

**BREWING**  
AND  
**DISTILLATION.**

BY  
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WITH  
**PRACTICAL INSTRUCTIONS**

FOR BREWING PORTER AND ALES ACCORDING TO THE ENGLISH AND  
SCOTTISH METHODS.

BY  
**WILLIAM STEWART.**

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## P R E F A C E.

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THE following TREATISES by Professor Thomson, contributed to the last Edition of the *Encyclopædia Britannica*, having been considered by Brewers and Distillers as containing the most valuable information on the subjects of their manufactures, the Publishers have been persuaded to print them in a separate volume. They have likewise added to the scientific works of Dr Thomson, Instructions by a practical Brewer, on the methods of brewing Porter and Ales, both in the English and Scottish manner, which, they hope, will render the book a valuable acquisition, not only to the extensive manufacturer, but to those also who brew only for their own consumption.

EDINBURGH, August 1, 1849.



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## TREATISE ON BREWING.



WE shall commence this treatise with a short view of the history of the art ; in the second chapter, we shall give an account of the different kinds of grain employed ; in the third, we shall treat of the process of malting ; in the fourth, of that of brewing ; and in the fifth, we shall give an account of the nature and properties of the different kinds of ale and beer manufactured by the brewer. The *Explanation of the Plates* will contain a description of the utensils and machinery used in a London porter brewery.

## CHAPTER I.

## HISTORY OF BREWING.

No notice is taken of beer or ale in the Books of Moses ; from which it is probable that they were unknown till after the death of that legislator. All the ancient Greek writers agree in assigning the honour of the discovery of beer to the Egyptians, whose

country, being annually inundated by the Nile, was not adapted to the cultivation of vines. Herodotus, who wrote about 450 years before the commencement of the Christian era, informs us that the Egyptians made their wine from barley, because they had no vines. *Οση δ' εκ κριθων πιπωμενη διαχρεισται ου γαρ σφιν εισι εν τη χωρη αμπελοι.* *Herodoti*, lib. ii., c. 78. Pliny says that this liquid in Ægypt was called *zythum* (*Plinii Hist. Nat.*, lib. xxii., c. 25). The same name was given to it by the inhabitants of Galatia, who, according to Diodorus Siculus, were unable to cultivate grapes on account of the coldness of their climate. Beer was distinguished among the Greeks by a variety of names. It was called *ονον κριθνον* (barley wine) from its vinous properties, and from the material employed in its formation. In Sophocles, and probably other Greek writers, it is distinguished by the name of *βρυρον*. Dioscorides describes two kinds of beer, to one of which he gives the name of *ζυθον*, and to the other *κουρμι*; but he gives us no description of either sufficient to enable us to distinguish them from each other. (*Dioscorides*, lib. ii., c. 79 and 80.) Both, he informs us, were made from barley; and similar liquids were manufactured in Spain and Britain from wheat.

Tacitus informs us, that, in his time, beer was the common drink of the Germans; and from his imperfect description of the process which they followed, it is not unlikely, or rather there can be no doubt, that they were acquainted with the method

of converting barley into malt. "Potui humor ex hordeo aut frumento in quandam similitudinem vini corruptus." (*De Moribus German.* c. 23.) Pliny gives us some details respecting beer, though they are by no means satisfactory. He distinguishes it by the name of *cerevisia* or *cervisia*, the appellation by which it is always known in modern Latin books.

This liquid does not seem to have come into general use in Greece or Italy; but in Germany and Britain, and some other countries, it appears to have been the common drink of the inhabitants, at least as early as the time of Tacitus, and probably long before. It has continued in these countries ever since, and great quantities of beer are still manufactured in Germany, in the Low Countries, and in Britain.

The first treatise published on the subject, as far as we know, was by Basil Valentine. This treatise, according to Boerhaave, is both accurate and elegant. In the year 1585, Thaddeus Hagecius ab Hayck, a Bohemian writer, published a treatise entitled *De Cervisia ejusque conficiendi ratione, natura, viribus et facultatibus*. This little treatise, consisting only of fifty pages, is written with great simplicity and perspicuity, and gives as accurate a description of the whole process of brewing as any treatise on the subject which we have seen. In the early part of the eighteenth century, Mr Combrune, who, we believe, was a practical London brewer, published a book, entitled *The Theory and Practice of*

*Brewing.* This book has gone through many editions, and, we believe, is still reckoned the standard book on the subject. But the attempts made in it to give a rational theory of brewing are far from being satisfactory. Nor can any stress be laid upon the experiments which it contains on the colour of malt, according to the temperature at which it is dried. The fact is, that malt may be rendered brown, or even black, by exposure to a very low heat; while it may be exposed to a very considerable temperature without losing its colour. The writer of this treatise has seen malt exposed on the kiln to a heat of 175° F. without losing its colour, or without being deprived of the power of vegetating when put into the ground; and he has reason to believe that these properties would have remained unaltered had the temperature been raised still higher. It is not the degree of heat applied, but the rapidity with which it is raised, that darkens the colour of malt. If the heat at first does not exceed 100°, and if, after the malt is dried as much as it can be at that temperature, the heat be raised to 120°, kept some time at that temperature, and then raised gradually higher, and if we continue to proceed in this manner, the temperature of the kiln may be elevated at least to 175° without in the least discolouring the malt.

In the year 1784 Mr Richardson of Hull published his *Theoretic Hints on Brewing Malt Liquors*, and his *Statical Estimates of the Materials of Brewing*, shewing the use of the *Saccharometer*. These books

are reprehensible, on account of the air of mystery in which the subject is invested, and the avowal of the author, that he conceals certain parts of the processes. If a brewer conceives he knows more of his art than his neighbours, and chooses to keep his knowledge to himself, there is nothing to be said ; but if he publish a book upon the subject, and yet persists in his concealment, he deserves no quarter. His book, in such a case, can be looked upon in no other light than as a quack bill to advertise the goodness of his wares. Mr Richardson, however, deserves considerable praise for the *sacchârometer*, which he appears to have been the first to bring under the notice of the brewer. This instrument is of material service, by making brewers acquainted with the strength of their worts, and consequently with the proportion of soluble matter which is furnished by the materials that they employ. Mr Richardson's *saccharometer*, indeed, was not accurate, because it was founded on an erroneous principle. The method which he followed was to determine the weight of a barrel of pure water. The liquid being then converted into wort, a barrel of it was weighed again, and the increase of weight was considered as the matter which the water held in solution. Mr Richardson did not seem to be aware that, when water dissolves the sweet portion of malt, its bulk is altered ; and that, for this reason, the specific gravity of it does not indicate the quantity of solid matter which it holds in solution. A set of experiments made on purpose, by dissolving determinate weights of the solid extract of

malt in given quantities of water, is necessary to determine the point. The same objection applies to the *saccharometer* of Dring and Fage, and to various others in common use. That of Dicas is nearly correct, having been constructed upon proper principles. But perhaps the best is one constructed about forty-five years ago by Dr Thomson, and used by the excise-officers in Scotland. It indicates the specific gravity of the wort; from which, by means of a sliding rule, which accompanies the instrument, the weight of saccharine matter contained in it is at once determined.

One of the latest books on the subject which we have seen, is entitled *Practical Treatise on Brewing and Distilling*. This book was published in quarto in the year 1805. The author, whose name is Shannon, appears to have had some practical knowledge of brewing; but he must have been extremely illiterate, as he was totally unable to write either grammar or common sense. The book is a tissue of absurdities from beginning to end; and the impracticability of his proposed improvements is surpassed only by the absurdity of his theory, which consists of scraps and sentences taken out of chemical books, and tacked together, so as to have no meaning whatever.

## CHAPTER II.

## OF THE KIND OF GRAIN USED BY BREWERS.

Every kind of grain, with perhaps hardly an exception, may be employed for the purposes of the brewer. In America it is not uncommon to make beer with the seeds of Indian corn or *Zea mais*. In order to convert it into malt, it is found necessary to bury it for some time under the ground; and when germination has made sufficient progress, it is dug up and kiln-dried. (See *Philosophical Transactions*, vol. xii., p. 1065.) Mr Mungo Park informs us, that, in Africa the negroes make beer from the seeds of the *Holcus spicatus*, and the process employed, as he describes it, seems to differ but little from the one followed in this country. (See Park's *Travels*, p. 63, 8vo edition.) Dioscorides assures us, that in Spain and Britain wheat was employed for the manufacture of beer; and the writer of this treatise has been informed by a gentleman in the service of the East India Company, that he has made beer from wheat at Madras. We have ourselves seen oats employed for this purpose in Great Britain; and in Germany and the north of Europe we believe that it is not uncommon to employ rye for the same purpose. But the material which answers

best, and which is almost solely used in Great Britain, and we believe in every part of Europe where beer is manufactured, is barley.

Barley is the seed of the *Hordeum vulgare*, a plant which has been cultivated from time immemorial, chiefly for the manufacture of beer. There are two species of *hordeum* under cultivation in Britain. The first is, the *Hordeum vulgare*, or barley in which the seeds are disposed in two rows on the spike. - This is the species usually cultivated in England and in the southern parts of Scotland. The second is the *Hordeum hexastichon*, called in the south of Scotland *bear*, and in Aberdeenshire *big*. In this species, the grains are disposed in two rows, as in the other; but three seeds spring from the same point, so that the head of *big* appears to have the seeds disposed in six rows. *Big* is a much more hardy plant than barley, and ripens more rapidly. Hence it thrives better than barley in cold and high situations. On this account it is sown in preference in the Highlands and northern parts of Scotland, where the climate is colder than farther to the south. We have been assured that there is a third species of *hordeum* cultivated in Scotland, in which the seeds in the spike are arranged in four rows. To this the term *bear* is exclusively confined by some. But we do not find it noticed by botanists. The trivial name *tetrastichon* might be applied to it.

The grains of barley are much larger than those of *big*, and the cuticle which covers them is thinner.

Indeed the thickness of the skin of barley itself varies according to the heat of the climate in which it is cultivated, being always the thinner the warmer the climate. Thus it will be found that the cuticle of Norfolk barley is thinner than that of Berwickshire or East Lothian barley; and if Norfolk barley be sown in Scotland for several successive years, its cuticle will be found to become thicker.

The specific gravity of barley is rather greater than that of big. The specific gravity of barley, tried in more than 100 different specimens, was found by us to vary from 1.333 to 1.250, and that of big from 1.265 to 1.227. The average weight of a Winchester bushel of barley was found to be 50.7 lbs. avoirdupois, and the average weight of a bushel of big 46.383 lbs. The heaviest barley tried weighed 52.265 lbs. per bushel, and the heaviest big weighed 48.586 lbs. The big grew in Perthshire, and the season was peculiarly favourable. It was not absolutely free from a mixture of barley, as was ascertained by sowing a quantity of it, but the proportion of barley was very small. The average weight of a grain of barley is 0.6688 grain, or very nearly two-thirds of a grain, while the average weight of a grain of big is 0.5613 grain. The average length of a grain of barley, from many thousand measurements, is 0.345 inch, while that of a grain of big is 0.3245 inch. So that the average of both would give us very nearly the third of an inch, which it ought to do, according to the origin of our measures, as commonly stated. The average breadth

of a grain of barley is 0.145 inch, while the average breadth of a grain of big is 0.136 inch. The average thickness of a grain of barley is 0.1125 inch, while the average thickness of a grain of big is 0.1055 inch. Thus we perceive that the grain of big is smaller than the grain of barley in all its dimensions.

To determine the relative weight of the skins of barley and big, we made choice of three parcels of grain, all excellent in their kinds, namely, Norfolk barley, Haddington barley, and Lanark big. The weights of the whole grain, and of the cuticles of each of these, were as follow :

	Weight of a corn in grains.	Weight of cuticle in grains.
Norfolk barley . . . . .	0.6809 . . . . .	0.110 or $\frac{1}{9}$
Haddington barley . . . . .	0.7120 . . . . .	0.123 or $\frac{1}{8}$
Lanark big . . . . .	0.5408 . . . . .	0.125 or $\frac{1}{8}$

From this we see that there is little difference between the weight of the skin of Norfolk and Haddington barley, but a very considerable difference between Haddington barley and Lanark big. Hence it would seem that this difference is not owing to the climate in which the barley vegetates, but rather to the nature of the two species.

