrees, the quantity of 1,70 quarters is required to make a volume equal to 34 gallons or a barrel of water according to the exciſe gauging without the bills of mortality.

The more the malt has been dried, the larger the interſtices are between its parts; the quantity of water it admits will conſequently be greater than what is abſorbed by ſuch as is leſs dry. More of this laſt malt will be neceſſary to make a volume, equal to that of the barrel of water; and every different degree of dryneſs muſt cauſe a variety in this reſpect. It will therefore be proper to repeat the operation with a high dried griſt.

Gauges of a brewing of 8 quarters of malt dried to 140 degrees.

	B.	F.	G.
The water uſed for the firſt maſh - - - -	11	2	4
Malt and water gauged together in the maſh juſt before the tap was ſet - - - -	26, 25 inches		

Allowed

Allowed for the ſpace under the falſe bottom of the maſh tun	0, 66 inches
Goods gauged in the maſh tun after the firſt tap was ſpent	22, 36 inches
	B. F. G.
Firſt piece gauged in the copper	5 0 0

	B. F. G.
The water for the ſecond maſh was	11 2 4
The maſh gauged juſt before the tap was ſet	35, 70 inches
Juſt after the tap was ſpent	22, 19 inches
	B. F. G.
The wort made of theſe two pieces gauged in the copper	17 0 0

	B. F. G.
The water uſed for the third maſh was	8 3 6
The maſh gauged juſt before the tap was ſet	31, 10 inches
And juſt after the tap was ſpent	21, 77 inches

	B. F. G.
The water uſed for the fourth maſh was	8 3 6
The maſh gauged juſt before the tap was ſet	30, 50 inches
And juſt after the tap was ſpent	21, 60 inches

The heat of the firſt extract was 142 degrees. Now by the table of expanſions (page 206.)

If 8,05——7,00——20,25

700

8,05 [1417500] 17,60 will be the real quantity of water upon an inch in the maſh tun, when heated to 142 degrees.

805

6125

5635

4900

4830

700

B. F. G.

Quantity of water in the firſt maſh = 11 2 4

34

44

33

17

4

395

Deduction for the evaporation at this period, one ſixth 65, 83

329, 17 true quantity of the water for the firſt maſh, which muſt be divided by the

the real quantity of water contained upon an inch in the maſh tun.

17,60 [329,1700] 18,70 inches taken up in the maſh tun by the water uſed in the firſt maſh.
1760
15317
14080
12370
12320
500

The maſh gauged juſt before the tap was ſet 26, 25 inches
Allowed for the ſpace under the falſe bottoms 0, 66
26, 91
Inches taken up by the water of the firſt maſh 18, 70
Space occupied by theſe 8 quarters of malt 8 [8, 21 inches of maſh tun
Space occupied by one quarter - - - 1, 02
17, 60
6120
714
102
17,9520 gallons of water, equal in volume to one quarter of this malt.

If

If 7,00——8,05——34
34
3220
2415
7,00 [273,70

39,10 expanſion of the barrel of water, out of which the ſeventh 5,58 is to be deducted for evaporation.

remains 33,52 for the barrel of water reduced, which the quarter of malt or 17,95 is to be compared to.

17,95 | 33,5200 [1,86 quantity of malt dried to 140 degrees, equal to one barrel of water
1795
15570
14360
12100
10770
1330

Having thus found the volume of the malt, at two diſtant terms of dryneſs, we might divide the intermediate degrees in the ſame manner as we have done before, could the certainty of theſe calculations be intirely depended upon; but as ſome allowances have been made without immediate proof, how near ſoever truth the reſult thereof may from experiments appear, it will be worth while to point out what is wanting to make our ſuppoſitions quite ſatisfactory.

Some part of the calculation depends on the quantity of the evaporation; this, in the ſame ſpace of time, may be more or leſs, as the fire under the water is briſk or ſlow, or as the weight of the atmoſphere differs. The gauges are taken at the time the malt and water are in contact, and more or leſs water may be imbibed in proportion, both of the dryneſs and age of the malt; water as a fluid, malt as a porous ſolid body, muſt differ in their expanſion, but in what proportion is to me unknown; effervеſcence may be another cauſe of want of exactneſs; the different cut the malt has had in the mill, its being or not being truly prepared, the difference laſtly in the time of the maſhing or ſtanding of the griſt, prevent our relying wholly upon the calculation. It is however not improbable that ſome of theſe incidents correct one another. Since 1, 70 quarters of malt dried to 125 degrees are equal to one barrel of water, and 1, 86 quarters of malt dried to 140 have the ſame volume, the difference being but 16 parts out of hundred, the whole of the error cannot be very great, and one quarter ſix buſhels of malt may, at a medium, be eſtimated of the ſame volume with one barrel of water. However, as experience is the ſureſt guide, I have, from a very great number of different brewings, collected the following proportions, and repeatedly found them to be true. I have added, in the table, the weight malt ought to have, at every degree of dryneſs.

A TABLE of the ſeveral quantities of malt differently dried, which are equal to the volume of one barrel of water, according to the exciſe gauge, without the bills of mortality.

	Degrees	weight in pounds	volume of grain.
Barley	80	376	1,56
	100	306	1,62
	105	301	1,62
	110	296	1,65
	115	291	1,67
Malt	119	286	1,68
	124	281	1,71
	129	276	1,74
	134	271	1,77
	138	266	1,80
	143	261	1,83
	148	256	1,86
	152	251	1,89
	157	246	1,92
	162	241	1,95
	167	236	1,98
	171	231	2,01
	176	226	2,04

With a table thus conſtructed, it is very eaſy to reduce every griſt to an equal volume of water. Suppoſe thoſe of the brewings we have already mentioned; that of the ſmall beer conſiſts of 6 quarters of malt dried to 130 degrees, the proportion of which in the table is as 1,75 to 1.

	quarter of malt	barrel of water	malt	water.
If	1,75 ——	1 ——	6 ——	3,42

Theſe ſix quarters of malt occupy therefore an equal volume with 3,42 barrels of water. The brown beer griſt is of 11 quarters dried to 138 degrees; the proportion of this in the table is as 1,80 to 1.

	malt	water	malt	water.
If	1,80 ——	1 ——	11 ——	6,11

The volume of theſe 11 quarters of malt is therefore the ſame with that of 6,11 barrels of water, and the whole being brought to the ſame denomination, we are enabled to find the heat of the firſt maſh; but the efferveſcence occaſioned by the union of the malt and water muſt prevent this calculation being ſtrictly true, the conſideration of which ſhall take place hereafter.

The circumſtances are different in the other maſhes; the water uſed in theſe meets a griſt already ſaturated, and the volume is increaſed beyond the quantity found for dry malt. The quantity to be allowed for this increaſe cannot be determined

mined by our former calculations, and new trials are to be made, in order to fix upon the true proportion.

Gauging is undoubtedly the moſt certain method of proceding in theſe reſearches; but even this becomes leſs ſure, on account of the expanſion, evaporation, effervefcence, and other incidents already mentioned. Our errors however cannot be very conſiderable, when we deduce our concluſions from numerous and ſufficiently varied experiments.

The volume of the griſt of pale malt was found, after the parting of the firſt extract, to be 15, 41 inches, though the ſpace occupied by the malt, when dry, was only 5, 51 inches; and the volume of the brown griſt, at the ſame period, was 22, 36 inches, though the dry malt filled only a ſpace of 8, 21 inches. The proportion in both theſe caſes, and in all thoſe which I have tried, anſwers nearly to one third, ſo that the volume of the griſt, in the ſecond and all ſubſequent maſhes, may be eſtimated at three times the bulk of the malt when dry.

Hence might be deduced a method for calculating the volume of the malt, leſs intricate than that which we were obliged to make uſe of. I forbear mentioning it here, as it muſt appear manifeſt.

It is found, by the gauges, that the goods, after the ſeveral taps are ſpent, remain ſenſibly of the ſame volume, or at leaſt very little diminiſhed; may we not conclude, that the part abſorbed

ſorbed by the water, in which the virtue of the grain and the ſtrength of the beer conſiſt, is contained in an amazing ſmall compaſs? It is indeed true that hot waters and repeated maſhes do ſwell a little the hulls and ſkins of the malt, but no allowance made for this increaſe will be ſufficient, to remove the cauſe of our ſurprize.

* * *

SECTION XI.

Of the proportion of cold WATER *to be added to that which is* BOILING, *in order to obtain the deſired heat in the* EXTRACT.

THE degree of heat, which cauſes water to boil is, as we have ſeen, determined, by Farenheit's ſcale, to 212. It is in our power to give to any part of the extracting water this degree of heat; and by adding to it a ſufficient proportion of water of an equal heat with that of the air, and blending theſe two quantities with the griſt of the malt, to bring the whole to the required temperature. The rules for obtaining this end are extremely ſimple, and cannot be unknown to thoſe, who are ſkilled in arithmetical operations. But as our view is to render this part of our work generally uſeful, we think it will be proper briefly to lay down theſe rules, and to illuſtrate them by the examples of our two brewings.

Rule to aſcertain the heat of the firſt maſh.

Let a expreſs the degree of boiling water, b the actual heat of the air, c the required degree for the extract, m the whole quantity of water to be uſed, n the volume of the malt; x, that part of the water, which is to be made to boil, will be determined by the following equation,

$$x = \frac{\overline{c-b} \times \overline{m+n}}{a-b}$$

or in other terms; the number of the barrels of water to be uſed being added to the volume of the malt, let the ſum be multiplied by the difference between the actual heat of the air and that which is required for the extract, and the produce be divided by the exceſs of the heat of the boiling water over that of the air.

The firſt example is that of a brewing of ſmall beer, when the heat of the air is at 60. The volume of the 6 quarters of malt, it conſiſts of, was eſtimated at 3,42 barrels; the firſt liquor is 14½ barrels, and the heat required for the firſt maſh 151 degrees.

Firſt maſh.

$m =$ 14,50 barrels of water
$n =$ 3,42 volume of the griſt

$m + n =$ 17,92 $c =$ 151 heat of the maſh
$c - b =$ 91 $b =$ 60 heat of the air

heat of boiling water 212 1792 $c - b = 91$
heat of the air - 60 16128

$a - b =$ 152] 1630,72 [10,72 barrels of water to be made to boil out of the 14½; the incidents to be mentioned hereafter are not included in this calculation.
152
1107
1064
432
304
128

This

The next example of a brewing is that of a griſt of 11 quarters of malt for porter or brown beer; the medium heat of the air is 40 degrees, the volume of the griſt 6,11 barrels, the firſt liquor to maſh with 16 barrels, and the heat of the extract 144 degrees.

Firſt maſh of brown ſtrong beer.

16,00 barrels of water
6,11 volume of malt

22,11 144 heat required in the maſh
104 40 heat of the air

heat of boiling water 212 8844 104
heat of the air - 40 22110

172 [2299,44] 13,36 barrels of water to be made to boil out of the $15\frac{1}{2}$.
172

579
516

634
516

1184

I will give one proof of the certainty of this rule, by ſetting down the ſtate of this firſt maſh from it,

13,36 barrels of boiling water
212
2672
1336
2672
B. 2832,32
number of degrees of heat in the 13.36 barrels of boiling water

16,00 water of firſt maſh
13,36 barrels made to boil
2,64 barrels to cool in
40 heat of the cold water
A. 105 60 degrees of heat in the cold water
13,36 boiling water
2,64 cold water
6,11 volume of griſt
22,11 barrels, volume of the whole maſh.