The bulks of these two species of grain with relation to each other are as follow :

Barley . . . . .	0.00217 cubic inch.
Big . . . . .	0.001777 cubic inch.

These quantities represent the average bulk of a corn of each kind. Thus it appears that a grain of barley is rather more than  $\frac{1}{3}$ th part larger than a grain of big.

Finally, from a comparison of many thousand corns of each species with each other, it appears that the inequality between the size of different grains of big is greater than that between different kinds of barley. Indeed, if we examine an ear of big when nearly ripe, we shall perceive that the corns towards the bottom of the ear are smaller than those towards the summit and about the middle of the ear. Several of these bottom grains are usually abortive, or consist only of skin; but this is not always the case. In an ear of barley, on the contrary, we shall find almost all the grains nearly of a size, though in some cases the grain constituting the upper termination of the spike is rather smaller than the rest.

These circumstances may strike the reader as too minute and trifling to be stated in such detail; but we shall find afterwards that they will furnish us with an explanation of some anomalous circumstances which occur when these two species of *hordeum* are converted into malt. The value of barley, or its produce in alcohol, is rather improved, while big, on the contrary, is deteriorated, by malting it, at least twenty per cent.

The constituents of the kernel of barley and big, as far as we are able to ascertain at present, are the same. Barley has been subjected to an elaborate chemical analysis by Einhoff, who obtained from 3840 parts of barley-corns the following constituents :

Volatile matter . . . . .	430
Husk or cuticle . . . . .	720
Meal . . . . .	2690
	<hr/>
	3840

From the same quantity of barley-meal he obtained,

Volatile matter . . . . .	360
Albumen . . . . .	44
Saccharine matter . . . . .	200
Mucilage . . . . .	176
Phosphate of lime with mucilage . . . . .	9
Gluten or vegetable fibrin . . . . .	135
Husk, with some gluten and starch . . . . .	260
Starch, not quite free from gluten . . . . .	2580
Loss . . . . .	76
	<hr/>
	3840

The writer of this treatise has likewise extracted from barley, by means of alcohol, a small quantity of an oily matter, which has an asparagus-green colour, and does not burn with the same readiness as an oil. It has very much the appearance of olive oil coagulated, but its consistence is less, and its colour is darker. It has little smell, and its taste resembles the flavour of spirits from raw grain. We have likewise found in big a quantity of nitrate of soda. Hence it is likely that this salt exists as a common constituent of barley. We obtained it by steeping big in water for two days, concentrating the liquid, and setting it aside in a dry place. Many rhomboidal crystals of nitrate of soda gradually make their appearance as the liquid evaporates.

We shall terminate this chapter by a table, exhibiting the most remarkable properties of a considerable number of specimens of British barley and big, as determined by the writer of this treatise. The different specimens are distinguished by the name of the county in which they grew. By the *bushel* in the table is meant the Winchester bushel of 2150·42 cubic inches.

TABLE OF PROPERTIES.

GRAIN.	WEIGHT in lbs. Avoirdupois.		Specific Gravity.	SIZE.		SHAPE.		EQUALITY OF SIZE.												
	Per Bushel.	Per Boll.		Average Weight of a Corn in Grains Troy.	Average Bulk of a Corn in Cubic Inches.	Average Length in Inches.	Average Breadth in Inches.	Average Thickness in Inches.	Weight of a Corn in Grains.			Length in Inches.			Breadth in Inches.			Thickness in Inches.		
									Greatest.	Least.	Difference.	Greatest.	Least.	Difference.	Greatest.	Least.	Difference.	Greatest.	Least.	Difference.
1st Norfolk.....	50-375	302-250	1-290	0-681	0-00210	0-346	0-145	0-112	0-6954	0-6647	0-0307	0-387	0-318	0-069	0-166	0-128	0-038	0-125	0-092	0-033
1st Kent.....	49-877	299-263	1-250	0-662	0-00209	0-343	0-142	0-108	0-6775	0-6410	0-0365	0-369	0-287	0-086	0-160	0-116	0-044	0-125	0-087	0-038
1st Suffolk.....	50-683	304-098	...	0-639	...	...	0-347	0-150	...	...	...	...	...	...	...	...	...	...	...	...
2d Norfolk.....	50-570	303-420	1-272	0-665	0-00216	0-344	0-145	0-110	0-6960	0-6940	0-0470	0-384	0-300	0-084	0-159	0-126	0-033	0-120	0-086	0-024
2d Kent.....	50-082	300-372	1-290	0-637	...	...	0-143	0-112	...	...	...	...	...	...	...	...	...	...	...	...
2d Suffolk.....	49-250	295-500	1-307	0-601	...	...	0-140	0-108	...	...	...	0-353	0-301	0-052	0-154	0-132	0-022	0-116	0-100	0-016
3d Norfolk.....	51-937	311-622	1-290	0-648	0-00198	0-345	0-141	0-107	0-6740	0-6250	0-0590	0-362	0-328	0-034	0-159	0-118	0-041	0-121	0-083	0-038
3d Essex.....	47-683	286-098	1-291	0-593	...	...	0-333	0-139	0-6020	0-5830	0-190	0-369	0-292	0-077	0-155	0-111	0-044	0-125	0-089	0-036
Average...	50-054	300-327	1-28	0-640	0-00208	0-343	0-143	0-108	0-6689	0-6415	0-0384	0-370	0-304	0-067	0-160	0-121	0-038	0-123	0-092	0-030
1st Haddington.	52-190	313-140	1-333	0-7120	0-00211	0-336	0-154	0-120	0-7342	0-6954	0-0380	0-368	0-286	0-082	0-171	0-107	0-064	0-131	0-089	0-042
1st Edinburgh.	52-164	312-984	1-290	0-7056	0-00217	0-335	0-149	0-116	0-7204	0-6906	0-0298	0-369	0-300	0-069	0-162	0-129	0-033	0-127	0-101	0-026
1st Berwick.....	52-062	312-372	1-307	0-6571	...	...	0-143	0-111	...	...	...	0-361	0-290	0-071	0-160	0-124	0-036	0-126	0-087	0-035
1st Linlithgow..	51-062	306-372	1-324	0-7650	0-00228	0-373	0-150	0-117	...	...	...	0-426	0-328	0-098	0-164	0-130	0-034	0-130	0-084	0-036
2d Haddington.	52-265	313-590	1-333	0-6900	0-00204	0-346	0-145	0-111	0-7020	0-6700	0-0320	0-380	0-288	0-092	0-170	0-111	0-059	0-132	0-072	0-060
3d Haddington.	48-987	293-922	1-250	0-6570	0-00208	0-341	0-144	0-108	0-6790	0-6260	0-0530	0-370	0-308	0-062	0-159	0-117	0-042	0-121	0-086	0-036
3d Linlithgow..	46-375	278-250	1-333	0-7000	...	...	0-347	0-139	...	...	...	...	...	...	...	...	...	0-164	0-120	0-044
Average.....	50-729	304-375	1-310	0-6981	0-00213	0-346	0-146	0-112	0-7089	0-6705	0-0384	0-379	0-300	0-079	0-164	0-119	0-044	0-128	0-088	0-039
Big.																				
1st Lanark.....	48-560	291-360	1-250	0-541	0-00170	0-328	0-133	0-103	0-5608	0-5341	0-0167	0-378	0-276	0-100	0-152	0-116	0-036	0-118	0-087	0-031
1st Perth.....	48-586	291-516	1-227	0-586	0-00189	0-324	0-136	0-105	0-6142	0-5668	0-0478	0-379	0-274	0-105	0-167	0-108	0-059	0-130	0-086	0-044
1st Dumfries....	47-500	285-000	1-246	0-560	0-00177	0-322	0-136	0-108	0-5857	0-5268	0-0607	0-370	0-267	0-103	0-160	0-114	0-046	0-122	0-088	0-034
2d Kirkcudbgt..	47-031	282-186	1-265	0-558	0-00174	0-324	0-139	0-106	0-5720	0-5520	0-0200	0-356	0-280	0-076	0-155	0-110	0-045	0-119	0-087	0-032
Average...	47-919	287-515	1-247	0-561	0-00177	0-324	0-136	0-105	0-5811	0-5449	0-0363	0-370	0-274	0-096	0-158	0-112	0-046	0-122	0-087	0-035

## CHAPTER III.

## OF MALTING.

It is always customary to convert barley into malt before employing it in the manufacture of ale. Not that this conversion is absolutely necessary, but that it adds considerable facility to the different processes of the brewer. The writer of this treatise has several times tried the experiment of making ale from unmalted barley, and found it perfectly practicable. Several precautions, however, are necessary in order to succeed. The water let upon the ground barley in the mash-tun must be considerably below the boiling temperature; for barley-meal is much more apt to *set* than malt, that is, to form a stiff paste, from which no wort will separate. The addition of a portion of the chaff of oats serves very much to prevent this *setting of the goods*, and facilitates considerably the separation of the wort. Care must likewise be taken to prevent the heat from escaping during the mashing, and the mashing must be continued longer than usual; for it is during the mashing that the starch of the barley is converted into a saccharine matter. This change seems to be owing merely to the chemical combination of a portion of water with the starch of the barley; just as happens when common starch is

converted into sugar, by boiling it with very dilute sulphuric acid, or any other acid. This method of brewing from raw grain answers admirably for small beer. Some years ago it was practised to a considerable extent by several brewers of small beer in Edinburgh, and their beer was considered as greatly preferable to small beer brewed in the usual manner. The practice was stopped by a decision of the Court of Exchequer,—a decision which, in our opinion, proceeded upon arbitrary grounds, and which was at all events detrimental to the public; for surely it is highly impolitic to prevent ameliorations in the manufactures in order to guard against any deficiency in the produce of the taxes. A wise government would have permitted the improvement, and would have levied the malt-tax in a different manner. In our trials the raw barley did not answer so well for making strong ale as for small beer. The ale was perfectly transparent, and we kept it for several years without its running into acidity; but it had a peculiar flavour, by no means agreeable. Probably a little practice might have enabled us to get rid of this flavour, in which case raw grain would answer in every respect as well for brewing as malt does.

A duty was first charged upon malt during the troubles of the reign of Charles I. But it continued very moderate till the war with France recommenced in 1803. It was then raised to the following sums per bushel:—

English malt, . . . . .	£0	4	4	or 100
Malt of Scotch barley, . . . .	0	3	8½	or 84·856
Malt of Scotch big . . . . .	0	3	0½	or 69·472

But two shillings of this tax were to continue only till the end of the war, and for six months after its conclusion. In consequence of this very heavy tax, several regulations were imposed upon the maltster, with a view to facilitate the levying of the duty, and to prevent him from defrauding the revenue. The most important of these are the two following:—1. The barley must remain in the cistern in which it is steeped with water for a period not less than forty hours. 2. When the malt is spread upon the floor the maltster is not at liberty to sprinkle any water upon it, or to moisten the floor. For a number of years past the malt-duties have been as follow:—

1. For malt made from barley, or other corn or grain, in any part of the United Kingdom, 2s. 7d., and 5 per cent., making together 2s. 8½d. per bushel.

2. For malt made from bear or big, in Scotland or Ireland, 2s. per bushel, and 5 per cent., equal together to 2s. 1½d.

The 5 per cent. was imposed in the year 1840, on all custom and exciseable articles, except spirits.

We shall now describe the process of malting, as is practised by the best-informed malt-makers in Great Britain.

Malting consists of four processes, which follow each other in regular order; namely, *steeping*, *couching*, *flooring*, and *kiln-drying*.

1. The steep is a square cistern, sunk at one end of the malt barn, lined with stone, and of a sufficient size to hold the whole barley that is to be malted at a time. The barley is put into this cistern with the requisite quantity of pure water to cover it. It is laid as evenly as possible upon the floor of the cistern. Here it must remain at least forty hours; but in Scotland, especially when the weather is cold, it is customary to allow it to remain much longer. We have seen barley steeped in Edinburgh for 112 hours by one maltster, and by another usually ninety-eight or ninety-two hours. It is the common practice to introduce the water into the cistern before the barley, and it is usually once drawn off and new water added during the steeping.

Three changes take place on the barley while in the steep. 1. It imbibes moisture and increases in bulk. 2. Some carbonic acid gas is evolved, most of which remains dissolved in the steep-water. 3. A portion of the husk or skin of the barley is dissolved, in consequence of which the steep-water acquires a yellow colour, and contracts a peculiar smell, not unlike that of moist straw.

The quantity of moisture imbibed by the barley varies according to the goodness of the barley, and the length of time during which it is allowed to remain in the steep. But the general average may be stated at 0.47; or 100 lbs. of barley, steeped the usual time, weigh, newly taken out of the steep and dried,

147 lbs. English barley acquires more weight than Scotch barley, while Scotch barley acquires greater weight than big. But big cannot safely be steeped for so long a time as barley. The swell of the grain in the steep obviously depends upon the quantity of water absorbed ; but it is not so great as that absorption, scarcely ever exceeding one-fifth of the original bulk of the barley, while the increase of weight amounts to nearly one-half of that of the original weight of the grain. The result of a good many trials by the writer of this treatise gives the bulk of one hundred measures of different kinds of barley, after steeping, as follow :—

English barley, . . . . .	124	measures.
Scotch barley, . . . . .	121·1	
Scotch big, . . . . .	118	

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

The average increase of the bulk of barley, when steeped for forty hours, is 0·222; or 100 barley becomes 122·2. This is very nearly in the proportion of 9 to 11. In charging the duty the swell of the grain is accounted for to the above amount. If the swell exceeds, and the malt carries the excess through the check-gauges on the floor until the malting is finished, a proportional duty is charged above the

quantity of barley when first steeped. If the swell is much under the proportional of 11 to 9, and the gauges on the floor and kiln correspond, the duty is charged under the quantity of barley. English barley seldom comes below the standard; but Scotch barley, except of very fine quality, is generally below it.

While the malt is in the steep-cistern it is repeatedly gauged by the exciseman, and the duty on the malt is levied by what is called the best gauge, or that which gives the greatest bulk of grain. It is in his power likewise to determine the quantity of malt in the subsequent processes, and if any of them exceeds the best gauge in the cistern, to levy the duty by it. But these subsequent gauges are not susceptible of the same precision as the gauges in the cistern, when the grain is surrounded on all sides by perpendicular walls.

That carbonic acid is evolved during the steeping of grain, is obvious from the most simple experiments. If the steep-water be mixed with lime-water, the whole becomes milky, and carbonate of lime is deposited. If the steep-water be agitated, it froths on the surface like ale. If it be heated, it gives out carbonic acid gas, which may be collected over mercury. But we never were able to observe bubbles of gas extricate themselves from the grain during the steep, except once or twice during warm weather when the steep-water was allowed to remain rather too long without being changed. In these cases, something

like a commencement of fermentation, or perhaps of putrefaction, appeared to take place. But in general, there is reason to believe that nearly all the carbonic acid evolved in the steep remains in solution in the water, or at least is extricated from the water in an imperceptible manner. From the observations of Saussure, it seems probable that the formation of carbonic acid in the steep is owing to the oxygen gas held in solution by the steep-water.

The steep-water gradually acquires a yellow colour, and the peculiar smell and taste of water in which straw has been steeped. At the same time, the barley becomes whiter, shewing clearly that the water has absorbed a portion of colouring matter which existed in the husk or skin of the grain. The average quantity of matter dissolved by the water amounts to about  $\frac{7}{10}$ th of the weight of the barley. The steep-water becomes much more deeply coloured when big is steeped in it than it does with barley, because big is darker in the colour, and its husk is thicker and contains more colouring matter. The matter of big taken up by the steep-water amounts to about  $\frac{1}{10}$ th of the weight of the whole grain. When this steep-water is evaporated it leaves a matter of a yellow colour and disagreeably bitter taste, which deliquesces in a moist atmosphere. The only salt which it contains in any notable quantity is nitrate of soda.

Thus the only notable alterations which the kernel of barley undergoes in the steep are the absorption of water and the resulting increase of bulk. The mat-

ter taken up by the water seems to proceed only from the skin, and the evolution of carbonic acid may perhaps be owing to some commencement of alteration which this dissolved matter experiences. It can scarcely be ascribed to any change going on within the kernel itself.

2. When the barley is judged by the maltster to have remained long enough in the steep, which is the case when its two ends can be easily squeezed together between the finger and the thumb, the water is let off and the grain allowed to drain. It is then thrown out of the cistern into the *couch*, which is formed of moveable wooden boards placed by the side of the cistern, and where the wetted barley can be gauged by the excise-officer with the greatest accuracy. While in this position, if it measure more than it did in the steep, the exciseman is at liberty to charge the duty upon the quantity to which the grain now amounts. The duty, we believe, is levied from the couch-gauge. The grain is allowed to remain in the couch without any alteration for about twenty-six hours.

3. If we plunge a thermometer into the grain, and observe it from time to time, we shall find that the barley continues for some hours without acquiring any perceptible increase of heat. During this period the moisture on the surface of the corns gradually exhales or is absorbed, so that they do not perceptibly moisten the hand. But at last the thermometer begins to rise, and continues to do so gradually till

the temperature of the grain is about ten degrees higher than that of the surrounding atmosphere. This happens usually in about ninety-six hours after it has been thrown out of the steep. It now exhales an agreeable odour, which has some resemblance to that of apples. If we thrust our hand into the heap we shall find that it feels warm, while, at the same time, it has become so moist as to wet the hand. The appearance of this moisture is called *sweating* by the maltsters, and it constitutes a remarkable period in the process of malting. We have reason to believe that a little alcohol is at this period exhaled by the grain.

If we examine the grains in the inside of the heap at the time of sweating, we shall perceive the roots beginning to make their appearance at the bottom of each seed. At first they have the appearance of a white prominence, which soon divides itself into three rootlets. In big the number of rootlets seldom exceeds three, but in barley it frequently amounts to five or six. These rootlets increase in length with great rapidity, unless their growth be checked by artificial means; and the principal art of the maltster is directed to keep them short till the grain be sufficiently malted. The writer of this treatise has seen them increase in length nearly two inches in the course of a single night; and when he purposely favoured the growth, in order to ascertain the effect upon the malt, he has seen them get to the length of

three inches or more. In such cases, the heat of the grain rose very rapidly, and on one occasion was little inferior to eighty degrees. Indeed it is probable that, if not checked, the temperature would rise sufficiently high to char the grain, if not to set it on fire.

The too great growth of the roots, and the too high elevation of temperature is prevented by spreading the grain thinner upon the floor, and carefully turning it over several times a-day. At first the depth is about sixteen inches; but this depth is diminished a little at every turning, till at last it is reduced to three or four inches. The number of turnings is regulated by the temperature of the malt, but they are seldom fewer than two each day. In Scotland, the temperature of the grain is kept as nearly as possible at fifty-five degrees; but in England we have generally found the temperature of the grain on the malt-floor about sixty-two degrees. It has been generally supposed that the Hertfordshire method of making malt is the best; but, after a very careful comparison of the two methods, we were unable to perceive any superiority whatever in the English mode.

About a day after the sprouting of the roots, the rudiment of the future stem begins to make its appearance. This substance is called by the maltsters the *acrospire*. It rises from the same extremity of the seed with the root, and, advancing within the husk or skin, would at last (if the process were con-

tinued long enough) issue from the other extremity in the form of a green leaf; but the process of malting is stopped before the acrospire has made such progress.

While the grain is on the malt-floor, it has been ascertained that it absorbs oxygen gas, and emits carbonic acid gas; but to what amount these absorptions and emissions take place, has not been ascertained. They are certainly small; for the average loss which the grain sustains when on the malt-floor is only three per cent.; a considerable portion of which must be ascribed to roots broken off, and grains of barley bruised during the turning. As the acrospire shoots along the grain, the appearance of the kernel, or mealy part of the corn, undergoes a considerable change. The glutinous and mucilaginous matter in a great measure disappears, the colour becomes whiter, and the texture of the grain so loose that it crumbles to powder between the fingers. The object of malting is to produce this change. When it is accomplished, which takes place when the acrospire has come nearly to the end of the seed, the process is stopped altogether.

At this period, it was formerly the custom in Scotland to pile up the whole grain into a pretty thick heap, and allow it to remain for some time. The consequence is the evolution of a very considerable heat, while, at the same time, the malt becomes exceedingly sweet. But this plan is now laid aside, because it occasions a sensible diminution in the malt, with-

out being of any essential service ; for the very same change takes place afterwards, while the malt is in the mash-tun, without any loss whatever.

The time during which the grain continues on the malt-floor varies according to circumstances. The higher the temperature at which the grain is kept, the more speedily it is converted into malt. In general, fourteen days may be specified as the period which intervenes in England from throwing the barley out of the steep till it is ready for the kiln ; while in Scotland it is seldom shorter than eighteen days, and sometimes three weeks. This, no doubt, is an advantage in favour of English malting, as every thing which shortens the progress, without injuring the malt, must turn out to the advantage of the manufacturer.

4. The last part of the process is to dry the malt upon the kiln, which stops the germination, and enables the brewer to keep the malt for some time without injury. The kiln is a chamber, the floor of which usually consists of iron plates full of holes, and in the roof there is a vent, to allow the escape of the heated air and vapour. Under this room is a space in which a fire of charcoal or coke is lighted. The heated air which supplies this fire passes up through the holes in the iron plates, and makes its way through the malt, carrying off the moisture along with it. At first the temperature of the malt is not higher than  $90^{\circ}$  ; but it is elevated very slowly to  $140^{\circ}$ , or even higher. We believe that in many cases it rises at

last almost as high as  $212^{\circ}$ , though we have never witnessed any such high temperature ourselves. But we have seen pale malt dried at a temperature of  $175^{\circ}$ , without any injury whatever. The great secret in drying malt properly consists in keeping the heat very low at first, and only raising it very gradually, as the moisture is dissipated. For a high temperature applied at first would infallibly blacken or even char the malt, and would certainly diminish considerably the quantity of soluble matter which it contains. We shall here insert the table drawn up by Mr Combrune, from his own experiments, of the colour of malt dried in different temperatures.

Heat.	
119°	. . . White.
124	. . . Cream colour.
129	. . . Light yellow.
134	. . . Amber colour.
138	. . . High amber.
143	. . . Pale brown.
148	. . . Brown.
152	. . . High brown.
157	. . . Brown inclining to black.
162	. . . High brown speckled with black.
167	. . . Blackish brown with black specks.
172	. . . Colour of burnt coffee.
176	. . . Black.

We have given this table, not on account of any information which it contains, but to put our readers on their guard against the false conclusions of this writer. We have taken malt dried at the temperature of  $175^{\circ}$ , put it into a garden-pot filled with soil,

and have seen it vegetate apparently as well as raw grain placed in the same situation. Now, this is only one degree lower than that in which Mr Combrune says malt is converted into charcoal, and it is four degrees higher than that in which his malt assumed the colour of burnt coffee. Certainly malt reduced to the colour of burnt coffee by heat would be deprived of the power of vegetating. Mr Combrune's experiments were made by putting malt into an earthen pan, which he placed over a charcoal fire in a stove, while he kept stirring the malt the whole time of the experiment. The bulb of the thermometer was placed half-way between the upper surface of the malt and the bottom of the vessel. Now the reader will perceive at once that the earthen pan would be much hotter than that part of the malt where the thermometer was placed. By the constant stirring of the malt, the whole of it was gradually exposed to the burning action of the surface of the pan. Had the experiment been made without stirring the malt at all, and had the thermometer been placed near the surface, in that case the changes in the colour of the malt at the surface would have indicated the temperature to which it was exposed. But in the way that Mr Combrune conducted his experiments, the temperatures which he obtained were entirely fallacious. We have not the least doubt that the temperature of the earthen pan, towards the end of his experiment, was above 400°.