6,11 barrels volume of griſt
40 heat in the griſt
244,40 degrees of heat in the griſt.
105,60 A.
2832,32 B.
[22,11] 3182,32 [144 the degree of heat required in the firſt maſh as above.
2211
9713
8844
8692

So long as the mixture conſiſts only of two quantities of different heat, as is always the caſe of the firſt maſh, the preceding ſolution takes place. But in the ſecond and other maſhes, as three bodies, each of different heat, viz. the boiling water, the cold water, and the maſh, are to be mixed, and brought to a determinate degree, the rule muſt be different; yet, like the former, it is the ſame with what is uſed in ſimilar caſes of allaying, when different metals are to be melted down into a compound of a certain ſtandard, or different ingredients of different value to be blended, in order to make a mixture of a determinate price. What the different denſity of the metals, or the different value of the ingredients are in theſe caſes, the different degrees of heat of the boiling water, the griſt, and the air, are in this.

Rule to aſcertain the heat of the ſecond maſh, and of the ſubſequent ones.

Let the ſame letters ſtand for the things they ſignified before, and d expreſs the actual heat of the griſt, then will

$$x = \frac{\overline{c-b}\times m + \overline{c-d}\times n}{a-b}$$

or in plain terms, multiply the whole number of the barrels of water to be uſed by the exceſs of the required heat over that of the air, multiply likewiſe the volume of the goods by the difference between the required and the actual heat of the maſh, add thoſe two produces together, divide the ſum by the difference between the heat of the boiling water and that of the air, and the quotient will give you the quantity of the water, which is to be made to boil, in order to bring the whole to the deſired degree.

We may now collect the circumſtances of the two brewings, we have had before, and find the quantity of boiling water required for their ſecond and ſubſequent maſhes, excluſively of the incidents which will hereafter be mentioned.

The firſt maſh for the ſix quarters of ſmall beer had 151 degrees of heat, but this and every maſh looſes, in the time the extract is parting from it, 4 degrees, which reduces the heat to 147 degrees. The volume of this griſt, in its dry ſtate, was 3,42 barrels, but now, by being expanded and having imbibed much water, it occupies three times that ſpace or

10,26 barrels; the air is ſuppoſed to continue in the ſame ſtate of 60 degrees of heat. The length and heat to be given to the three remaining maſhes are as follows.

Degrees of heat	151	169	176	183
barrrels of water	14½	14½	11	11
liquors.	1	2	3	4
	1 wort		2 wort.	

Second maſh of ſmall beer.

$c = 169$ heat required in the maſh

$b = 60$ heat of the air

$c - b = 109$

$m = 14{,}50$ barrels of water

5450

436

109

$c - b \times m = 158{,}0{,}50$

$c - d \times n = 225{,}72$

$c = 169$ heat required

$d = 147$ heat of the goods

$c - d = 22$

$n = 10{,}26$ volume of goods

132

44

220

$c - d \times n$ 22572

$a - b = 152$] 1806,22 [11,88 water to be made to boil, out of the quantity of barrels allowed for the ſecond maſh.

152

286

152

1342

1216

126

Third

Third maſh.

176	176
60	165
116	11
11,00	10,26
116,00	66
116	22
	110
1276,00	
112,86	112,86

152] 1388,86 [9,13 barrels to boil for the third maſh.
1368
208
152
566
456
110

Fourth maſh.

183
60
123
11,00
12300
123
1353,00
112,86
152] 1465,86 [9,64 barrels to boil for the fourth maſh;
1368
978
912
666
608
58

183
172
11
10,26
112,86

The liquors of this brewing muſt therefore be ordered in the following manner.

boiling water ; barrels	10¾	12	9¼	9¾
cold water ; barrels	3¾	2½	1¾	1¼
	14½	14½	11	11
liquors	1	2	3	4

The heat of the firſt maſh for the 11 quarters of brown beer was 144 degrees, and, after the parting of the extract from it, 140; the volume of the griſt, in its dry ſtate, was valued at 6,11 barrels of water, but, for the reaſons before mentioned, it now occupies three times that ſpace, or 18,33 barrels. The air is ſuppoſed to continue at 40 degrees, and the length and heat to be given to the different maſhes were determined as follows.

Degree of heat	144	152	156	159	162
barrels of water	16	8	12	9	9
liquors	1	2	3	4	5

$$\underbrace{1 \qquad 2}_{\text{1 wort}} \qquad \underbrace{3}_{\text{2 wort}} \qquad \underbrace{4 \qquad 5}_{\text{3 wort.}}$$

Second maſh of brown ſtrong beer.

$$\begin{array}{rrl}
 & 152 & \\
 & 40 & \\ \hline
 & 112 & \\
 & 8,00 & \\ \hline
212 & 896,00 & \\
40 & 219,96 & \\ \hline
172\ ] & 1115,96 & [\ 6,48 \text{ barrels of water to boil for the ſecond maſh.} \\
 & 1032 & \\ \hline
 & 839 & \\
 & 688 & \\ \hline
 & 1516 & \\
 & 1376 & \\ \hline
 & 140 &
\end{array}
\qquad
\begin{array}{r}
152 \\
140 \\ \hline
12 \\
18,33 \\ \hline
36 \\
36 \\
96 \\
12 \\ \hline
219,96
\end{array}$$

Third

Third maſh.

156
40

116
12,00

232,00
116

1392,00
146,64

172] 1538,64 [8,94 barrels of water to boil for the third maſh.
1376

1626
1548

784
688

96

156
148

8
18,33

24
24
64
8

146,64

⁂

Fourth maſh.

159
40
119
9,00
1071,00
128,31
172] 1199,31 [6,97 barrels of water to boil for the fourth maſh.
1032
1673
1548
1251
1204
47

159
152
7
18,
21
56
7
128,

Fifth maſh.

162
40
122
9,00
1098,00
128,31
172] 1226,31 [7,13 barrels of water to boil for the fifth maſh.
1204
223
172
511

162
155
7
18,33
128,31

The

The liquors of this brewing of brown beer muſt therefore be ordered in the following manner;

barrels of boiling water	$13\frac{1}{4}$	$6\frac{1}{2}$	9	7	$7\frac{1}{4}$
barrels of cold water	$2\frac{3}{4}$	$1\frac{1}{2}$	3	2	$1\frac{3}{4}$
	16	8	12	9	9
liquors.	1	2	3	4	5

Each of theſe calculations may be proved in the ſame manner as was done before. This method of diſcovering the proportion of water to be cooled in, deſerves, by its plainneſs and utility, to be preferred to any other, which only depends upon the uncertain determination of our ſenſes.

⁂

SECTION XII.

Of MASHING.

IT may be ſaid, that, in general, the conſtruction and diſpoſition of moſt brew-houſes would admit of very little farther improvement. The great copper, in which the waters for two of the extracts receive their temperature, is built very near the maſh tun, ſo that the liquid may readily be conveyed to the ground malt. A cock is placed at the bottom of the copper, which being opened lets the water have its courſe, through a trunk, to the real bottom of the maſh tun. It ſoon fills the vacant ſpace, forces itſelf a paſſage through ſome holes made in the falſe bottom, which ſupports the griſt, and increaſing in quantity buoys up the whole body of the corn.

In order to blend together the water and the malt, rakes are firſt employed. By their horizontal motion, leſs violent than that of maſhing, the fineſt parts of the flower are wetted, and prevented from being ſcattered about, or loſt in the air.

But as a more intimate penetration and mixture are neceſſary, oars are afterwards made uſe of. They move perpendicularly, and by their beating or maſhing, the grains of the malt are bruiſed, and a thorough imbibition of the water procured.

The time employed in this operation cannot be ſettled with an abſolute preciſion. It ought to be continued, till the malt is ſufficiently incorporated with the water, but not ſo long as that the neceſſary heat for the extraction be loſt. As bodies cool more or leſs ſpeedily, in proportion to their volume and the coheſion of their parts, a maſh which has but little water, commonly called a *ſtiff-maſh*, requires a longer maſhing to be ſufficiently divided, and, on account of its tenacity, is leſs liable to loſe its heat. This accounts for the general rule, that the firſt maſh ought always to be the longeſt.

After maſhing, the malt and water are ſuffered to ſtand together unmoved, generally for a ſpace of time equal to that they were maſhed in. Was the extract drawn from the grain, as ſoon as the maſhing is over, many of the particles of the malt would be brought away undiſſolved, and the liquor be turbid, though not rich. But, by leaving it ſome time in contact with the grain, without any external motion, many advantages are gained. The different parts of the extract acquire an uniform heat, thoſe that are the heavieſt and moſt terreſtrial ſubſide, the pores being opened, by heat, imbibe more readily the water, and give way to the attenuation and diſſolution of the oils. When the tap comes to be ſet, or the extract to be drawn from the griſt, as the bottom of the maſh is become more compact, the liquor is a longer time in its paſſage through it, and conſequently extracts more ſtrength from the malt, and becomes more homogeneous and tranſparent.

Such are the reaſons why the griſt ſhould not only be maſhed pretty long, but likewiſe be ſuffered to reſt an equal time. It is the practice of moſt brewers and experience ſhews it is beſt to rake the firſt maſh half an hour, to maſh it one hour more, and to ſuffer it to ſtand one hour and half. The next extract is commonly maſhed three quarters of an hour, and ſtands the ſame ſpace of time; the third, and all thoſe that follow, are allowed one half hour each, both for maſhing and ſtanding.

The heat of the griſt being in this manner equally ſpread, and the infuſion, having received all the ſtrength from the malt, which ſuch a heat could give it, is let out of the tun. This, undoubtedly, is the fitteſt time, to obſerve, whether our expectations have been anſwered. The thermometer is the only inſtrument proper for this purpoſe, and it ought to be placed, where the tap is ſet, at the underback cock. The obſervation is beſt made, when the extract has run nearly half, and as, by it, we are to judge, with what ſucceſs the proceſs is carried on, it is neceſſary to examine every incident, which may cauſe a deviation from the calculated heat.

SECTION XIII.

Of the INCIDENTS, *which cauſe the* HEAT *of the* EXTRACT *to vary from the calculation, the allowances they require, and the means to obviate their effects.*

BY incidents, I mean ſuch cauſes, as affect either the malt, the water, or the maſh, ſo as to occaſion their heat to differ from what is determined by calculation. As theſe might frequently be a reaſon of diſappointment, an inquiry into their number and effects will not only furniſh means to prevent and rectify the errors they occaſion, but alſo ſerve to confirm our practice.

In our reſearches on the volume of malts, ſome notice was taken of the increaſe of bodies by heat, and the loſs occaſioned by evaporation. Water, when on the point of ebullition, occupies the largeſt ſpace; but contracting again, when cold water is added to it, the true volume of both, when mixed together, remains uncertain, and may cauſe a difference between the calculated and real degree of heat. This cauſe, however, producing an effect oppoſite to, and balanced in part by, evaporation, becomes ſo inconſiderable, as hardly to deſerve any farther conſideration.