Mr Combrune's law, however, that the heat of the

water in mashing ought to be regulated by the colour of the malt; namely, that the paler the malt is, the lower ought the temperature of the mashing water to be, is founded on accurate observations. The fact is, that boiling water would answer better than any other for mashing, because it would dissolve most speedily the soluble part of the malt. The only reason for not using it is, that the tendency of the malt to *set* increases with the temperature of the water. Now the higher the colour of the malt, the less is its tendency to set; but we may nevertheless use water of a higher temperature to mash with it. For the same reason, when raw grain is used, the temperature of the mashing water must be still lower than when malt is employed; because raw grain has a very great tendency to set.

The old malt-kilns had a bottom of haircloth instead of the iron plates full of holes, which constitute a more recent improvement. We have seen the thermometer in such a kiln, when the bulb touched the haircloth, rise as high as  $186^{\circ}$ . In general, the temperature of the malt-kiln is very carelessly regulated. We have seen malt for the very same purpose dried at a temperature which never rose higher than  $136^{\circ}$ ; while a portion of the very same malt, put into another kiln, was heated as high as  $186^{\circ}$ . But such a careless mode of drying malt is reprehensible, and must be more or less injurious to the brewer. In general, the more rapidly malt is dried, the more does its bulk increase. This method, ac-

cordingly, is practised by those who malt for sale, as is the case with most of the English maltsters; because malt is always sold by measure and not by weight. The brewers would find it more for their interest to buy malt by weight than by measure. In that case the maltsters would dry their malt at as low a temperature as possible. But this would signify very little, or rather would be advantageous to the brewer; because dried malt soon recovers part of the moisture lost on the kiln, when kept for some time in sacks. And when malt is dried at a low temperature, we are sure that none of it is injured by the fire. It will, therefore, go farther in the production of beer. The time of kiln-drying varies considerably, according to the quantity of malt exposed to the action of the heat; but when that quantity is not too great, we may estimate the time of kiln-drying, in general, at two days. After the fire is withdrawn, the malt is allowed to remain on the kiln till it has become nearly cold.

Pale malt is best made by applying a low heat, at first, and increasing it at regular intervals. If done judiciously, the heat may be carried up to 170° without injuring the colour. But such a heat is not necessary, as the malt becomes dry enough and fit for keeping at 140°.

Brown or porter malt is dried by applying the same heat at first as to pale malt, and after it is half dried, by *blowing* it (as it is termed) on the kiln. This is done by raising the heat as high as the men

who turn it on the kiln can possibly stand. This may be stated at 200° for the first turning, and higher afterwards.

By the kiln-drying, the roots of the barley, or, as the maltsters call them, the *comings*, are dried up and fall off. They are separated from the malt by passing it over the surface of a kind of wire screen, which allows the *comings* to drop through, while the wires are too near each other to permit the grains of malt to pass.

If 100 lbs. of barley malted in this manner, with all the requisite care, be weighed just after being kiln-dried and cleaned, they will be found, on an average, to weigh 80 lbs. But if the raw grain be kiln-dried at the same temperature as the malt, it will lose 12 per cent. of its weight. Hence 12 per cent. of the loss which barley sustains in malting must be ascribed to moisture dissipated by the kiln-drying; so that the real loss of weight which barley sustains when malted amounts to eight per cent. This loss, from a great many trials made in the large way, with all the requisite care, we conceive may be accounted for in the following manner:—

Carried off by the steep-water,	.	.	1·5
Dissipated while on the floor,	.	.	3·0
Roots separated by cleaning,	.	.	3·0
Waste,	.	.	0·5
			8·0

These numbers were obtained from above thirty

different maltings, conducted in four different malting-houses, with as much attention to every circumstance as was compatible with practical malting. The matter carried off by the steep-water, which amounts to about  $\frac{1}{8}$ th of the weight of the whole grain, we conceive to be dissolved from the skin or husks. It may, therefore, be left out of view. The waste is owing to grains of malt crushed by the workmen while turning the malt on the floor, and afterwards dissipated or destroyed during the subsequent processes. We were not able to collect these bruised grains and weigh them; the number therefore given for them in the preceding table is hypothetical; but, from a great many circumstances, which it would be too tedious to mention here, we believe that, in our trials,  $\frac{1}{8}$ th part of the whole very nearly represents the amount of the crushed grains. Thus the real loss of weight by malting (supposing nothing lost by steeping, and no grains crushed) is only six per cent., and of this loss four per cent. may be safely ascribed to the roots; so that not above two per cent. at most can be assigned to the carbon dissipated by the evolution of carbonic acid on the floor and on the kiln. Indeed we have reason to conclude, from a good many trials, that the greatest part of this loss of two per cent. is sustained on the kiln. For, if malt dried carefully at a low temperature be afterwards kiln-dried, or exposed, as was our method, to the heat of a steam-bath, it never afterwards recovers its former weight by ex-

posure to the air. And every time this experiment is repeated, by artificially moistening and drying the same malt, a new loss of weight is sustained. The same observation was made by Saussure, who conceived that the loss was to be ascribed to the formation and dissipation of water in the barley-corn. But we have no proof whatever that any such formation takes place. It is more probable that the loss is owing to the formation and escape of carbonic acid gas.

Big sustains a considerably greater loss of weight when malted than barley. The average loss of weight in our trials with barley was only eight per cent., while that of big was fifteen per cent., or nearly double. This, we conceive, is owing to the destruction of a much greater number of the corns during the process of malting big than barley. But in all our experiments on big, that grain was manifestly oversteeped. To this, perhaps, a good deal of the difference may be ascribed. Our maltsters had not been in the habit of malting big, and therefore were not likely to do it so much justice as they did to the barley. Hence it would be improper to venture upon any general conclusions from the experiments which we made upon the malting of big.

The bulk of the malt is usually greater than that of the barley from which it was obtained; but this varies a good deal according to the goodness of the grain and the mode of drying the malt. In our trials,

made all in the same way, 100 bushels of the different kinds of grain gave, on an average, the following results :—

English barley, . . . . .	109
Scotch barley, . . . . .	103
Scotch big, . . . . .	100.6

The greatest quantity in bushels obtained from 100 bushels of English barley was 111½, the least 106 bushels. The greatest quantity obtained from 100 bushels of Scotch barley was 109, and the least 98 bushels. The greatest quantity obtained from 100 bushels of big was 103 bushels, the least 97 bushels. Hence it appears, that, on malting English barley, there is a profit of nine per cent., while big yields scarcely any thing more than its bulk before malting. The English maltster makes more bushels of malt than he pays duty for ; but the maltster of big, on the contrary, obtains fewer.

We shall subjoin here two tables, which exhibit in one view the result of a considerable number of trials made by the author of this treatise, on malting different varieties of grain. The barley is distinguished by the name of the county where it grew. To understand the first table the reader must know that excisemen estimate the quantity of malt by subtracting one-fifth from the best or highest gauge in the steep or couch, and charge the duty accordingly.

TABLE I.

BIG.	Original Bulk of Grain.	Bulk by best Gauge in Steep or Couch.	Produce in Malt.	Malt charged Duty.	Difference per Cent.
<i>First Qualities.</i>					
Dumfries.....	100	112·0	97·6	89·6	
Dumfries.....	100	132·8	97·9	106·2	
Lanark .....	100	121·6	103·3	96·3	
Perth .....	100	120·9	102·9	96·7	
Perth .....	100	120·7	99·1	95·5	
Perth .....	100	112·8	97·4	89·2	
Aberdeen .....	100	127·3	100·7	101·8	
Aberdeen .....	100	125·6	99·9	100·5	
Aberdeen .....	100	114·5	94·1	91·6	
Aberdeen .....	100	124·0	98·7	99·2	
Average.....	100	121·2	99·1	97·0	2·1
<i>Second Qualities.</i>					
Kirkcudbright	100	119·5	101·2	95·6	
Ayr.....	100	114·2	101·1	91·3	
Angus.....	100	127·4	96·8	101·9	
Angus.....	100	121·6	94·5	97·2	
Mearns.....	100	121·3	96·5	97·0	
Average ....	100	120·8	98·1	96·6	1·5
<i>Third Qualities.</i>					
Kirkcudbright	100	110·6	94·5	88·4	
Aberdeen .....	100	123·1	105·0	98·4	
Average ....	100	116·8	99·7	93·4	6·3
General Average	...	...	...	...	3·3

TABLE I.—*continued.*

BARLEY. ENGLISH.	Original Bulk of Grain.	Bulk by best Gauge in Steep or Couch.	Produce in Malt.	Malt charged Duty.	Difference per Cent.
<i>First Qualities.</i>					
Norfolk.....	100	123·0	109·5	98·4	
Norfolk.....	100	121·5	104·5	97·2	
Kent.....	100	128·0	111·2	102·4	
Kent.....	100	119·7	106·3	95·8	
Suffolk.....	100	123·7	101·6	98·6	
Suffolk.....	100	116·8	100·8	93·4	
Average....	100	122·1	105·6	97·6	8·
<i>Second Qualities.</i>					
Norfolk.....	100	129·6	109·2	103·7	
Norfolk.....	100	122·0	103·9	97·6	
Suffolk.....	100	137·9	107·6	109·5	
Kent.....	100	133·2	109·2	106·5	
Kent.....	100	125·6	106·3	100·4	
Average....	100	129·6	107·0	104·4	2·6
<i>Third Qualities.</i>					
Norfolk.....	100	128·2	106·4	102·5	
Norfolk.....	100	127·1	104·5	101·6	
Essex.....	100	134·5	106·5	107·6	
Essex.....	100	126·3	106·8	101·0	
Essex.....	100	128·0	102·1	102·4	
Essex.....	100	120·5	97·6	96·4	
Average....	100	127·4	103·4	101·9	1·9
General Average	...	...	...	...	4·03

TABLE I.—*continued.*

BARLEY. Source.	Original Bulk of Grain.	Bulk by best - Gauge in Steep or Couch.	Produce in Malt.	Malt charged Duty.	Difference per Cent.
<i>First Qualities.</i>					
Berwick and } Haddington }	100	119·8	100·6	95·8	
Haddington.....	100	121·0	109·4	96·8	
Haddington.....	100	121·0	103·1	96·8	
Linlithgow.....	100	118·7	106·2	94·9	
Perth.....	100	127·3	102·4	101·8	
Fife.....	100	125·3	100·1	100·2	
Angus.....	100	123·8	103·6	100·6	
Edinburgh.....	100	123·8	98·6	99·0	
Edinburgh.....	100	116·7	102·7	93·3	
Average....	100	119·6	102·9	97·6	5·3
<i>Second Qualities.</i>					
Berwick and } Haddington }	100	119·4	100·9	95·5	
Haddington.....	100	125·8	103·2	100·6	
Perth.....	100	114·2	96·9	91·3	
Fife.....	100	119·6	94·0	95·6	
Average....	100	119·7	98·7	95·7	3·
<i>Third Qualities.</i>					
Berwick.....	100	115·2	98·2	92·1	
Haddington.....	100	120·0	101·6	96·0	
Linlithgow.....	100	113·6	92·3	90·8	
Linlithgow.....	100	121·0	93·4	96·8	
Fife.....	100	117·5	91·5	94·0	
Angus.....	100	120·8	101·1	96·6	
Average....	100	118·0	96·3	94·4	1·9
General Average	...	...	...	...	3·4

TABLE II.

BARLEY.	Weight per Bushel in lb.	Bushels Measured out.	Swimmings in Bushels.	Swimmings in lb. Avoirdupois.	Weight of Grain really Steeped, in lb.	Hours in Steep.	Swell per cent. in Steep.	Swell per cent. in Couch.	Days on Floor.	Clean Malt in Bushels.	Weight of Clean Malt in Bushels.	Apparent loss of Weight, % cent.	BUSHELS OF MALT.		POUNDS OF MALT.	
													From 100 Bushels Grain.	From 100 lb. Grain.	From 1 Bushel Grain.	From 1 lb. Grain.
<b>ENGLISH.</b>																
Norfolk .....	50-375	150	1-4	43-18	7509-82	116	16	23-08	18	162-75	36-58	20-0	109-5	2-17	40-063	0-793
Norfolk .....	50-375	150	1-75	43-00	7513-50	93-75	21-5	21-5	16	155-00	38-40	21-2	104-5	2-08	40-152	0-788
Kent .....	49-750	90	1-96	56-45	4421-05	86	25	28	12	98	34-88	23-0	111-2	2-22	38-816	0-773
Kent .....	49-914	90	1-75	40-50	4442-63	52	16-7	19-7	17	93-87	35-76	25	106-3	2-11	38-926	0-755
Suffolk .....	50-508	150	2-68	84-15	7494-00	49		23-3	13	149-75	40-58	21	101-6	2	41-227	0-810
Suffolk .....	50-859	72	1-28	29-44	3632-40	44		16-8	13	71-31	39-11	23-2	100-8	1-96	39-435	0-768
Average...	50-297					73-4	18-9	22-06	14-6		37-55	22-2	105-6	2-09	39-736	0-781
<b>SCOTCH.</b>																
Berwick and Haddington...	53-093	114-75	1-23	23-87	6063-60	119		19-8	18	114-18	39-60	25-4	100-6	1-88	39-840	0-746
Haddington...	52-190	60	0-5	13-75	3117-50	92	21	21	20	64-50	38-06	21	199-4	2-07	41-618	0-787
Haddington...	52-190	75	0-3	74-70	3902-80	112	21	21	19	77	39-18	23	103-1	1-97	40-386	0-773
Linlithgow...	51-082	66	0-56	18-34	3352-81	109	24-5	18-7	9	69-5	39-09	19	206-2	2-07	41-520	0-810
Perth .....	50-226	66	0-75	65-25	21-00	3293-95	67	27-3		66-68	38-18	22-49	102-4	2-03	39-131	0-775
Fife .....	51-589	148	1-62	44-38	40-00	7578-78	81	25-3	14	146-54	38-80	25-07	100-1	1-93	38-843	0-749
Angus .....	49-312	66	1-68	64-32	44-37	3210-25	26-8	23-8	8	66-6	36-76	24	103-6	2-07	38-074	0-763
Edinburgh...	52-164	111	1-50	109-5	41-37	5748-82	70	23	14	108	41-92	21	98-6	1-88	41-345	0-787
Edinburgh...	52-164	90	1-25	88-75	4660-29	52-5	14-8	16-7	16	91-12	40-24	22	102-7	1-95	41-319	0-787
Average	51-549					86-5	21-7	19-6	13		39-09	22-6	102-9	1-98	40-23	0-775

Big.	47-000	75	3-28	71-72	77-00	3448-00	73		12	13	70	36-81	23-5	97-6	2-03	35-930	0-765
Dumfries ....	47-726	80	2-03	77-97	59-96	3758-16	80	25-8	32-8	8	76-31	37-70	23-5	97-9	2-03	36-899	0-765
Lanark .....	48-552	150	2-67	147-33	79-65	7204-72	80	11	21-6	18	152-25	36-44	23	103-3	2-11	37-637	0-770
Perth .....	48-585	100	2-00	98	61-84	4796-66	104	17	20-9	13	100-94	34-44	27-5	102-9	2-10	35-374	0-724
Perth .....	48-552	98	3-25	94-75	97-45	4661-68	73	18	20-7	13	93-86	37-57	24-5	99-1	2-01	37-237	0-757
Perth .....	48-552	90	3-00	87-00	81-06	4289-56	45	9-4	12-8	15	84-75	36-53	28	97-4	1-97	35-586	0-722
Aberdeen ....	48-226	90	2-09	87-91	55-81	4284-57	74	23	27-3	8	88-50	38-37	21	100-7	2-06	38-633	0-793
Aberdeen ....	48-552	150	2-68	147-32	88-19	7196-19	89		25-6	10	146-25	36-03	26-8	99-3	2-13	35-770	0-732
Aberdeen ....	48-312	90	2-25	87-75	67-50	4291-62	58		14-5	10	82-60	39-00	25	94-1	1-93	36-712	0-751
Aberdeen ....	49-172	90	2-26	87-74	60-75	4364-72	57		24		86-58	39-44	21-7	98-7	1-98	38-906	0-783
Average ..	48-327						73	17-3	21-2	10-8		37-23	24-4	99-1	2-03	36-868	0-756
Second Quality																	
ENGLISH.																	
Norfolk .....	50-57	150	2-56	147-44	58-00	7527-50	115	24	29-6	15	161-00	38-437	18	109-19	2-113	41-972	0-822
Norfolk .....	51-00	150	3-50	146-50	70-87	7579-20	88		22-0	13	152-13	37-562	24-6	103-86	2-007	39-013	0-784
Suffolk .....	48-845	80	3-12	76-87	85-00	3822-49	87	37-9	37-9	9	82-77	36-5	21	107-67	2-165	39-229	0-790
Kent .....	50-062	80	2-25	77-75	62-87	3942-13	84	27-8	33-2	9	84-87	39-125	16	109-16	2-165	42-612	0-842
Kent .....	49-945	150	4-43	145-57	112-37	7385-24	89		25-6	12	153-00	36-876	23-46	105-31	2-072	38-823	0-765
Average...	50-084						92	29-9	29-6	13		37-699	20-61	107-03	2-104	40-343	0-794
SCOTCH.																	
Berwick and																	
Haddington	50-53	126	1-50	124-50	44-00	6323-00	97		19-4	16	125-69	38-501	23-46	100-95	1-990	38-865	0-765
Haddington	52-26	150	1-25	148-75	32-81	7507-03	118	22	25-8	19	163-50	37-298	27	103-19	1-960	38-490	0-733
Perth.....	48-19	66	1-90	64-10	48-37	3132-51	64		14-2	10	62-12	39-531	21-6	96-91	1-983	38-310	0-784
Fife.....	48-51	100	1-45	98-55	36-12	4834-25	47½		19-6	11	92-68	40-039	23-24	94-04	1-917	38-669	0-767
Average...	49-87						81-6	22	19-7	14		38-842	23-82	98-77	1-962	38-583	0-762

TABLE II.—continued.

BARLEY.	Weight per Bushel, in lbs.	Bushels Measured out.	Swimmings in Bushels.	Bushels really Steeped.	Swimmings in lbs. Avotripols.	Weight of Grain really Steeped, in lbs.	Hours in Steep.	Swell per cent. in Steep.	Swell per cent. in Couch.	Days on Floor.	Clean Malt in Bushels.	Weight of Clean Malt in Bushels.	Apparent loss of Weight % cent.	BUSHELS OF MALT.		POUNDS OF MALT.	
														From 100 Bushels Grain.	From 100 lbs. Grain.	From 1 Bush. Grain.	From 1 lb. Grain.
<i>Second Quality.</i>																	
<i>Big.</i>																	
Kirkcudbrt...	46.87	150	4.56	145.44	112.16	6109.10	89	15	19.5	15	147.25	36.400	26.5	101.24	2.128	36.853	0.744
Ayr.....	47.94	160	2.84	147.16	77.00	7113.62	66½	14.2	14.2	16	148.75	37.832	20.89	101.08	2.091	38.330	0.791
Angus.....	47.03	108	3.12	104.87	85.87	4993.50	83	21	27.4	8	101.53	37.547	24.70	96.81	2.033	36.349	0.763
Angus.....	47.39	160	4.34	145.66	119.72	6989.46	57	21.6	21.6	13	137.73	38.570	24.8	94.55	1.971	36.083	0.751
Mearns.....	47.91	126	1.82	124.18	51.87	5985.27	57	21.3	21.3	13	119.87	37.55	24.8	96.52	2.004	36.288	0.752
Average....	47.42						70.45	18	20.8	13		37.579	24.33	98.06	2.045	36.770	0.760
<i>Third Quality.</i>																	
<i>ENGLISH.</i>																	
Norfolk.....	51.937	150	1.75	148.25	46.0	7744.64	91	22	28.2	12	157.75	36.68	23	106.41	2.037	39.038	0.747
Norfolk.....	51.625	160	2.47	147.53	60.5	7663.70	84	27.1	27.1	14	163.14	37.61	24.8	104.50	1.998	38.774	0.759
Essex.....	47.633	90	3.59	86.44	107.2	4179.72	98	30	34.5	13	92.06	35.12	23	106.55	2.202	37.423	0.770
Essex.....	48.414	100	3.87	96.12	119.6	4721.71	82	22.4	26.3	10	101.50	36.86	21	105.83	2.149	38.923	0.794
Essex.....	48.000	100	3.50	96.50	84.0	4716.00	73	28.0	28.0	10	98.56	35.66	25.5	102.13	2.090	36.417	0.745
Essex.....	46.410	100	6.25	93.75	159.0	4482.37	45	20.5	20.5	11	91.26	38.67	21	97.66	2.036	37.772	0.790
Average....	49.004						78	24.8	27.4	11		36.76	23	103.84	2.085	38.057	0.767



Thus it appears, that the process of malting is nothing else than causing the barley-corns to germinate, and stopping that process before the green leaf makes its appearance. A quantity of roots are formed, which are afterwards rubbed off and separated, and the weight of which amounts to about four per cent. of the grain malted. The kernel of the grain undergoes a remarkable change by this process. It consists almost entirely of starch; but it was agglutinated in the grain, so as to form a solid and very firm mass; whereas, in the malt, it is quite loose and mealy. Hence it would appear that the glutinous and mucilaginous matter of the barley-corn is chiefly employed in forming the roots; and that this is the purpose for which it was laid up in the grain. How far the starch is altered does not appear. It is probable that it has undergone some change. Malt has a slightly sweet taste, much more agreeable than the taste of the raw grain, without any of that strong and cloying sweetness which distinguishes wort. But the most distinguishing character of the starch of malt is the ease with which it dissolves in hot water; though cold water does not act upon it sensibly. Whether this property be peculiar to the starch of barley, or be induced by the malting, we cannot say. We conceive it probable, that barley-starch is more easily soluble in water than wheat-starch, from the ease with which raw grain is constantly employed by distillers to form their worts. In its other chemical characters, the starch of barley-malt agrees with that of wheat-starch.

We should err very much, however, were we to suppose that the whole kernel or starchy part of the malt is dissolved by the hot water used in brewing. At least one-half of the malt still remains after the brewing is over, constituting the grains, which are known to constitute a most nourishing article of food for cattle, and therefore to contain much more than the husks or skin of the malt-corn. 100 lbs. of malt from different kinds of grain, after being exhausted as much as usual of the soluble part of the kernel by hot water, were found to weigh as follows:—

English barley,	. . .	50·63 lbs.
Scotch barley,	. . .	50·78
Scotch big,	. . .	52·69

100 lbs. of raw grain being converted into malt, and the soluble part of the malt extracted by hot water, the residue weighed,—

English barley,	. . .	51·558 lbs.
Scotch barley,	. . .	50·831
Scotch big,	. . .	53·500

In another set of experiments, 100 lbs. of malt left the following residues:—

English barley,	. . .	54·9 lbs.
Scotch barley,	. . .	56·9
Scotch big,	. . .	56·6

100 lbs. of the raw grain being converted into malt, and the soluble part of the malt extracted by hot water, the residues weighed,—

English barley,	. . . .	54·8 lbs.
Scotch barley,	. . . .	56·9
Scotch big,	. . . .	56·6

Hence we see, that in all these cases the bulk of the malt was very nearly the same as the previous bulk of the barley before it was malted.