Water, juſt on the point of ebullition, may be eſteemed heated to 212 degrees. Though, by the continuation of the fire, or by any other cauſe*, the heat never goes beyond this, yet was cold water added to that, which violently boil's, the medium degree would be exceeded; for the cold water abſorbing the ſuperfluous quantity of fire, which otherwiſe fly's off, becomes hot of itſelf, and fruſtrates the intent. The time therefore of adding the cold water to the hot is immediately, before the ebullition begins, or when it is juſt ended; and in proportion as we deviate from this practice, the heat in the extract will differ from the calculated degree.

The water, for every maſh, ſhould, as much as poſſible, be got ready to boil, and be cooled in juſt before it is to be uſed. A liquor, which remains a long time after the ebullition is over, and the fire has been damped up, loſes part of its heat, and if cold water is applied to it, the effect cannot be the ſame as it would have been at firſt. If, on the contrary, the liquor is got ready too ſoon and cold water immediately added to it, in order to gain the proper degree of temperature, by leaving the mixture long in the copper, though the fire is ſtopped up, more heat than neceſſary will be received from the copper and brickwork, eſpecially if the utencils are large. In both caſes, the degree in the extract will no more anſwer the heat, which was expected.

---

* Different quantities of water are differently affected by the ſame portion of fire; when the ebullition is juſt over, and the ſurface of the liquor is become ſmooth, if ſome of it is, by a cock, drawn from the bottom of the copper, where the coldeſt water always is, the remaining part, having a greater proportion of fire than before, again begins to boil, though not affected by any increaſe of heat.

The effect of efferveſcence next deſerves our conſideration, but only takes place when the water firſt comes in contact with the malt. Germinated grains muſt, to become malt, be dried ſo, that their particles be forced from one another, beyond their ſpheres of attraction; being thus deprived of the parts, to which their union was due, when they come in contact with other bodies, (as water,) they ſtrongly attract the unitive particles they want, and excite an inteſtine motion, which generates heat. This motion and this heat are more active in proportion as the grain has more ſtrongly been impreſſed by fire, and the extracting water is hotter.

A large quantity of liquor applied to the griſt is leſs heated than a ſmall one, by the ſame power of efferveſcence. The leaſt quantity of water, neceſſary to ſhew the whole of that power, muſt be as much as malt requires to be ſaturated, which we have ſeen to be double the volume of the grain. When more water is put to the griſt than what has been mentioned, the real efferveſcing heat is by ſo much leſſened, being diſperſed in more than a ſufficient ſpace.

A table ſhewing the heat of efferveſcence for every degree of dryneſs in the malt, can only be formed from obſervations. To apply this table to practice, and to find out, for any quantity of water uſed in the firſt maſh, the degrees of heat produced by efferveſcence, three times the volume of the griſt muſt be multiplied by the number expreſſing the efferveſcing heat for malt of ſuch a degree of dryneſs, and this produce be divided by the real volume of the whole maſh.

A TABLE ſhewing the heat occaſioned by the effervefcing of malt, for its ſeveral degrees of dryneſs.

Dryneſs of malt	heat of effervefcence
119°	0
124	3½
129	7
134	10½
138	14
143	17½
148	21
152	24½
157	28
162	31½
167	35
171	38½
176	40

Malt dried only to 119 degrees raiſes no effervefcence, and the ſtrongeſt is generated by malt, dried to 176 degrees. The heat occaſioned by it amounts to 40 degrees, and probably would exceed this number, could the firſt griſt, notwithſtanding all our endeavours, be intirely penetrated by the water. The more it is ſo, the greater is the increaſe in the degrees of heat produced by effervefcence, till the liquor be perfectly ſaturated; and in this ſtate of progreſſion, which takes up the whole time of the firſt maſhing and ſtanding, the air cannot produce any diminution of heat, an incident, which affects conſiderably every maſh but the firſt.

The little copper being more diſtant from the maſh tun than the other, the water prepared in it waſtes, in its paſſage to the goods, a greater part of its heat. And in proportion to the water uſed, to the number of the extracts that have been made, and according as the maſhes have more or leſs conſiſtency, in the ſame time do they part, with more or leſs of their heat. Obſervations made ſeparately upon ſtrong and ſmall beer have ſhewn the proportions of this loſs to be as follows:

For ſtrong beer.

Maſhes	2	3	4	5
heat loſt	8°	12°	8°	8°

For ſmall beer.

Maſhes	2	3	4
heat loſt	8°	16°	20°

By employing hard corns, or a griſt not perfectly malted, the expectation of the computed degree is diſappointed, as the volume cannot be ſuch as was eſtimated from the dryneſs of the grain. It has been obſerved that, in true malts, the ſhoot is very near preſſing through the exterior ſkin of the grain. By ſo much as it is deficient in this particular, muſt it be accounted only as dried barley, or hard corn. I know no better way of judging what proportion of the corn is hard to what is malted, ed, than by putting ſome in water, as by that means, the grains not ſufficiently grown will ſink to the bottom. Were this to be done in a glaſs cylinder, the proportion between the hard and malted corn might eaſily be found with exactneſs. The unmalted parts being eſtimated with regard to their volume, as barley, a quarter of them will be to the barrel of water as 1,56 to 1. Suppoſing therefore that, in the brown beer griſt before mentioned, the proportion of hard corns is of 2 quarters out of 11, to diſcover the true volume of ſuch a griſt, the following rule may be uſed.

2 quarters
9 quarters of true malt . 1,56 volume of
1,80 volume at 138° of dryneſs —— 1 quarter
3,12
16,20
3,12 volume of 2 quarters of hard corn

total number 11] 19,32 [1,75 true volume of one quarter of this malt to one barrel of water, and conſequently the 11 quarters will fill a ſpace equal to that of 6,28 barrels.

By means of this rule, we may find what increaſe of heat any proportion of hard corns will require, as will be ſeen in the following table.

Proportions of hard corns	$\frac{1}{4}$	$\frac{1}{6}$	$\frac{1}{8}$	$\frac{1}{16}$	$\frac{1}{32}$ of the griſt
greater heat of the maſh	4°	3	2	1	$\frac{1}{2}$

But the brewing of ſuch malt ought to be avoided as much as poſſible, as the hard parts afford no ſtrength to the extract.

If a griſt is not well and thoroughly maſhed, the heat not being uniformly diſtributed in the different parts of the extract, the liquor of the thermometer, when placed in the running ſtream of the tap, will fluctuate, and at different times, ſhew different degrees of heat. In this caſe, the beſt way is to take the mean of ſeveral obſervations, and to make that the true heat of the maſh.

If the gauges of the coppers are not exactly taken, a variation muſt be expected.

Though the ſmall and hourly variations in the ſtate of the atmoſphere have but little influence upon our numbers, a difference will be obſerved in any conſiderable and ſudden changes either of the heat or of the weight of the air. Our inſtruments, and in particular the thermometer, are ſuppoſed to be well conſtructed and graduated. If the water cooled in with is more or leſs hot than eſtimated, or if the time of maſhing or ſtanding is either more or leſs than was allowed for, the computation muſt be found to vary from the event.

While the malt is new, and the heat received from the kiln has not ſufficiently ſpent itſelf, this additional heat is not eaſily accounted for. This is likewiſe the caſe, when malt is laid againſt the hot brickwork of coppers; and on the contrary a loſs of dryneſs may be occaſioned, if the ſtore rooms are damp.

The artiſt ſhould be attentive to all theſe incidents; the not pointing them out might appear neglectful, enumerating more would exceed the bounds of uſe.

Small griſts brewed in large utencils loſe their heats more readily, by laying thin and greatly expoſed to the air; and on the contrary a leſs allowance, for the loſs of heat, is required in large griſts and proportionable veſſels.

This indeed is, or ought to be, the only difference between brewings carried on in large publick brewhouſes, and thoſe that are made in ſmall private places, in other reſpects conſtructed upon the ſame plan and with an equal care. I know popular prejudices are on the other ſide, but as I believe, not on that of truth. It has been commonly imagined that, in large places, ſtronger extracts could be forced from the malt, in proportion to its quantity, and that more delicate beers would be made in ſmaller veſſels leſs frequently uſed. Theſe aſſertions, from what has been ſaid, will, I hope, need no farther enquiry. Brewings will moſt probably ſucceed in all places, where the griſt is not too large to exceed the bounds of man's labour, and not ſo ſmall as to prevent the heat from being uniformly maintained. The diſadvantages are great on all ſides, when a due proportion is not obſerved between the utenſils and the works carried on.

It will now be proper to continue the delineation of our two brewings, and to put all the circumſtances relating to them under one point of view.

* * *

A brewing for porter or brown ſtrong beer computed for 40 degrees of heat in the air.

11 quarters of malt dried to 138 degrees; 132 pounds of hops
27 barrels ½ to go out at 3 worts, 29 inches above braſs

6,11 volume of griſt
3
18,33
14 effervеſcing degree
7332
1833

volume of griſt 6,11
water for firſt maſh 16,00
22,11] 25662 [11 degrees of heat gained in the firſt maſh by effervеſcence.
2211
1552

11 effervеſcing degrees
3 degrees for hard corns
14 degrees equal to 3 ¼ inches leſs cooling in for the firſt maſh.

Maſhes	1	2	3	4	5
Degrees of heat	144	152	156	159	162
whole quantity of water uſed, barrels	16	8	12	9	9
Quantity to be cooled in; barrels	2¾	1½	3	2	1¾
Coppers to be charged with; barrels	13¼	6½	9	7	7¼
Allowances for incidents; inches.	G. C. leſs 3½. *	L. C. more 2. †	L. C. more 3. ‡	L. C. more 2. †	L. C. more 2. †

* Deduction from the 1 maſh for heat created by effervеſcence of the hard corns.

† Additions to the next maſhes, on account of the refrigeration occaſioned by maſhing and ſtanding.

‡ G. C. ſtands for great copper, L. C. ſtands for little copper.

A brewing for common ſmall beer computed for 60 degrees of heat in the air.

6 quarters of malt dried to 138 degrees; 36 pounds of hops
30 barrels ¾ to go out 56 inches above braſs.

Volume of griſt 3,42
3
20,26

grift 3,42
water] 14,50
17,92] 71,82 [4 degrees of heat gained in the maſh by efferveſcence.
7168
14

7 efferveſcing degree for malt at 130 (ſee table page 237,)

4° for efferveſcence
1° for hard corns
3° for new malt hot
8° to be deduced from the firſt cooling in.

Maſhes	1	2	3	4
Degrees of heat	151	169	176	183
whole quantity of water uſed, barrels	14½	14½	11	11
Quantity to be cooled in, barrels	3¾	2½	1¾	1¼
Coppers to be charged, barrels	10¾	12	9¼	9¾
Allowances for incidents; inches;	[*] G C. leſs 2;	[†] G. C. more 2;	[†] L. C. more 4;	[†] L. C. more 5.

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[*] The charge of the firſt liquor is for 10¾ barrels, with a deduction of 2 inches, according to the gauges of the coppers, page 181. Theſe two inches anſwer to the 8 degrees of heat for the efferveſcence, hard corns, and new malt.

[†] The ſecond and following maſhes are to be charged with as many more inches of boiling water, as anſwer to the fourth part of the number of degrees of heat loſt by the refrigeration of the maſhes.