In another set of experiments, 100 lbs. of malt left the following residues:—

English barley,	. . . .	54·0 lbs.
Scotch barley,	. . . .	56·1
Scotch Big,	. . . .	56·6

100 lbs. of the raw grain being converted into malt, and the soluble part of the malt being extracted by hot water, the residues weighed,—

English barley,	. . . .	54·63 lbs.
Scotch barley,	. . . .	56·09
Scotch big,	. . . .	56·59

Here also the bulk of the malt differed but little from that of the raw grain. The first of these sets of experiments was made with grain of the best quality, the second with grain of the middling quality, and the third with grain of the third quality.

It is probable that an additional portion of the kernel would be dissolved if the malt were ground finer than it is customary to do. The reason for grinding it only coarsely is to render it less apt to set. But this object might be accomplished equally well by bruising the malt between rollers, which would reduce the starchy part to powder, without

destroying the husk. This method, indeed, is practised by many brewers, but it ought to be followed by all.

## CHAPTER IV.

## OF BREWING.

Brewing consists of five successive processes, which are distinguished by the following names: 1. *Mashing*; 2. *Boiling*; 3. *Cooling*; 4. *Fermenting*; 5. *Cleansing*. We shall afterwards give a description and view of the utensils employed in a large London porter brewery, where they have been carried to the greatest perfection. But we conceive it better to give a description of the processes themselves, in the first place, without referring them to any specific form of vessels; observing only, that the size of all the utensils must be proportional to the quantity of beer which it is proposed to make at once.

1. The specific gravity of malt varies a good deal, according to the way in which it is dried upon the kiln; but its mean specific gravity may be stated at 1.201. In general the specific gravity of big-malt is rather inferior to that of malt from barley. Let us suppose, for the sake of stating the comparative quantities, that it is our object to employ in a single brewing fifty bushels of malt. The first thing to be done is to grind the malt in a mill, and the best kind

of mill for the purpose is that in which the malt is made to pass between two iron rollers.

We must be provided with a copper boiler capable of containing at least the fifty bushels of malt; or its solid contents must, at the smallest, amount to 382 ale gallons, which are rather more than 107,521 cubic inches, or  $62\frac{1}{2}$  cubic feet. This copper boiler must be placed over brick-work upon a furnace, and there must be conveniences for filling it with water, and for letting the water off when sufficiently heated, into the mash-tun.

The mash-tun is a wooden vessel composed of staves properly fixed by means of iron hoops, and usually placed in the middle of the brew-house. It has a false bottom full of holes at some little height above the true bottom. Its capacity varies according to the extent of the brewery establishment; but a mash-tun capable of mashing fifty bushels of malt must be at least one-third larger than the bulk of the malt, or it must be capable, at least, of containing seventy-five bushels.

A quantity of water, equal at least in bulk to that of the malt, is to be put into the boiler, and heated up to  $190^{\circ}$  or  $180^{\circ}$ , according to the fancy of the brewer and the quality of the malt; but the best brewers, in general, employ the lowest temperature.

The boiler should contain a quantity of water, about two-thirds more than the quantity of finished ale required. That is to say, to brew twenty barrels

of ale, the open boiler should hold thirty-five barrels of wort.

When an upper back is used, or when a condensing pan is placed on the top, less room is required for the wort; but it is always better for the brewer to have the boiler above the standard than under it.

There are two methods of mashing; *first*, by letting the water rise up through the malt from the false bottom of the mash-tun. The first mash at 170° heat, the second at 190°. The *second* method is by first filling into the mash-tun the whole quantity of water for the first mash at 180° of heat, and running the malt into it from the hopper above, stirring, at the same time, either with oars or by the machine. The second mash at 190°.

The temperature of the water in the first mash is lowered in both methods about 40°; but the mash afterwards rises 20° from the chemical action of the malt upon the water.

The quantity of water for the mash must be regulated by the required strength of the wort.

Edinburgh brewers fix the prices of their ales at from £3, £4, £5, £6, £7, and £8, per hogshead, according to the price of barley, &c.

The flowing of the wort takes time according to the quantity in operation. In large mash-tuns the stop-cock is made large in proportion to the size of the mash-tun, making allowance for the velocity with which the worts escape by the pressure. In a brewing of thirty barrels, the wort will flow in half an

hour. But when sparging is taken into account, it may take six hours to finish the mashing and flowing of the wort.

After the water is mixed with the malt, the mixture is completely stirred and all the clots broken, either by workmen, who use for the purpose very narrow wooden shovels, or, when the capacity of the mash-tun is very great, as in the London breweries, by a machine which is driven by a steam-engine. Great care must be taken to break all the clots, because the whole of the malt within them would otherwise escape the action of the water, and be lost to the brewer. When the water and malt are sufficiently mixed, the mash-tun is covered and left in this state about three hours. But the time varies according to circumstances.

Though the specific gravity of a malt-corn be greater than that of water, yet if it be thrown into that liquid it always swims. The reason is, that between the skin and the kernel there is lodged a quantity of air, which it is not easy to drive away. Accordingly, brewers are in the habit of judging of the goodness of malt by throwing a certain quantity of it into the water, and, reckoning the grains which fall to the bottom, these indicate the proportion of unmalted grain which the malt contains. Of course, the more of them that exist in any given quantity of malt, the worse must the malt be considered. But though malt, when we consider only single corns, is about a sixth heavier than water, yet a bushel of

malt does not weigh so much as one-third of a bushel of water. For, on one occasion, the hot water in the mash-tun, before the addition of the malt, stood at the height of twenty-two inches. On adding the malt, it rose to the height of twenty-nine inches. The bulk of the water was fifty-one bushels; that of the malt before grinding, forty-seven and a half bushels. We see from this that the real space occupied in the mash-tun by the forty-seven and a half bushels of malt was only seven inches, while the fifty-one bushels of water occupied the space of twenty-two inches; therefore about two-thirds of the bulk of the unground malt consisted of interstices filled with air.

The temperature of the water is considerably lowered when it is mixed with the malt, but we have been unable to determine how much, from the impossibility of thrusting a thermometer down to the centre of the mash-tun, the only place that would give a correct result. But we may state a few out of the many observations which we have made on the subject; fifty-one bushels of water of the temperature of  $192^{\circ}$  were mixed with forty-seven and a fourth bushels of malt; after mixture, the temperature at the surface of the mash was  $140^{\circ}$ . Two hours and a half after, when the wort began to run off, its temperature was  $156^{\circ}$ , and at that time the surface of the mash was at the temperature of  $136^{\circ}$ . If we suppose in this case that the whole mash lost four degrees as well as the surface, and take the mean between the bottom and top, we shall have the mean

heat of the whole, after the mashing,  $150^{\circ}$ ; so that the water has lost  $32^{\circ}$  of heat, while the malt (its temperature before mixture was  $48^{\circ}$ ) gained  $102^{\circ}$ .

The weight of the water, reckoning it

at 51 bushels, was .....3965·25 lbs.

That of the malt was .....1788·80 lbs.

This would make the specific heat of the malt 0·69, which is probably considerably above the truth; for, according to the experiments of Dr Crawford, the specific heat of barley is only 0·421; so that our supposition, that the mean temperature after mashing was only  $150^{\circ}$ , is not quite accurate. Were we to suppose the specific heat of malt to be 0·42, which cannot be very far from the truth, in that case the mean temperature, after mashing, would be  $169^{\circ}$ , if the water was  $192^{\circ}$  and the malt  $48^{\circ}$ , and the weight of each as above stated.

In another experiment, in which sixty bushels of malt were mashed, the heat of the water was  $180^{\circ}$ , that of the malt  $56^{\circ}$ , the temperature, on adding the malt to the water and mixing it well, was at the surface  $141^{\circ}$ . Four hours after, when the wort began to be drawn off, its temperature was  $150^{\circ}$ , and that of the surface of the mixture of malt and water in the mash-tun was  $138^{\circ}$ .

The bulk of water was  $66\frac{1}{2}$  bushels, its weight...5157· lbs.

The weight of the malt was .....2283·6 lbs.

Any person may easily, from these data, calculate what the heat of the mixture after mashing ought to be, supposing the specific heat of the malt to be

0.42. The common formula for the calculation is

$S = \frac{W \times w - m}{B \times m - b}$ , in which S denotes the specific heat

of the malt, W the weight of water used,  $w$  its temperature, B the weight of malt used, and  $b$  its temperature, and  $m$  (which in the present case is the quantity sought) the temperature after mixture. We do not think it worth while to give any more examples of these changes of temperature, though we are in possession of abundance of them ; because we do not conceive that they can lead to any useful results.

After the mash has continued for about three hours (or longer or shorter according to circumstances), a stop-cock, placed below the false bottom in the mash-tun, is opened, and the wort allowed to run out into a vessel prepared to receive it, and known by the name of *underback*. At the same time the cover is taken off the mash-tun, and quantities of water of the temperature of  $180^{\circ}$  are occasionally sprinkled over it from the boiler, which had been again filled with water to be heated as soon as the water for mashing was drawn off. No specific directions can be given respecting the quantity of hot water added in this manner by sprinkling, because that must depend upon the views of the brewer. If he wishes to have ale of very great strength, he will, of course, add less water ; if the ale is to be weak, he will add more. The best way is to determine the strength of the liquor as it flows into the underback, by means

of a saccharometer, or by taking its specific gravity. When the specific gravity (at 60°) sinks to 1·04 or 1·05, or when it contains only 36½ or 46½ lbs. per barrel of solid matter in solution, it would be useless or injurious to draw any more off for making strong ale. But an additional portion may still be drawn off and converted into small beer. We have seen the brewers in Edinburgh continue to draw off small beer from the mash-tun till the liquid indicated only 23½ lbs. per barrel, or even till it indicated 17½ lbs. per barrel; that is, till its specific gravity at 60° was reduced to 1·027 or 1·020. Indeed the strength of small beer is often much weaker than this when it is obtained from malt without drawing off any strong ale wort; but when it is the residue of strong ale, it is necessary to make it stronger, otherwise its quality will be bad. About fifty years ago, it was customary with some of the small-beer brewers in Edinburgh to make the small beer of considerable strength; and after the exciseman had determined its quantity, and the duty to be paid on it, they diluted it largely with water, just when they were sending it out of the house. This fraud was easily put in practice, because the small beer is usually disposed of the moment it is mixed with the yeast, and before it has undergone any fermentation whatever. It ferments sufficiently in the small casks in which it is sent to the consumers. In Edinburgh it is customary to bottle this small beer, which makes it clear and very brisk, and, consequently, very agreeable to the palate.

Neither can any general rule be laid down for the specific gravity or strength of the wort when it begins to flow from the mash. It will obviously depend upon the goodness of the malt, and upon the quantity of mashing-water employed, when compared with the quantity of malt. We have seen it begin to flow from the mash-tun of the specific gravity 1·084, 1·0805, 1·0815, 1·0835, 1·091, 1·094, or containing respectively  $78\frac{1}{2}$ ,  $74\frac{1}{2}$ ,  $75\frac{1}{2}$ , 78, 85, and  $87\frac{1}{2}$  lbs. per barrel.

The wort, as it first flows from the mash-tun, is a transparent liquid of a fine amber colour, a peculiar smell, and a rich, luscious, sweet taste. If it is cloudy, as sometimes happens, it is a proof that the water used for mashing was of too high a temperature. We have seen the wort run cloudy from the mash-tun when the temperature of the water had been as high as  $200^{\circ}$  or  $191^{\circ}$ , but never when it was no higher than  $180^{\circ}$ . This affords an additional reason with the brewers for keeping the temperature of the mashing-water low. But we have some doubts about the accuracy of the reason. For, when the wort is afterwards boiled, it always deposits a copious flocky sediment. The boiling would render even turbid wort transparent, and would not probably increase the sediment much. At the same time it must be acknowledged that some obscurity hangs upon this part of the process of brewing. For we have seen wort continue opaque during the whole process of boiling, cooling, and fermenting, and requiring ultimately to be

clarified, or *fined*, as the brewers termed it, by means of isinglass. The substance which rendered the ale in this case turbid seemed to be a variety of starch, or some particular form of that substance, for it was completely precipitated by infusion of nutgalls, and the precipitate was redissolved by the application of a moderate heat.