Theſe

Theſe computations, perhaps will appear more troubleſome than they really are the more ſo, as they vary, for every brewing; but, beſides the facility, which exerciſe always gives for operations of this kind, the ſatisfaction of proceeding upon a leſs precarious foundation than what has been hitherto thought ſufficient, will, I hope, encourage the practitioner in this additional labor. One advantage muſt greatly leſſen it, and at the ſame time ſecure the uniformity of the drinks; *viz.* that tables for each may be made before hand, and will ſerve as often as the circumſtances are the ſame. The trouble of the computations will by that means be ſaved, and by collecting together different brewings of the ſame kind, the artiſt will, at any time, have it in his power to ſee what influence the leaſt deviation from his rules had upon his operations, and to what degree of preciſion he may hope to arrive.

That nothing may be wanted, in this work, that may facilitate the intelligence thereof, I beg leave to inſert, in two tables, the examples of ſome actual brewings made according to the computations, I have here ſucceſſively traced down. The firſt column contains the numbers computed, the next the brewings made from theſe numbers with their dates, and the laſt the variations in the charges of the coppers, occaſioned by unforeſeen incidents, upon the principle, that each inch of cooling in anſwers to four degrees of heat.

* * *

Small Beer 6 Quarters of Malt at 130°.

Length, 30¾ Barrels, Air at 60°.

	Comput. Degrees.	1759						
		July 20.	July 22.					
1 Maſh	147	147	145					1 Liquor, great copper charged 2 inches above braſs; cooled into 13 and a half inches above braſs.
2 Maſh.	165	163	167					2 Liquor, great copper charged 9 inches above braſs, cooled into 13 inches and a half.
3 Maſh	172	174	172					1 wort came in 33 inches above braſs - went out 28 inches above braſs - boiled 1 hour & half 3 Liquor, little copper charged 12 inches above braſs; cooled in to 13 inches above braſs.
4 Maſh	179	179	179					4 Liquor, little copper charged 13 inches above braſs; cooled in nothing.
								2 wort came in 39 above braſs - went out 28 inches above braſs Length 31 barrels

Porter, 11 Quarters of Malt at 138°
Length, 27½ Barrels, Air at 40°.

		1759		1760			
	Comput. Degrees.	Nov. 16.	Dec. 8.	Feb. 20.	Feb. 28.		
1 Maſh	140	140	138	142	140		1 Liquor, great copper charged 6 and a half inches above braſs, cooled in to 17 inches.
2 Maſh	148	146	150	146	148		2 Liquor, little copper charged half an inch below braſs, cooled in to three inches above braſs.
3 Maſh	152	154	152	150	150		1 wort came in 16 inches above braſs —— went out 13 inches above braſs —— boiled 1 hour 3 liquor, little copper, charged 9 inches above braſs, cooled in to 16 inches above braſs.
4 Maſh	155	155	155	157	157		2 wort came in 11 inches above br. (braſs went out 5 in. above —— boiled 2 hours. 4 liquor, little copper charged 1 inch and a half above braſs, cooled in to 6 inches above braſs.
5 Maſh	158	158	160	158	158		5 liquor, little copper charged 2 inches and a half above braſs, cooled into 6 inches above braſs. 3 wort came in 24 in. above br. (braſs went out 11 in. above Length 27 bar. 3 4ths

SECTION

SECTION XIV.

Of the diſpoſition of the WORTS *when turned out of the* COPPER, *the thickneſs they ſhould be laid at in the* BACKS *to* COOL, *and the heat they ſhould retain for fermentation, under the ſeveral circumſtances.*

WHEN a proceſs of brewing is regularly carried on, the worts come in courſe to boil, as the extracts which formed them are produced. It would be tedious and unneceſſary to deſcribe the minuteſt parts of the practice; which vary as the brewing offices are differently conſtructed, or the utenſils variouſly arranged. Without the aſſiſtance of a brewhouſe, it is perhaps impoſſible to convey to the imagination the entire application of the rules before laid down, but with one, I hope, they need little, if any, farther explanation.

The worts, when boiled, are muſts poſſeſſing, in their intended proportions, all the fermentable principles, except air. This was expelled by the fire, and until the boiling heat is removed, thoſe worts cannot be ſaid to be in a fermentable ſtate.

In muſts, which ſpontaneouſly ferment, the included air excites in the oils an agitation, which, opening the pores of the liquor, renders them capable to receive part of the external air. The caſe is not exactly the ſame with regard to

thoſe

thoſe muſts, which require ferments. The air wanted in boiled worts muſt be ſupplied by the means of yeaſt. Was the heat of the wort ſuch, as to occaſion the immediate burſting of all the air bubbles contained in the yeaſt, an effervefcence rather than a fermentation would inſue. Now a heat ſuperior to that of 80 degrees has this effect, and is therefore one of the boundaries in artificial fermentation; that of 40 degrees, for want of being ſufficient to free the air incloſed in the yeaſt bubbles, and to excite their action, is the other. Within theſe limits, muſt the wort be cooled to; and the preciſe degree, which varies according to the different circumſtances they are in, and to the intent they are to be applied to, is, together with the means of procuring this heat, the purport of this ſection.

Worts, when in the copper, boil at a heat ſomewhat ſuperior to that of 212 degrees, and the more that heat is exceeded, the ſtronger the liquor is. The inſtant the wort is ſuffered to go out of the copper, it loſes more heat, than at any other equal ſpace of time after it has been expoſed to the air. In the courſe of the natural day, or in 24 hours, the heat of the air varies ſometimes, (eſpecially in ſummer time,) as much as 20 degrees. If the wort, after having reached the loweſt degree in this interval, was ſuffered to remain in the coolers, till the return of a greater heat in the air, it would be influenced by this increaſe, expand, and be put again in motion. Should, at that time, any elaſtic air happen to be in the veſſels, which ſometimes happens, either from the ſediment of former worts, the backs not being clean ſwept, or the wood being old and ſpungy, the wort ſuppoſed to be left to cool, will, before it is removed, bring on, in a lower degree, the act of fermentation; and this accident is by the artiſt called the *backs being ſet.*

For this reaſon, a wort ſhould never be ſuffered to lay ſo long as to be expoſed to this injury, which generally may happen in a little more than twelve hours. Thus are we directed to ſpread or lay our worts ſo thin in the coolers, as that they may come to their due temperature within this ſpace; in ſummer it is ſufficient if the backs be covered; in winter a height of two inches may oftentimes be allowed.

From the inclination of the coolers or backs to the place, where the worts run off, from their largeneſs, or from the wind and air warping them, a wort ſeldom, perhaps never, lays every where at an equal depth, and cannot therefore become uniformly cold in the ſame ſpace of time. This renders the uſe of the thermometer difficult, in this caſe, though perhaps not impracticable. To ſupply the want of this inſtrument with ſome degree of certainty, the hand intended to feel the worts is brought to the heat of the body, by placing it in the boſom, until it has fully received it. Then dipping the fingers into the liquor, we judge, by the ſenſation it occaſions, whether it is come to a proper degree of coolneſs to be fermented. As the external parts of our bodies are generally of about 90 degrees of heat, ſome degree of cold muſt be felt, before the worts are ready for the purpoſe. But that degree varies for different drinks, and in different ſeaſons. I will endeavour to ſet forth the rules to be obſerved in judging of ſmall beers, A greater preciſion, both for that and for other drinks, will be found in the following table.

In July and Auguſt, no other rule can be given, than that the worts be got as cold as poſſible. The ſame rule holds good in June and September, except the ſeaſon is unnaturally cold. In May and October, worts ſhould be let down nearly thirty degrees colder than the hand; in April, November, and March, the worts ſhould be about twenty degrees colder than the hand, and only ten in January, February, and December.

It may perhaps be thought that the heats here ſpecified are great, but worts cool as they run from the backs to the working tuns, they are alſo affected by the coldneſs of the tuns themſelves, and perhaps theſe circumſtances are not ſo trivial, but that an allowance ſhould be made for them. In general, the heat of no muſt ſhould exceed 60 degrees, becauſe fermentation increaſes this or any other degree, in proportion to that under which this particular part of the proceſs begins.

A TABLE ſhewing the degrees of heat, worts ſhould have, when the yeaſt is applied to them, according to the ſeveral degrees of heat in the air.

Heat of the air	common ſmall	all keeping beers	amber or ales.
25	75	59	55
30	70	56	54
35	65	53	53
40	60	50	52
45	55	50	51
50	50	50	50

55 } In theſe caſes, when the medium heat of the air is
66 } greater than that which the worts ſhould ferment at, the cold of the night muſt be made uſe of, to bring them as near as poſſible to their temperature. It has been obſerved, that the coldeſt part of the natural day is about one hour before ſun riſing.

The conſequences of worts being ſet to ferment at, in an undue heat, are the following. In ſtrong beers, or ſuch as are intended for long keeping, if the worts be too cold, a longer time is required for their fermentation, and the drinks grow fine with more difficulty; if, on the contrary, they are too hot, acidity and a waſte of ſome of the ſpirituous parts muſt inſue. Either of theſe diſadvantages appears more conſpicuous in common ſmall beer, as, in winter, this drink, is ſeldom kept a ſufficient time, to correct the defect, and in ſummer, from being too hot, it becomes putrid, or, in the terms of the brewery, is hereby *foxed.*

SECTION XV.

Of YEAST, its NATURE and CONTENTS, and of the manner and quantities, in which it is to be added to the WORTS.

MUSTS or worts, though ever ſo rich, when unfermented, yield no ſpirit, by diſtillation, nor inebriate, if drank in any quantity. The oils, which are not ſufficiently attenuated for this purpoſe, become ſo by fermentation. Air is abſolutely neceſſary for this act, in the courſe of which, ſome of the aerial parts mixing with, and being enveloped by, oils greatly thinned, are incloſed in veſicles not ſufficiently ſtrong, to reſiſt the force of elaſticity, or prevent a burſting and exploſion. As the proceſs goes on, the air joins with oils both coarſer and charged with earthy particles, a coat is formed capable of reſiſting its expanſion, and if the bubbles cannot come to a volume, ſufficient to be floated in and upon the liquor, they ſink to the bottom, and take the appellation of *lees of wine*.

Between theſe two extremes, there is another caſe, when the bubbles are ſufficiently ſtrong to hold the air, but not weighty enough to ſink. They are buoyed upon the ſurface of the liquor, and there remaining entire are termed the *flowers of wine*. Both lees, and flowers, are therefore veſicles formed out of the muſt, and filled with elaſtic air, and either ſeparately or when mixed together, they obtain the general denomination of *yeaſt*.

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We have often mentioned the power of the fire in driving the air out of worts. Yeaſt fraught with the principle now wanted, for fermentation, is therefore the propereſt ſubject, to be added to the muſts; but its texture is various, in proportion to the different heats of the extracts, it was formed from. Keeping drinks, extracted with hotter waters, yield a yeaſt, the oils of which have a greater ſpiſſitude. It is conſequently ſlower, more certain, and moſt fit to promote a cool and gentle fermentation. That, on the contrary, which is produced from ſmall beer, being weak, and acting at once, is apt, not only to puff up the drinks, but to excite a motion like that of efferveſcence; ſuch yeaſt ought, therefore, not to be uſed, but when there is no poſſibility, to obtain the other.

The longer wines or beers are under the firſt act of fermentation, the greater variety will be found in the texture of the bubbles, which compoſe their flower and lees. Wines made out of grapes require ſome time, before this firſt period is at an end; and we have ſeen, that in them fermentation firſt brings forth air bubbles, whoſe conſtituent parts are moſt tender, and afterwards ſome that are of a ſtronger texture. As malt liquors require a leſs time to ferment, their bubbles are more ſimilar; on this account, the whole quantity of yeaſt, neceſſary to ferment a wort, ſhould not be applied at once, leaſt the air bladders, burſting nearly in the ſame time, ſhould prevent that gradual action, which ſeems to be the aim of nature, in all her operations.

Cleanſing is dividing the drink into ſeveral caſks; this checks the motion, occaſioned by fermentation, and conſequently retards it. To prevent this from being too ſenſibly felt, ſome yeaſt ſhould be put to the drink, before it is removed into the caſks. As the conſtituent parts, in ſtrong beers, are more tenacious, than in ſmall, and require a greater motion to entertain the fermentation, the drinks, before they be thus divided, ſhould, beſides the addition of the yeaſt, be well rouſed with a ſcoop, or by ſome other means, for one hour. This not only blends all the parts together, but attenuates and heats the liquor, and makes it more ready to begin to ferment again, when in the caſks. One ſixth part of the whole of the yeaſt uſed is generally reſerved for this purpoſe; and the remainder is equally divided as the worts are let down. It muſt be obſerved, that this ſtirring, though as neceſſary to ſmall, as to ſtrong, drinks, is only to be continued, for a ſpace of time proportioned to their ſtrength.

We have before ſeen, that, when malt is entirely extracted for one and the ſame purpoſe, one gallon of yeaſt to eight buſhels of grain affords a ſufficient ſupply of air, to perfect the fermentation. This takes place, when the heat of the air is at 40 degrees; and in the hotteſt weather, experience ſhews, that half that quantity is the leaſt that ought to be uſed. But as, in ſome ales, the whole virtue of the malt is not extracted, and what remains is appropriated to the making of ſmall beer, the quantity of yeaſt, uſed for theſe drinks, muſt be only in proportion to the ſtrength extracted. From theſe premiſes, the following tables have been formed, exhibiting the quantity of yeaſt neceſſary, for the ſeveral ſorts of drinks, and the different heats of the air.

A Table ſhewing the quantities of yeaſt neceſſary for common ſmall beer in every ſeaſon.

Heat of the air	pints of yeaſt to one quarter of malt	
35	9	The whole quantity of yeaſt to be put into the firſt wort.
40	8	
45	8	
50	7	
55	7	The firſt wort to have $\frac{3}{4}$ The ſecond wort to have $\frac{1}{4}$.
60	6	
65	6	The firſt wort to have one half of the whole quantity. The ſecond wort to have the remainder.
70	5	
75	5	
80	4	

⁂

A TABLE ſhewing the quantities of yeaſt neceſſary for all keeping drinks, both brown and pale, ſmall and ſtrong.

Heat of the worts*	pints of yeaſt to one quarter of malt
30	9
35	9
40	8
45	8
50	7
55	7
60	6
65	5
70	5
75	4
80	4

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* In beers intended for long keeping, the fermentation is to be governed by the heat of the worts or muſts, more than by that of the exterior air.

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* * *

A TABLE ſhewing the quantities of yeaſt neceſſary for amber and all ſorts of ales, after which ſmall beer is made.

Heat of the air	pints of yeaſt to one quarter of malt
30	$6\frac{3}{4}$
35	$6\frac{1}{4}$
40	6
45	$5\frac{1}{2}$
50	$5\frac{1}{4}$
55	5
60	$4\frac{1}{2}$
65	4
70	$3\frac{3}{4}$
75	$3\frac{1}{4}$
80	3

In every heat of the air, the quantity of yeaſt to be uſed for the ſmall beer made after ale, muſt be one third part of the quantity, which the ale required.

* * *

SECTION

SECTION XVI.

Of practical FERMENTATION, *and the management of the ſeveral ſorts of* MALT LIQUORS, *to the period, at which they are to be cleanſed or put into the* CASKS.

THE laws of fermentation are univerſal, and uniform; and when it proceeds regularly, its different periods are known by the different appearances of the fermenting liquor. As a particular appellation is given to each of theſe appearances, it may not be unneceſſary here to deſcribe them.

1. The firſt ſign of a wort fermenting is a fine white line, compoſed of very ſmall air bubbles, attached to the ſides of the tun; it is then ſaid to *have taken yeaſt*.

2. When theſe air bubbles are extended over the whole ſurface of the muſt, the wort is ſaid to be *creamed over*.

3. Bubbles continuing to riſe, a thin cruſt is formed; but as the fermentation advances rather faſter near the ſides of the tun, than in the middle, this cruſt is continually repelled: from which ariſes the denomination of *the wort parting from the tun ſide*.

4. When the ſurface becomes uneven, as if it were rock work, this ſtage of fermentation, which has no particular uſe, is diſtinguiſhed by its *height*.

5. When

5. When the head becomes lighter, more open, more uniform, and of a greater depth, being round or higher in the middle, than in any other part, and ſeeming to have a tendency ſtill to riſe, the liquor, in the caſe of ſtrong beer, is ſaid to be, by ſo many inches, *not fit to cleanſe.*

6. This head having roſe to its greateſt height, begins to ſink and to become hollow in the middle, and at the ſame time, more ſolid, the colours changing to a ſtronger yellow or brown; the wort is then ſaid to be *in a fit ſtate to cleanſe.*

After this, no farther diſtinctions are made; and if the fermentation is ſuffered to proceed in the tun, the head continues to ſink, and the liquor is often injured.

As the denominations and taſtes of liquors brewed from malt are numerous, it is impoſſible to ſpecify each ſeparate one; we ſhall therefore only particularize ſuch ſorts of drinks, as were taken notice of in the ſection of extraction, they being moſt in uſe; but, from what will be ſaid about them, the method of managing any other malt liquor may eaſily be deduced.

Spontaneous pellucidity ariſes from a due proportion of the oils to the ſalts, in the worts, but the advantage of long keeping depends not only on the quantity of oils and hops the muſts poſſeſs, but alſo on the fermentation being carried on in a ſlow and cool manner. The drinks, intended to be kept, are therefore beſt formed in cold weather, and made to receive their yeaſt at ſuch temperature, as is ſet forth in the table. The quantity of the yeaſt is divided in proportion to that of the wort let down, un-

till

till the whole, being mixed together, receives all its allotted yeaſt, except that part, which is put in juſt before cleanſing. Under theſe circumſtances, drinks, which are brewed for keeping, without the aſſiſtance of precipitation, are ſuffered to go through the firſt proceſs of fermentation, till they are ſo attenuated, that the liquor becomes light, and the head, or the yeaſt, laying on the ſurface of the beer, begins to ſink. When this head has fallen to nearly half its greateſt height, a remarkable vinous ſmell is perceived, and the liquor, at this term, is to be put into caſks, being firſt well rouſed with the remaining part of the yeaſt, in the manner mentioned in the preceding ſection.

By the deſcription given of the origin of yeaſt, it appears that it is formed rather of the coarſer oils of the worts. If the cleanſing is not done when the head is ſunk down to half the greateſt height, it roſe too, by falling lower, ſome part of theſe coarſer oils return into the beer, then under fermentation, and give it a flat greazy taſte, technically termed *yeaſt bitten*. When, on the contrary, beers or ales are removed too ſoon from the firſt tumultuous fermentation, for want of having been ſufficiently attenuated, and from not having depoſited their lees, nor thrown up in flowers their coarſer oils, they are leſs vinous, than otherwiſe they would have been, but appear heavy, aley, and are ſaid *not to have their body ſufficiently opened.*

The fermentation of common ſmall beer is, through neceſſity, carried on ſo haſtily, that it is hardly poſſible to wait

for

for the ſigns, which direct the cleanſing of other beers. This drink being generally brewed and fermented within twenty four hours, its ſtate, with regard to fermentation, is beſt judged of by the quantity of its froth or head at the time of cleanſing, which, in proportion to the heat of the air, may be determined by the following table.

A TABLE ſhewing the proper quantity of head, which common ſmall beer ſhould have to be properly cleanſed, in every ſeaſon of the year.

Heat of the air	head on the beer in the tun.
25 degrees	6 inches
30	5
35	4 ¼
40	3 ½
45	2 ¾
50	2
55	1 ½
60	1
65	¾
70	½
75	¼
80	juſt taken.

As it is chiefly by the action of the air that wines are formed, if we contrive to ſhift this powerful agent on the ſurface of a muſt under fermentation, and to convey it both more forcibly and more haſtily into it, its efficacy will be renewed, the fermentation accelerated, the liquor quickly become tranſparent, and ſoon be brought to the ſtate of maturity age might ſlowly make it arrive at.

Amber, or pale ales, require very hot extracts to be rendered ſoft and ſmooth to the palate; but, as a continuation of a great degree of heat prevents ſpeedy pellucidity, and ales do not admit of any large quantity of hops, which would alter their nature, there is a neceſſity to perform haſtily the act of fermentation, and to carry it on to a higher degree than is common in other malt drinks. As the method of exciting and conducting repeated fermentations, with ſucceſs, is perhaps not only the moſt difficult, but the moſt curious, part of the proceſs, I ſhall conclude with an account of it, what I have to ſay with regard to the practice of fermentation.

The amber wort being let down, at its proper degree of heat, into the fermenting tun, out of the whole quantity of yeaſt allowed for this drink, in the table page 257, one gallon muſt be kept to be uſed as hereafter ſhall be mentioned. Suppoſe that the heat of the air is at 40 degrees, and that eight quarters of malt have been wetted for this purpoſe; the whole of the yeaſt required is 6 gallons, from which one is to be reſerved. Of the five remaining gallons, one half, or two gallons and a half are to be put to the wort on its firſt coming down, and of the laſt 2 gallons, about three quarts muſt be

added

added to the drink, every twelve hours, untill it ferments to the higheſt pitch of the period mentioned in article 5 page 259. This ſucceſſive putting in of the yeaſt is called *feeding the drink*; about the time the head is got to this height, all the dirt or foul yeaſt, that riſes on the ſurface, muſt be carefully ſkimmed off; it is eaſily diſtinguiſhed from the pure white froth, by its color, and by the ſinking of the head occaſioned by its weight. Length of time might attenuate ſome of theſe coarſer oils in a leſs artificial fermentation, but as this help is wanted, and every obſtacle to pellucidity is to be removed, the brewer's attention to this point cannot be too great. At this time, the reſerved gallon of yeaſt is to be uſed, in order to give to the ale a ſufficient power to bear the repeated fermentations it is to undergo, by being beat in, every two hours, with a jett or ſcoope, for one quarter of an hour, ſo that the head on the drink be reduced to the leaſt height it is capable of. This ſtriking in being continued, the drink will periodically require it, and be damaged if it be neglected. After it has undergone more or leſs of theſe fermentations, in proportion to the heats of the worts and of the air, the brewer is carefully to obſerve, when the head ceaſes to riſe to its accuſtomed height, and then to examine the drink, by having the jett filled with it at the bottom, and brought through the whole body to the top, a ſmall part of which being poured in an handgatherer, he will ſee whether the lees form themſelves in large white flakes and readily ſubſide, and be informed, by the taſte, whether the ſweet of the wort is gone of, and the ale become vinous. When theſe two circumſtances concur, the drink is to be beat in with the jett as before, but not rouſed as porter or other beers are, for, by this management, the lees, which in this drink are in greater quantity, would ſo intimately be mixed with it, as with difficulty to ſeparate themſelves. It is then time to cleanſe it; but the caſks, more eſpecially in ſummer time, muſt be well filled up with clean drink, that is, part of the very drink, which was cleanſed, avoiding that produced in the ſtillings, as this, for want of ſtanding a ſufficient time, is always yeaſty, and the yeaſt, being greatly attenuated by the working of the drink eaſily diſſolves in the ale, and renders it foul and ill taſted.