The flowing of the wort from the mash-tun takes up six or eight hours. As it advances the colour diminishes, the smell becomes less agreeable, and the taste less sweet. At last the colour becomes nearly opal, and the smell becomes sour, and somewhat similar to the odour emitted by an infusion of meal and water left till it has become sour. Yet it produces no change on vegetable blue colours.

If the wort which first comes over be evaporated to dryness, it leaves behind it a yellow-coloured residuum, which has a sweet taste, dissolves readily in water, absorbs water from the atmosphere, and becomes clammy, and similar in appearance to treacle. Its specific gravity is 1.552. This does not differ much from the specific gravity of common refined sugar, if we take a mean of the experiments of Fahrenheit and Hassenfratz. Fahrenheit found the specific gravity of sugar 1.6065, while Hassenfratz found it 1.4045, the mean of which is 1.5055. There can be no doubt that this residue contains a good deal of sugar, precisely the same in its properties with the sugar into which starch is converted by boiling it in a very dilute acid, called by chemists *glucosin*. But

it is mixed likewise with a considerable portion of starch, which has become soluble in water, without being converted into sugar. For wort gives a copious precipitate with the infusion of nutgalls, and this precipitate is redissolved by a moderate increase of temperature,—properties which characterise starch.

From the experiments of Saussure, it would appear that starch-sugar is nothing else than a combination of starch and water. Hence it is probable that, during the mashing, a combination takes place between the starch of the malt and the water, the result of which is the formation of starch-sugar. This sugar agrees in its properties with the sugar of grapes. It crystallizes in needles grouped together in the form of small sphericles like granulated honey. It does not go so far in sweetening as common sugar, and, like sugar of grapes, it ferments without the addition of yeast. We have attempted in vain to separate the saccharine part of the residue of wort from the starch. When alcohol is poured over it, no solution takes place; but such is the affinity of the residue of wort for water, that it deprives the alcohol of a portion of its water, just as carbonate of potash or muriate of lime does, and a very viscid liquid, consisting of the residue of malt dissolved in a very small quantity of water, is formed at the bottom of the vessel.

It is exceedingly difficult to evaporate wort without partly decomposing the extractive residue. The best way is to put it upon a very flat dish, and to apply a

heat not greater than 120°. We have charred it completely in a glass vessel, filled with alcohol, without applying heat sufficient to make the alcohol boil. Indeed we never succeeded in obtaining the residue of wort without its colour being a good deal darker than that of the wort from which it was obtained.

The wort which runs off last contains very little saccharine matter; but some starch and mucilaginous matter may still be detected in it. The flavour and beauty of the ale is increased if we take only the wort that runs first off, and throw away the last drawn worts, or employ them only in the manufacture of small beer.\*

\* Brewers differ in practice when drawing off the wort. When the whole is intended for ale the first mash is laid on at a greater length, to obtain the greatest possible quantity of wort of a required strength. The mash holds wort of the same weight as that drawn off. The second mash not only takes up the wort which saturates the goods, but the formation of saccharum still proceeds, and when this mash is run, supposing its weight 40 to 45 lbs. per barrel, the saccharum that remains in the mash is only that contained in the wort which is taken up by the malt left in the mash-tun. The water run into the mash, say ten barrels added to that which saturates the malt, will make fifteen barrels, of the weight of 13 lbs. of saccharum per barrel, allowing wort of the weight of 40 lbs. to have been left in the second mash. Most brewers, therefore, use the third mash for small beer, as, were they to mix this weak third mash with the two first, they would lose more by boiling down to strength than its worth, besides damaging their ale.

The weight of the saccharine extract of the first and second mash of a brewing of ale will be in proportion to the required price of the production.

The price of ale in Edinburgh increases from £3 upwards to £8 per hogshead, and the strength or weight of saccharum is in proportion. The weight of a barrel of wort, boiled and cooled down

2. The next process in brewing is the *boiling* of the wort. The wort is pumped up from the *under-back* into the copper boiler, where it is boiled till it has acquired the degree of strength which is wanted by the brewer.

It may be proper to give some examples of quantities, to enable the reader to form a better idea of the effect of the boiling.

From sixty bushels of malt there were obtained 23·465 barrels of wort, of the strength of 64·37 lbs. per barrel, or of the specific gravity 1·0683. It was boiled down to 17·736 barrels of the strength of 82·7 lbs. per barrel, or of the specific gravity 1·089.

From sixty bushels of big-malt there were obtained 23·8193 barrels of the specific gravity 1·0648, or of 58·75 lbs. per barrel of saccharine matter. It was boiled down to 17·736 barrels of the specific gravity 1·078, or of 72½ lbs. per barrel of saccharine matter.

to the fermentation point, will be from 50 lbs. to 140 lbs. of saccharine extract, according to the above prices.

The destruction of the wort by evaporation on the coolers is so great as to make it an object of vast importance to devise a method of cooling without so much loss. Distillers who run their wort into the coolers from the mash have accomplished their object by running the wort through pipes of great length immersed in water. But this method of cooling does not answer the brewer of ales, owing to the fecula remaining in solution, and damaging the quality of the production, when such a plan is adopted.

Coolers formed of iron plate answer the purpose better than the wooden coolers now in general use. On the iron cooler, by lowering its temperature by running cold water over it, and mopping it clean and dry, wort, by being then spread to the depth of 1½ or 2 inches successively, may be cooled down, even in summer heats, to as low a degree as brewers require.—W. S.

From seventy-two bushels of malt 24·1388 barrels, of 78·6 lbs. per barrel were obtained. It was boiled down to 17 barrels of the specific gravity 1·1055, or of 98½ lbs. per barrel of saccharine matter.

From fifty bushels of malt 17·444 barrels of wort were obtained, of 74·125 lbs. of saccharine matter per barrel. It was boiled down to 12·083 barrels of the specific gravity 1·1015, or of 94½ lbs. per barrel.\*

Various contrivances have been fallen upon to economise the boiling process; but these will come under our consideration with more propriety when we proceed to give an account of the utensils in a London brewery.

The flocky precipitate which forms during the boiling of the wort, as far as we have been able to determine its properties, approaches nearly to the nature of gluten or vegetable albumen, for these two substances differ very little from each other.

While the wort is in the boiler, the requisite quantity of hops is added to flavour the ale, and render it capable of being kept for a considerable length of time without souring. Hops, as is well known, are the seed-pots of the *Humulus lupulus* or hop-plant, which is cultivated in considerable quantities in the south of England, especially in Kent and Hampshire. The seed-pots of this creeping plant are collected when ripe, and dried upon a kiln. They are then packed up in bags, and sold to the brewers. Hops

\* In these examples, the worts are given as boiled and cooled down to the point of fermentation.

are well known to have a peculiar bitter taste, and a weak aromatic odour, and to possess sedative qualities to a considerable extent. A pillow filled with hops has often been found to induce sleep when every thing else has failed. If they be digested for some days in alcohol, that liquid acquires a slight greenish colour, a peculiar taste, and an odour in which that of the hop can be distinctly perceived. If the alcohol, previously freed from the undissolved matter, be distilled in a retort, there remains behind a solid green-coloured oil. It is to this oil that hops owe their peculiar smell. Its taste is peculiar, sharp, and scarcely bitter, but putting one in mind of the peculiar flavour of good ale. This oil is the part of the hops which gives ale its distinguishing flavour. It is apt to be dissipated by long boiling. Hence, when hops are too long boiled in wort, the aromatic odour and peculiar flavour are nearly dissipated, and a bitter taste substituted. It is the opinion of brewers, that the intoxicating qualities of ale are to be partly ascribed to the oil of the hop. Indeed it has been pretty common to ascribe intoxicating qualities to bitter-tasted substances in general. Thus, a woman of the name of Johnston, who kept a public-house a little to the south side of the Meadows, near Edinburgh, about the beginning of the last century, was famous for brewing a pleasant and very intoxicating ale; and the last quality was universally ascribed to the broom tops which she employed as a bitter instead of hops. This woman's name is re-

membered, because her ale and her house are celebrated in the poems of Allan Ramsay. But the opinion above stated, though very general, does not appear to be founded upon any precise experiments or observations. We are not acquainted with any volatile oil which produces intoxication; though some of them, as oil of turpentine, act with great energy upon the stomach. No infusion of any bitter whatever, not even of hops, is known to produce intoxication; nor is any effect in the least similar to intoxication produced when considerable quantities (2 oz. per day for example) of Peruvian bark are swallowed in substance.

Besides the volatile oil, hops contain likewise a quantity of bitter principle, which may be easily extracted from them by water. As far as we are able to determine the point, this bitter matter possesses the characters of the bitter principle in perfection. No re-agent that we tried is capable of throwing it down except acetate of lead, a somewhat ambiguous precipitant, because it throws down the greater number of vegetable substances, and because the lead in this salt is partially thrown down by carbonic acid, if it happens to be present in the solution. Nitrate of silver is likewise a precipitant, throwing down the bitter principle of hops in light yellow flocks. But this precipitant is also somewhat ambiguous, for the same reason that renders acetate of lead so. The bitter principle of hops is likewise very soluble, both in water and in alcohol.

Hops communicate both their flavour and their bitter taste to wort. The quantity employed varies very much, according to the taste of the persons who are to drink the ale. The stronger the ale, the greater is the quantity of hops which it can bear without injury. In general, English brewers employ a much greater quantity of hops than the Scotch brewers. To elucidate the subject, we shall give a few examples of the quantity of hops used in making Edinburgh ale : which is known to be mild, and, in general, is much relished by most of those who are in the habit of drinking ale.

Sixty bushels of malt yielded 11·75 barrels of strong ale wort, measured at the end of the boiling, and 40 lbs. of hops had been mixed with it in the boiler.

Forty-seven and a quarter bushels of malt furnished 10·83 barrels of wort, measured after being boiled and cooled, and 36 lbs. of hops had been mixed with it in the boiler.

Sixty bushels of malt furnished fifteen barrels of wort, measured after boiling and cooling, and 45 lbs. of hops had been mixed with it in the boiler.

Sixty bushels of malt from big furnished 14·7 barrels of wort, after being boiled and cooled. It was mixed with 40 lbs. of hops in the boiler.

In another brewing in which 72 bushels of malt from big, furnished 10½ barrels of wort, 66 lbs. of hops had been added in the boiler.

In general, when the ale has considerable strength,

the Edinburgh brewers are in the habit of adding one pound of hops for every bushel of malt employed. Sometimes, indeed, when they wish their ale to be very superior in flavour and quality, they employ a greater quantity of hops than even this. Thus we have seen 100 lbs. of hops boiled in the strong ale wort extracted from 72 bushels of malt. When the ale is but weak, and consequently cheap, the usual allowance is one pound of hops to a bushel and a half of the malt.

The peculiar flavour of the best ales is communicated by the skilful use of the hops; and both the quantity employed and the time of the boiling, require the best consideration of the brewer. The best hops for ale are the Kent growth, of a pale-green colour, glossy, and having an aromatic flavour. No arbitrary rule can be given for the quantity to be used in brewing ales of different strengths, and much depends on the views of the brewer, with regard to the future disposal of the ale.

In Edinburgh they use from 1 lb. to  $1\frac{1}{2}$  lbs. per bushel for the best strong ales, using a third more for the summer keeping ale than for winter ale, or ale brewed for immediate use. The peculiar substances in hops connected with brewing have been already noticed. The bitter ingredient if too much is used, renders the ale very unpalatable. The Nottingham brewers, who are the best in England, sometimes use as much as 15 lbs. of hops to nine bushels of malt. The porter brewers of London use very little Kent hops of

fine quality ; but prefer the cheaper red hops of Sussex and other districts. The quantity of hops, as used by the English provincial brewers, is  $2\frac{1}{2}$  lbs. per barrel of 36 gallons made from 3 bushels of malt.