As the brewing of amber well is looked upon as the higheſt pitch of the art of pale beer brewing, I have dwelt thereon more than otherwiſe it might ſeem neceſſary, to ſhew the connection there is between every ſort of malt liquors, and to remove this prejudice, that an artiſt, by brewing well one kind of drink, is incapacitated of excelling in another. But, to return to our ale, the ſame method of fermenting it, is to be practiſed, both winter and ſummer, varying only the quantities of yeaſt in proportion to the ſeaſon; ſo that whereas, in winter time, this drink is fed with three quarts of yeaſt, in every twelve hours, half a gallon will be ſufficient in ſummer. Though the proceſs is thus contrived to accelerate fermentation, yet the more coolly and gently it is performed, the better will the ales be. I have before hinted, that, if Madeira wines were fermented in this manner, they would ſooner become fit for uſe, more eſpecially, as they need no ferment to excite them. This method of fermenting drink has, indeed, been taxed with being unwholeſome, but, upon what grounds, I could never diſcover; as no reaſon of any moment has ever been alledged for this aſſertion.

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SECTION XVII.

Of the SIGNS *generally employed in the proceſſes of* BREWING, *and their compariſon with the foregoing* THEORY *and* PRACTICE.

WE have now brought our barley wines into the caſks, and this, on principles which are agreeable and conſonant to each other. The charge of novelty may, perhaps, ſtill be alledged, to invalidate what has been offered. It is but juſt to pay ſo much regard to a long and, upon the whole, ſucceſsful practice, as to recite, if not all, at leaſt the principal, maxims, and ſigns in brewing, which hitherto have guided the artiſt. By comparing theſe with the preſent method, they will not only illuſtrate each other, but perhaps cauſe both to be better underſtood; and though, with reſpect to the art itſelf, this may be thought rather a curious than an inſtructive part, yet we may learn from hence that ſuch practice, which long experience has proved to be right, will always correſpond with true theory.

1. *When a white flour ſettles, either in the underback or copperback, which ſometimes is the caſe of a firſt extract, it is a ſure ſign, that ſuch an extract has not been made ſufficiently hot, or in technical terms, that* the liquor has been taken too ſlack.

Malt, when dried, has it's oils made tenacious, in proportion to the power of heat it has been affected with; the grain,

grain, though ground, if the water for the extraction is not at leaſt as hot, as what occaſioned this tenacioufneſs, muſt remain in great meaſure undiſſolved in the firſt extract, and depoſite itſelf as juſt now was mentioned.

2. *The firſt extract ſhould always have ſome froth or head in the underback.*

The oils and ſalts of the malt, being duly mixed, form a ſaponaceous body, the character of which is that, on being ſhook, it bears a froth, on it's ſurface.

3. *The head or froth in the underback appearing red, blue purple or fiery, ſhews the liquors to have been taken too hot.*

The more hot the water is, when applied to the malt, the more muſt the extract abound with oils, and conſequently be more capable to reflect colors in a ſtrong manner. But how precarious this method of eſtimating the quality of an extract is, in compariſon to that which the thermometer affords, will appear from the following obſervation of Sir Iſaac Newton; "ſaponaceous bubbles will, for a while, appear tinged with "a variety of colors, which are agitated by the external air, "and thoſe bubbles continue until ſuch time as growing exceſſive thin, by the water trickling down their ſides, and "being no longer able to retain the incloſed air, they burſt". Now as theſe bubbles vary in their denſity, in proportion to their duration, the colors they reflect muſt alſo continually change; it is therefore, hardly poſſible to judge of the condition and ſaponaceouſneſs of the extracts, by the appearance of their froth.

4. *When the griſt feels ſlippery, it generally is a ſign that the liquors have been taken too high.*

This appearance proceeds from an over quantity of oil being extracted, and this is the effect of too much heat.

5. *Beer ought always to work kind, out of the caſk, when cleanſed, but the froth, in ſummer time, ſhould be ſomewhat more open than in winter.*

The higher and hotter the extracting water is, the more oils doth it force into the muſt; when a wort is full charged with oils, the fermentation is neither ſo ſtrong nor ſo ſpeedy, and conſequently the firſt froth, eſpecially, is thin, open and weak. This improves as the liquor is more attenuated, and in ſummer time, heat, which expands all bodies, muſt act in the ſame manner on yeaſt, the principal part of which is elaſtic air.

However vague and indeterminate theſe ſigns are, it would not be impoſſible to bring them to ſome degree of preciſion; but as, upon the whole, they would ſtill be much inferior to the rules we have endeavoured to eſtabliſh, we think it unneceſſary to purſue any farther a reſearch rather more curious than uſeful.

SECTION XVIII.

An enquiry into what may be, at all times, a proper ſtock of BEER, *and the management of it in the* CELLARS.

THE buſineſs of a brewer is not confined to the mere manufacture of his commodity; his concerns, as a trader, deſerve no leſs regard, and, in a treatiſe like this, ſhould not be intirely omitted.

As it is a fault not to have a ſufficient ſtock of beers, in the cellars, to ſerve the cuſtomers, it is one alſo to have more than is needful. By the firſt of theſe errors, the beers would be generally new and ill diſpoſed for precipitation; by the other, quantities of ſtale beer muſt remain, which becoming harder and harder, will at laſt be unfit for uſe, unleſs blended with new brewed beers, to their detriment. Theſe faults, if continued, may in time affect a whole trade, and ought therefore carefully to be avoided. For theſe reaſons, the whole quantity to be moved or expected to be ſupplied from the brewer's ſtore cellars, during the ſpace of one twelvemonth, ſhould be calculated, as near as poſſible; half this quantity ought to be the ſtock kept up from November to May incluſive, and nearly one third part the ſtock remaining in September. From hence a table may be formed, by which it will be very eaſy, at one view, to know the quantity, that ſhould be maintained at every ſeaſon of the year, and to avoid almoſt every inconveniency, which otherwiſe muſt ariſe. Suppoſe for example, the number of caſks expected to be moved in a year to be 320 butts and 248 puncheons, the ſtore cellars ought to be ſupplied, as to time and quantity, in the following proportion.

	Butts	puncheons.
January	160	124
February	160	124
March	160	124
April	160	124
May	160	124
June	146	113
July	133	103
Auguſt	120	93
September	107	82
October	133	103
November	160	124
December	160	124

After beers have been ſtarted in the cellars, the caſks ſhould be well and carefully ſtopped down, as ſoon as the repelling force of fermentation is ſo much leſſened, as not to be able to oppoſe this deſign. Otherwiſe the elaſtic air, which is the vivifying principle of the drink, being loſt, it would become vapid, and flat; and if left a long time in this condition, perhaps grow ſour.

It has already been obſerved, that cellars, in winter, are more hot than the exterior air by 10 degrees, and more cold in ſummer by 5 degrees. But beſides this general difference,

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repoſitories of beer vary ſurpriſingly in their temperature; from the nature of the ſoil in which they are built, from their expoſition to the ſun, or from other incidental cauſes. As heat is a very powerful agent in accelerating fermentation, it is by no means ſurpriſing, not only that ſome cellars do ripen drinks much ſooner than others, but alſo that a difference is often perceived in the ſame cellar. The perſons, intruſted with the choice of beers, with which the cuſtomers are ſerved, ſhould not be ſatisfied to ſend out their guyles, in the progreſſive order, in which they were brewed, but ought, on every occaſion, to note any alteration, that happens in the drink, as this is doing juſtice both to the commodity, and to the conſumer, who has a conſtant right to expect his beer in due order.

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SECTION XIX.

Of PRECIPITATION and other REMEDIES, applicable to the DISEASES incident to BEERS.

NO accident can be ſo detrimental in cellars as leaky or ſtinking caſks, which loſe or ſpoil the whole or part of the contained drink. The neceſſity of having, on theſe occaſions, a remedy at hand was undoubtedly the reaſon, why coopers were firſt introduced in ſtore cellars. Conſtant practice might have qualified their palates ſo, as to make them better judges of the taſtes of wines and beers, and to enable them to know which were the fitteſt for immediate uſe. The preparing or forcing them for this ſervice was a matter, which the profit gained by it made them ready enough to undertake. The chymiſts, whom they conſulted on this occaſion, gave them ſome informations, and by theſe means, the coopers became the poſſeſſors of a few noſtrums, the effects of which they were ſuppoſed to have experienced. But, as they are ignorant of the cauſe of theſe effects, and unacquainted with the conſtituent parts of beers, it is not to be expected that their ſucceſs ſhould be conſtant and uniform. The brewer certainly knows beſt, how he formed the drink, and ought conſequently, in any diſorder, to be prepared to direct the propereſt remedy.

The intent of this treatiſe has been to diſcover the means, by which

which errors may be avoided. Chymical applications are intended to remedy thoſe errors, which may be occaſioned either by careleſneſs or accident. The wholeſomeneſs or propriety of the applications, which will be indicated, muſt be left to the judgment of my readers; it is moſt likely that there is ſufficient room for improvement, and we might expect it from thoſe, whoſe profeſſion it is to ſtudy every thing, that may be conducive to the ſafety of mankind.

Whatever vegetables, wines are produced from, whenever they deviate from the reſpective perfection, a well conducted fermentation might have made them arrive at, they may be ſaid to be diſtempered. Foulneſs or want of tranſparency, is not the leaſt evil, but according to its degree it obtains various appellations, and requires different helps. From what has been ſaid, nothing can be more plain, than that it is always in our power, to form beers and ales, which will be bright. Yet porter or brown beer is conſtantly ſo brewed as to need precipitation: the reaſons for this management have before been offered. Were we to wait, till the liquor became tranſparent by age, a more real diſorder would enſue, than that of acidity. Precipitation is then ſerviceable, eſpecially when beers are to be removed from one cellar to another, a ſhort ſpace of time before they are to be uſed. By being ſhook, and the lees mixed with the liquor, a ſtrong acid taſte is conveyed therein, and the power of ſubſiding, which is wanted, renders forcing in that caſe abſolutely neceſſary. In beers brewed with high dried malts, no flatneſs is occaſioned thereby; as the caſe is, under

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like circumſtances, with liquors produced from pale or low dried grain. The degree of foulneſs in porter may however be limited; its bounds ought not to exceed the power of one gallon of diſſolved iſinglaſs, to a butt. Iſinglaſs is diſſolved in ſtale beer, and ſtrained through a ſieve, ſo as to be of the conſiſtence of a jelly. The beer is ſet in motion with a ſtick, which reaches one third part down the caſk, before and after this jelly is put in, and a few hours are ſufficient to obtain the deſired effect. We have before obſerved, that this quantity of jelly of iſinglaſs is equal to a medium of 14 degrees dryneſs in the malt, and heat of the extracts. When the opacity exceeds this degree, the liquor is termed *ſtubborn*; the ſame quantity of diſſolved iſinglaſs repeated is often ſufficient, in that caſe; and, if not, ſix ounces of the oil of vitriol, are mixed with it. An efferveſcence is, by this addition, produced; the oils of the drink become more attenuated, and the weight added to the precipitating matter, is a means to render it more efficacious. Inſtead of the oil of vitriol, ſix or eight ounces of the concrete of vitriol pounded and mixed with the iſinglaſs are ſometimes uſed with ſucceſs.

A foulneſs in beer beyond that which is called *ſtubborneſs*, gives to the drink the denomination of *gray beer*. This ariſes from the oils which float upon the ſurface, and which the liquor has not been able to abſorbe. In this caſe, the ſame methods, as before mentioned, are repeated; the quantity of diſſolved iſinglaſs is often increaſed to three gallons, that of vitriol to more than twelve ounces, and ſometimes a ſmall quantity of *aqua fortis* is added to theſe ingredients.

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The next ſtage of opacity is *cloudineſs*; when the cooper confeſſes, that the diſtemper exceeds the power of his menſtruums, and that his attempts extend no farther than to hide the evil. Calcined treacle, from its acidity, is of ſome ſmall ſervice, and by coloring the drink ſomewhat leſſens the grey duſky hue thereon; a quart of this is generally uſed in a butt. This ingredient is called *blacking*; and to prevent it to be known by the conſumer, the practice is to put thereon what is called *a good cauly flowered head.* This might be done by uſing as much pounded ſalt of ſteel as will lay upon a ſhilling, but the difference in price between this ſalt and copperas makes the laſt generally to be preferred. The ſtrong froth on the top of the pot, and that which foams about it, together with ſomewhat of a yellow caſt, are often miſtaken for the ſigns of a ſuperior merit, though in fact they are thoſe of deceit. A little reflection that the natural froth of beer cannot be yellow, nor continue a long time, eſpecially if the liquor has ſome age, would ſoon cure mankind of this prejudice. Cloudy beers, under theſe circumſtances, though not cured, are generally conſumed.

Beers become *ſick*, from their having ſo large a portion of oils, as to prevent the free admiſſion of the external air into them. The want of this enlivening element makes them appear flat, though not vapid. Such beers ſhould not, if poſſible, be brought immediately into uſe, as age alone would effect their cure. But when this cannot be complied with, every means that will put the beer upon the fret, or under a new fermentation, muſt be of ſervice. By pitching a butt head over head, the

the lees of the beer, which contain a large proportion of air, being mixed again with the drink, help to bring on this action, and to remove the *ſickneſs*.

Burnt hartſhorn ſhavings, to the quantity of two penny worth put into a butt, are often of uſe.

Balls made with eight ounces of the fineſt flower, and kneaded with treacle, convey likewiſe air to the drink, and promote its briſkneſs.

Beers, by long ſtanding, often acquire ſo powerful an acid, as to become diſagreeable. The means of correcting this defect is by alkaline, or teſtaceous ſubſtances, and in general by all thoſe which have the property of abſorbing acids. To a butt of beer in this condition, from four to eight ounces of calcined powder of oyſter ſhells may be put, or from ſix to eight ounces of ſalt of wormwood. Sometimes a penny worth or two of whiting is uſed, and often twenty or thirty ſtones of unſlacked lime; theſe are better put in ſeparately than mixed with the iſinglaſs.

In proportion as beers are more or leſs forward, from two to four ounces of ſalt of wormwood and ſalt of tartar, together with one ounce of pounded ginger, are ſucceſsfully employed.

Two pounds of hops boiled in ſome of the drink, eight ounces of calcined oyſter ſhells, and as many of bean flower, kneaded with ſome of the liquor into a paſte, and dropp'd into the caſk, will mellow and ſoften the beer. The ſooner the effect is intended to take place, the ſlacker the paſte muſt be made. As all theſe ſubſtances abſorbe acids, they, at the ſame time, leave a flatneſs in the liquor.

Sometimes in ſummer, when beer is wanted for uſe, we find it on the fret; as it is then in a repelling ſtate, it does not give way to the finings, ſo as to precipitate. In this caſe about two ounces of cream of tartar are mixed with the iſinglaſs, and if this is not ſufficient, four ounces of oil of vitriol are added to the finings next uſed, in order to quiet the drink.

Some coopers attempt to extend their art ſo far as to add ſtrength to the beer; but let it be remembered that the principal conſtituent parts of beer ſhould be malt and hops. When ſtrength is given to the liquor by any other means, its nature is altered, and it is no more beer that we drink. Treacle in large quantities, half an ounce of the berries of the *Cocculus Indicus*, of the grains of paradiſe, or of the Indian ginger pounded fine, and mixed with a precipitating ſubſtance, are ſaid to produce this extraordinary ſtrength.

To heigthen the flavor of the drink, half an ounce of grains of paradiſe pounded are uſed, and this, in my opinion, is the leaſt hurtful ingredient among them.

Formerly brown beers were required to be of a very dark brown, inclinable to red. As this color could not be procured by malt properly dried, the juice of elder berries was frequently mixed with the iſinglaſs. But this juice ſeems now to have given way to the calcined ſugar; both are needleſs, when

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the malt and hops have been properly choſe, and applied to their intended purpoſe.

Such are the remedies chiefly made uſe of for brown beers. Drinks formed from pale malts are always ſuppoſed to become ſpontaneouſly fine, and when they are ſo, by being bottled, they are ſaved from any farther hazard. As it is impoſſible for any fermented liquor to be abſolutely at reſt, the reaſon of beers being preſerved by this method is that, by it, more than by any other means, they are deprived of a communication with the air, and without riſk, gain all the advantages, which age, by ſlow degrees, can procure, and art can never imitate. Were we as curious in our ales and beers as we are in the liquors imported, did we but give, to the product of our own country, the ſame care and attendance which we beſtow on wines; we might enjoy them in a perfection, at preſent ſcarcely known, and perhaps cauſe foreigners, to eſteem our beers, as much as we do their wines.

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SECTION XX.

Of TASTE.

DOCTOR Grew, who has treated of this matter, divides taſte into ſimple and compound; he mentions the different ſpecies of the firſt, and calculates the various combinations of the latter, the number of which exceeds what at firſt might be expected. Without entering in this detail, I think that the different taſtes reſiding in the barlies, or formed by their being malted, and brewed with hops, may be reduced to the following; the acid, which is a ſimple taſte; the ſweet, which is an acid ſmoothed with oils; the aromatic, which is the compound of a ſpirituous acid, and a volatile ſulphur; the bitter, which, according to our author, is produced by an oil well impregnated either with an alkaline or an acid ſalt, ſhackled with earth; the auſtere, which is both aſtringent and bitter; and laſtly the nauſeous and rank, which is, at leaſt in part, ſome times foundin beers, which have either been greatly affected by fire, or by long age have loſt their volatile ſulphurs, and have nothing left but the thicker and coarſer oils, reſembling the empyreumatic dregs of diſtilled liquors not carefully drawn.

The number of circumſtances, on which the taſte of fermented liquors depends, are ſo various, that perhaps there never was any two brewings, or any two vintages, which produced drinks exactly ſimilar in taſte. But in this as well as in other things, varieties may be reduced under ſome general claſſes; the better to diſtinguiſh theſe, let us enquire, which taſtes belong to different malt liquors, according to the ſeveral circumſtances in which they are brewed.

In beers and ales, the acid prevails in proportion as the malt has been leſs dried, and heat was wanting in the extracting water. The ſweet will be the effect of a ballance preſerved between the acids and the oils. When, by the means of hotter water, oils more tenacious are extracted from the grain, the taſte becomes higher in reliſh, or aromatic. If the heat is ſtill increaſed, the greateſt part of the acids, and the moſt volatile oils, will be diſſipated, and the bitter of the hops appear more diſtinctly. A greater degree of fire will impreſs the liquor with an auſtere, rough or harſh taſte; and a heat beyond this charrs or burns the particles of the grain, and extracts the empyreumatic and nauſeous oils. Beſides heat, there may be other cauſes, which produce ſome variation in theſe taſtes; as a ſuperior dryneſs in the hops; an irregularity in the ordering of the heat of the extracts; too great an impetuoſity or ſlowneſs in the fermentation; the difference of time in which the drink is kept; but as theſe cauſes affect the liquor, in a low degree, in compariſon to the drying and extracting heats of the grain, an enquiry into their conſequences is not abſolutely material.

Beers or ales, formed of pale malt, in which a greater portion of acids is contained, with leſs tenacious oils, are not only more proper to allay thirſt, but in general more aromatic, than brown drinks. The oils of theſe laſt being, by the effect of fire, rendered more compact, and more tenacious of the terreſtrial parts raiſed with them, are attended with ſomething of an auſtere and rank taſte. This ſeems to be the reaſon, why brown beers require more time, after they have been fermented, to come to their perfection. The air, little by little, ſoftens and attenuates theſe oils, and by cauſing the heterogeneous particles to ſubſide, makes them at laſt, unleſs charring heats have been uſed, pleaſing to the palate, whereas they were before auſtere, rank and nauſeous.

By means of the thermometer, we have endeavoured to fix the different colors of malt, the duration of the principal ſorts of drink, and the tendency each has to become tranſparent. The ſame inſtrument cannot probably have the ſame uſe, when applied to diſtinguiſh the different taſtes, as theſe depend on a variety of cauſes not eaſy to be aſcertained. Yet ſomething of this nature may be attempted, upon the following principles.

As the chief circumſtance, which produces a variety of taſtes in malt liquors, is fire or heat acting on the malt and hops, and the effect of the air, put in motion by the ſame element, the table here ſubjoined may point out what taſtes are in general occaſioned by the combination of theſe two cauſes.

A Table determining the taſtes of malt liquors.

Heat of the air	dryneſs and extracting heat	predominant taſtes
80°	119°	Acid
76	124	ac. ac. ſweet
73	129	ac. ſw.
70	134	ac. ſw. ſw. bitter
66	138	ſw. ſw. bit.
63	143	ſw. bit.
60	148	bit. bit. aromatic
56	152	bit. arom.
53	157	bit. arom. auſtere
50	162	arom. auſt. auſt.
46	167	auſt. auſt. nauſeous
43	171	auſt. nau.
40	176	nauſeous.

The firſt column of the table ſhews the fermentable degrees reverſed, as the hotter the ſeaſon is, the more fermented drinks tend to acidity, the direct contrary of which is the conſequence of an increaſe in the heat, malt or hops are dried or extracted with.

The aſſiſtance of this table, though ſmall, ought perhaps not to be intirely ſlighted, as it ſeems at leaſt to ſhew that the uſeful is ſeldom ſeparated from the pleaſing, and that a medium between extremes is moſt agreeable both to the operations of nature, and the conſtitution of our organs.

The impreſſions of taſtes are leſs in proportion as the drinks are weak. The ſtrongeſt wine yields the moſt acid vinegar. Time wears away this acidity much ſooner, than it doth the nauſeouſneſs occaſioned by vehement heats. This circumſtance ſhews how neceſſary it is, in the beginning of the proceſs of brewing, to avoid extracts which are too weak, and, in its concluſion, ſuch as too great a heat would render rank and diſagreeable. That proportion between the ſalts and the oils, which conſtitutes true ſaponaceouſneſs, is moſt pleaſing to the taſte, and ſeems to be the utmoſt perfection of the art. As the ſun never occaſions a heat capable of charring the fruits of the vine, we never meet with wines, endued with a taſte reſembling to the empyreumatic, which we have here repreſented. This error, being inexcuſable in any liquor, ought carefully to be guarded againſt, and from what we have here ſaid we may learn this important truth; that nature is the beſt guide, and that, by following her operations, we ſhall never be diſappointed in our ends.

⁂

APPENDIX.

APPENDIX.

THOUGH this work has already been carried to a great length, I hope thoſe of my readers, who may have done me the honor to go attentively through the whole of it, will pardon me the addition of a few incidental thoughts and queries. The chain of arts is ſo well connected, that reſearches originally intended for the illuſtration of any one of them, can hardly fail of throwing ſome light upon others.

1. The ſeed of plants cannot be put in a fitter place, for perfect vegetation, than when buried under ground, at a depth ſufficient to defend the young ſhoots from the viciſſitudes of heat and cold, and the diſadvantages of too much moiſture. The manuring of the earth, and the ſteeping the ſeed into ſolutions of ſalts or calcined ſubſtances, have been found, in ſome caſes, to increaſe the ſtrength of the grain, to correct its original defects, and to prevent the noxious impreſſions of a vicious ground. Plants are made to germinate in water alone, and this experiment ſo ſucceſsfully carried on every winter, in warm apartments, may ſtill be improved by diſſolving alkaline ſalts in the water. Could the barley uſed for malt-

ing be put in the ground, its growth would be more natural, and its oils becoming more miſcible with water, by the ſaline nouriſhment derived from the earth, might yield more vinous, more ſtrong, and more laſting liquors. But as this method is impracticable, would it be impoſſible to increaſe the efficacy of that which is uſed? Might not lime be added to the water, with which the grain is moiſtened? Is it not uſed with ſucceſs to manure land? Is not a ſolution of it in water employed by the farmer to ſteep his ſowing ſeed in? Might it not attract many uſeleſs acids from the grain, and poſſibly from the water itſelf, as it doth thoſe of the ſugar? I barely mention this as one of the ſubſtances, that might be imployed in the malting of barley, and am far from thinking it the only one. Perhaps different ſalts ſhould be uſed, according to the nature of the ſoil, from which the corn was produced; but a variety of experiments ſeems to be required, in order to diſcover how far art might in this caſe imitate and improve nature.

2. A ſmall quantity of malt, at all times, but eſpecially when brewed in large veſſels, parts too readily with the heat which extraction requires; and on the contrary, that heat may be continued too long, if the quantity of malt be very great and not ſufficiently ſpread. A forward beer inclinable to acidity often reſults from too ſhort a griſt, a thick, ſtubborn, and rank liquor is produced from too large one. Every advantage may be had in brewing, properly, five or ſix quarters of malt; it is difficult to ſucceed if the number exceeds fifty.

3. The

3. The ſtrong pungent volatile ſpirit, which exhales from a muſt, when under full fermentation, has in general been ſuppoſed to be a loſs, which might be prevented; and accordingly attempts have been made to retain theſe flying impetuous particles, by ſtopping the communication between the atmoſphere and the fermenting drink. That there is a diſperſion of ſpirits is beyond doubt, and that theſe exhaling vapors conſiſt of the fineſt oils, which the heat forces out of the muſt, is equally certain. But this loſs ſeems to be abundantly ſupplied by the ſtronger oils, which the ſame degree of heat attenuates and ſubſtitutes, in a larger quantity, to the former. The laſt oils could never come under the form of a vinous liquor, but by a power, which ſooner or later diſſipates ſome of the firſt. Pale ales or amber not only lay, for many days, expoſed to the open air, but ſuffer, by the periodical renewal of the action of the air, every two or four hours, a much more conſiderable loſs of ſpirits, than when fermentation is carried on uniformly. Yet experience ſhews, that ſo many oils are, by this method, attenuated, that the ſtrength acquired greatly ſurpaſſes that which is loſt.

4. The practice of fermenting *by compreſſion*, recommended to diſtillers, ſeems, on this account, leſs uſeful, than it might be concluded to be from theory, ſince the intent of the diſtiller as well as of the brewer is to extract the greateſt quantity of ſpirituous oils. It is impoſſible to ferment a muſt *in vacuo*; air is abſolutely neceſſary for carrying on this operation, and even a ſuperabundant quantity of oils, by obſtructing the free admiſſion of the air, impedes fermentation, prevents the wine from be-

coming pellucid, and ſometimes may in part render it putrid.

5. When the pureſt ſpirit is intended to be drawn from the grain, the fermented waſh ought to be ſuffered to ſettle, till it becomes tranſparent. The diſpatch, with which the diſtillery is generally carried on, prevents this uſeful circumſtance taking place, and occaſions a want of vinoſity in the liquor. In many caſes, the extraordinary charges of extracting the griſt in the manner, which has been directed for drinks intended long to be kept, and of ſuffering the maſh to become ſpontaneouſly tranſparent, might be abundantly repaid. Yet, if hurry muſt be a part of the diſtiller's buſineſs, he ſhould at leaſt make ſuch extractions as admit of the ſpeedieſt and readieſt fermentation. He cannot expect corn ſpirits equal to the brandies of France, unleſs his worts are ſimilar to the wines diſtilled in that kingdom. He would therefore ſecure to himſelf the greateſt probability of ſucceſs, did he regulate his extracts by ſuch heats as have been fixed for ſmall beer, eſpecially as the length uſed in diſtillery is nearly the ſame. The omiſſion of the hops would render ſuch muſts fit for the ſtill, immediately after fermentation. By too ſtrong heats, more oils are forced into the muſt than can be converted in ſpirits; and fermentation being, by this over charge, in ſome meaſure, clogged and impeded, a leſs yield is made, and a liquor obtained of a rank and often empyreumatic taſte.

5. Why are the brandies of Spain inferior to thoſe prepared in France? The wines of the laſt country are the growth of a weaker ſun; they contain no more oils than can be aſſimilated by fermentation, and form a clean dry nutty ſpirit. The Spaniſh wines abounding with more oleaginous than acid parts, this over proportion becomes not only uſeleſs but hurtful in the ſtill, and produces the rankneſs obſerved in Spaniſh brandies. The cleanneſs of the ſpirit ariſes in great meaſure from the weakneſs of the muſt, and its vinoſity from the due proportion of the oils to the ſalts. This ſeems to be the reaſon why the moſt grateful ſpirits are produced, from wines unable to bear the ſea or to be long kept.

6. The native ſpirits of vegetables, ſays Boerhaave, are ſeparated by heats between 94 degrees and 212. To obtain the whole of theſe, the fire muſt be gradually increaſed; for a ſuperior heat diſſipates the ſpirits raiſed by an inferior one. Such parts as might be obtained by 100 degrees are loſt if the heat applied be much greater. Though the parts of vegetables immerſed in water cannot ſo eaſily be diſſipated as if they were in open air, yet, by the rarefaction of the liquid, a proportional evaporation muſt inſue, and the oils raiſed by a greater heat may ſo effectually envelope the finer ones, as to make them hardly perceptible either to our ſmell or taſte. Thus, though heated water is able to extract all the virtues reſiding in the vegetables, the different application of the fire will alter, not only their proportions, but perhaps their properties alſo.

7. The vinegar maker is equally concerned with the diſtiller in the brewing proceſs. Vinegar is produced by the laſt ſtage of fermentation, when a groſs, tartareous, unctuous matter, conſiſting of the coarſer oils extracted either from the grain or the grapes, generally falls to the bottom of the liquor, and no longer prevents its acidity, or affects its flavor. Though the beſt vinegar proceeds either from the ſtrongeſt wines or beers, this ſtrength conſiſts in the quantity of fermentable principles, and not in that of mere oleaginous parts. By properly adapting the extracting waters, this hurtful impediment may be removed, and the vinegar from malt liquors become as neat and as ſtrong as that, which is extracted from wine.

8. As the acid taſte of vinegar is the effect of a continued fermentation, many people have thought it immaterial how ſpeedily the firſt parts of the operation were carried on. But violent fermentations not only diſſipate ſome of the fine oils, which ſhould be retained in the vinegar, but alſo cauſe the muſt to tend towards putrefaction. Boerhaave, after he has directed a frequent tranſvaſion of the liquor, obſerves that, whenever the weather or the workhouſe is very hot, it is often neceſſary to fill the half emptied veſſels every twelve hours, not only to procure a ſupply of acids from the air, but alſo to cool the wine, and check the too violent fermentation, which ariſing in the half full caſks, might diſſipate the volatile ſpirits before they are properly ſecured and intangled by the acid. Hence the liquor might be ſower indeed, but at the ſame time flat, and would never become a ſharp and ſtrong vinegar.

9. Uſes

9 Uſes have frequently been found for materials, which before were ſuppoſed of no value. The grains, after the brewer has drawn his worts out of them, are generally employed for the feeding of cattle ; but I do not know that hops, after their boiling, have been put to any farther uſe. Is there nothing more left in this vegetable, after it has imparted the virtue wanted to the beer? All plants burnt in open air yield alkaline ſalts, though in a greater or leſs quantity, according to the quality of the plants. Boerhaave ſays that thoſe, which are auſtere, acid, or aromatic, yield in their aſhes a great abundance of ſalts, and that theſe being put in fuſion, and mixed with flint or ſand run into glaſs. Hops thrown, after decoction, in no great quantity on the fire, cauſe the coals to vitrefy, or as it is generally termed, to *run into clinkers.* If therefore the remains of the hops were burnt in open air, or in a proper furnace, it ſeems moſt likely that no inconſiderable quantity of ſomewhat like potaſhes might be obtained, and this, conſidering the many tun weight of hops employed in large cities, and thrown away as uſeleſs, might become an object of private emolument to the brewer, and of public benefit to the nation.

FINIS.

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Fermen-

Wines,

F I N I S.

E R R A T A.

PART I. *Page* 36, *line* 6, dele $161+\frac{1}{3}$, *p.* 51, *l.* 15, for *ſoon* read *ſooner*, *p.* 109, *l.* 7, for *heated* read *wetted.*

PART II. *Page* 117, *line* 18, for *worts* read *extracts*, *p.* 119, *l.* 1, dele *laſtly*, *p.* 147, *l.* 2, for 10 *wt.* read 10 *lb wt. p.* 147, *l.* 7, for 3 *wt.* read 3 *lb. wt. p.* 174, *l.* 6, for *beſore* read *before*, *p.* 191, *l.* 7, for 1, 4, *per quarter* read 1, 3, *per quarter*, *p.* 201, *l.* 6, for 24, 30, read 24, 00, *p.* 221, *l.* 15, for $15\frac{1}{2}$ read 16, *p.* 224, *l.* 16, for 158, 0, 50, read 1580, 50, . 235, *l.* 10, for *as much* read *as near p.* 237, *l.* 21, for *notwithſtand* read *with*, *p.* 243, *l.* 3, for 138, read 130, *p.* 243, *l.* 7, for 20, 26, read 10, 26, *p.* 253, *l.* 6, after *yield* dele *a p.* 262, laſt line for 2 *gallons* read 2 *gallons* $\frac{1}{2}$, *p.* 274, *l.* 21, for *ſtubborneſs* read *ſtubborn.*