3. After the wort has been boiled down to the requisite strength, which, in Edinburgh, is commonly between the specific gravities 1.09 and 1.10, it is let out into the *coolers*. The coolers are floors of wood, surrounded with a wooden ledge, and water-tight, placed in the most airy and exposed situation in the brewery. They are of such a size as to hold the whole of the wort at a depth not exceeding three or four inches ; so that, in large breweries, they are of an enormous extent. The object is to cool down the wort as rapidly as possible to the temperature of the atmosphere ; because, if it were allowed to remain long hot it would run the risk of becoming sour, which would spoil the whole process. A great deal of the superiority of some breweries over others depends upon the construction of the coolers, or rather, upon their being as well adapted as possible for reducing the temperature of the wort speedily to that of the atmosphere. A free current of air ought to pass over them, and great care should be taken to keep them perfectly clean.

The wort is either pumped out of the boiler into the coolers, or let into them by simply opening a stop-cock, according to the construction of the brewhouse. It soon spreads itself over all the surface of the coolers, and a very great evaporation is the consequence.

This evaporation ought always to be taken into consideration by the brewer ; because it both materially adds to the strength of the ale and diminishes its quantity. The amount of it depends upon the temperature of the air compared with that of the atmosphere, and upon the skill with which the coolers have been constructed. We shall give a few examples of the quantity of evaporation which took place during the cooling of worts in coolers by no means remarkable for the goodness of their construction.

Temperature of the Wort when let into the Coolers.	Temperature of ditto when Cold.	Quantity of Wort when let into the Coolers in Ale Barrels.	Ditto when Cooled.	Quantity evaporated in Ale Barrels.	Time of Cooling in Hours.
160°	56°	16-1388	14-8611	1-2777	11½
176°	51°	18-6666	17-2222	1-4444	11½
208°	50°	11-5555	8-75	2-8055	9½
208°	52°	16-6388	12-0832	4-5556	14
208°	50°	14-0555	10-2222	3-8333	9
208°	53°	14-7777	10 5	4-2777	16
210°	52°	13-6944	9-1388	4-5556	8
208°	51°	13-3333	9-3055	4-0278	8
206°	52°	12-6388	8-2777	4-3611	6
200°	52°	14-0555	9-4444	4-6111	6½
200°	54°	13-6944	9-1388	4-5556	6
200°	53°	11-0833	8-5000	2-5833	7
204°	56°	14-0555	10-6111	3-4444	8
Mean		14-1067		3-5640	

In the first two examples in the above table, the quantity of wort was estimated just when it was let down into the coolers ; in all the others it was estimated in the boiler before it was pumped out. It appears from the preceding table that rather more than one-fourth of the whole wort is dissipated by evaporation during the cooling ; and, if we had excepted from

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the general consideration the first two examples, the proportion evaporated would have been still greater.

When the wort is let out of the boiler into the cooler, the hops still remain, and, as they are soaked with wort, a considerable loss would be sustained if they were thrown away. Thus we found, in one instance, that 45 lbs. of hops retained half a barrel of wort after they were drained so completely that no more wort would drop out. In another case, 35 lbs. of hops retained in the same way 0.3666 of a barrel, which is rather more than one-third of a barrel. To recover this wort it is proper to subject the hops to pressure. We do not know whether this is attended to by the great brewers, though it probably is. By several of the Edinburgh brewers it is, we believe, too much neglected.

In cold weather, where the brewery is small, and the apartment in which the fermenting vessels are placed, cold, it is proper not to reduce the temperature of the wort as low as that of the atmosphere. From want of attention to this circumstance, we have seen wort refuse to ferment for some time, and the brewer under the necessity of heating it artificially before fermentation could be brought on. In such cases the wort is very apt to be lost altogether by contracting acidity. The temperature, in such cases, ought not to be reduced lower than 56°. But when the apartment in which fermentation is carried on is warm, 51° or 52° is a very good temperature. When the brewer is obliged to make ale in warm summer

weather, it is material to reduce the temperature as low as possible. In such cases great advantage would attend cooling the wort in coolers without any roof or covering whatever, but quite open to the sky ; because in clear nights, the wort might be cooled in this way, eight or ten degrees lower than the temperature of the atmosphere. The reason is obvious. It is owing to the rays of heat, which, in such a case, radiate from the wort, and are not returned again by the clear sky. Wort, being a good radiator of heat, would be particularly benefited by this method of cooling. We have no doubt that it might be put in practice with advantage in hot climates ; and that, by means of it, good ale or porter might be manufactured in the East and West Indies. Such a manufacture, if successful, would be particularly relished in India, and would, we doubt not, prove a lucrative article of manufacture to an enterprising man.

While a duty was levied on ale and beer according to their quantity, excisemen were in the habit of gauging the wort while in the boiler and when on the coolers. Not that the duty was levied according to the quantities there found, but to serve as a check upon the more accurate gauges taken in the fermenting-tuns. For a certain allowance being made for evaporation while the wort is in the cooler, which the excisemen, from long observation, are enabled to do with some accuracy, they have it in their power, from these checks, to determine whether any of the wort from the coolers has been secreted or carried off with

a view to evade the excise laws. In the year 1830 the duty on beer was taken off. The consequence of this is, that the brewer is now entirely freed from the exciseman, and at liberty to improve his processes at pleasure. We doubt not that in a short time this will be followed by considerable improvements in *brewing*.\*

\* The following communication to the author of this treatise, on the mode of cooling wort with the smallest loss of saccharine matter, deserves the attention of the brewer :—

From a given quantity of malt, required the greatest possible weight of the solid extract of saccharum in solution at the fermentation point.

The first step is to prove the weight of the saccharine extract from the mash, and to shew the loss in each succeeding part of the process.

In every brewing, from fair average pale malt, when the weight in lbs. of the solid extract of saccharum per barrel, as indicated by the saccharometer, is multiplied by the number of barrels of wort obtained from the mash, and the product divided by the number of bushels of malt in operation; the maximum weight of saccharine extract per bushel will be found. Pursuing the same method to ascertain the loss of saccharum by evaporation in boiling and cooling down the wort to the fermentation point, an approximation is obtained—

Weight of saccharum from the mash, 28 lbs. per bushel.	
Loss in two hours' boiling, . . . . .	2 lbs.
„ in cooling, . . . . .	1½
„ in hop-draining, . . . . .	½
	3½
Remains, . . . . .	24½ lbs.

as the average weight at the point of fermentation obtained by ale-brewers by the present method of brewing, being a loss of 12½ per cent. of the whole saccharum obtained from the malt in operation.

4. When the wort is sufficiently cooled down by exposure on the coolers, it is let down into the fermenting-tuns, or, as the brewers call them, the gyle-

To prevent part of this loss, and to establish a method of brewing, by which the greatest possible quantity of wort, and weight of the solid extract may be brought down to the point of fermentation, is the next step to which the attention of brewers may be called.

A sample of wort was drawn from the boiler, just before the contents were run into the coolers. The tin jar was immediately plunged into a pail of cold water, and the process of cooling by evaporation was superseded by the caloric being transmitted through the sides of the jar, by the action of the water on every part of its surface. The contents of the jar, and the worts in the cooler, being accurately weighed both at 60°, the real strength of the wort in the boiler, and loss by evaporation on the coolers, were determined.

On making this trial it became obvious, that, were an elongated square utensil filled with wort, and placed in a horizontal position, and a stream of cold water run continuously over the surface, the process of cooling would rapidly go on without any loss whatever, either by evaporation of the wort or destruction of the saccharum. The action of refrigeration would be vertical, and the fecula of the wort would be as effectually precipitated, as during the process of cooling by evaporation in the open coolers.

On subjecting the wort to experiment on a small scale, the success was complete; and I believe it has only to undergo a fair trial to become a most important and valuable acquisition to brewers and distillers.

On constructing a cooler on this new principle, it would be requisite to make it at once simple and perfect, to fit it for practical utility, in which view I would unite the hop-drainer, on the most improved construction, to it, making the hop-drainer a reservoir to keep the cooler continually full; and thus save the whole wort and extract lost by the present method of evaporation on the coolers.

The refrigeratory power of such a cooler is very great, as the liquid within must cool down to the degree of heat of the substance which is applied to the surface; so that, in addition to cold

tuns, in order to be fermented; by which process it is converted from the luscious, sweet-tasted liquor called *wort*, to the brisk intoxicating liquor which constitutes *ale*. The gyle-tuns are cylindrical wooden vessels, varying in size according to the extent of the brewery. In the London breweries, and in the distilleries, they are of prodigious size; but in private houses they often do not exceed the size of a wine-hogshead, or even of a beer-barrel. The fermentation is perhaps conducted with the greatest economy in large vessels; but good ale may be made in comparatively small quantities. How far this is the case with porter, it is more difficult to say. Good porter has scarcely ever been made, except by those who manufacture it upon a large scale.

The fermenting-tuns are not to be filled by the wort, because a considerable increase in bulk takes place during the fermentation, in consequence of

water, were ice used, refrigeration may be carried rapidly down to the freezing-point in any experiment that may be tried.

With regard to boiling, during which so large a destruction of wort and saccharum takes place, the subject is one of difficulty.

The double-boiler, used in the London breweries, might be adopted by ale-brewers towards avoiding part of the loss. It must act under diminished atmospheric pressure, and save part of the saccharum and wort; but the capacity of the saccharum to escape being greatest at the boiling point, the destruction must go on to a great extent in it also. The best form, perhaps, would be the common boiler, with an upper back, so constructed as to present as small a surface as possible to the action of evaporation; and by regulating the time of boiling,—and this is particularly requisite in the English method of brewing,—I am certain a saving of 1 lb. per bushel may be effected on the whole malt in operation.—W. S.

which the liquor would run over, unless allowance were made for it.

The fermentation of ale or beer is never carried to any great length. The object of the brewer is, to retain the flavour and good qualities of the ale or beer, not to develop the greatest quantity of spirits, which can hardly be done without allowing the wort to run into acidity. The violence of the fermentation depends upon the quantity of yeast added. Brewers, accordingly, mix yeast with their worts only in very sparing quantities, while the distiller adds it in great doses, and repeatedly.

Yeast is a frothy substance, of a brownish-grey colour and bitter taste, which is formed on the surface of ale or wine while fermenting. If it be put into sacks, the moisture gradually drops out, and the yeast remains behind in a solid form. It has very much of the flavour and taste of cheese when in this state; but its colour is still darker. This dried yeast promotes or excites fermentation, but it does not answer quite so well as fresh yeast. At one period, some of the Scotch distillers employed considerable quantities of it; but all of them with whom we conversed on the subject affirmed, that it was much less profitable than even the bad porter yeast which they were in the habit of bringing down from London. From the resemblance which dried yeast has to cheese, one would be disposed to infer, that it is a species or variety of gluten. But if we attempt to

induce fermentation in wort by adding the gluten of wheat, we will be unsuccessful.

When yeast is kept for some time in cylindrical glass vessels, a white substance, not unlike curd, separates and swims on the surface. If this substance be removed, the yeast loses the property of exciting fermentation. This white substance possesses many of the properties of gluten, or vegetable *fibrin*, though it differs from it in others. Its colour is much whiter; it has not the same elasticity, and its particles do not adhere with the same force. In short, it agrees much more nearly, in its properties, with the curd of milk than with the gluten of wheat. We are disposed to consider this substance as the true fermenting principle in yeast, though we were never able to procure a sufficient quantity of it to put its fermenting powers to the test of experiment. We have sometimes seen a similar substance separate in the fermenting-tuns in distilleries, when the fermentation was nearly at an end; or, rather, when such a quantity of spirit had been generated as put an end to the fermenting process altogether. But we could never learn that the distillers had formed any opinion respecting this curdy substance. It did not interfere with the success of their operations, and, on that account, they bestowed little attention on it. We attempted, once or twice, to collect such a quantity of it as might enable us to try its powers as a ferment, but we did not succeed.

The only chemist who has attempted to subject

yeast to a chemical analysis is Westrumb; but, though this philosopher was distinguished for his accuracy, the task was too difficult for the resources of the science of the time (1796) when he published his *Experiments*. From 15,360 parts of fresh beer yeast, he obtained the following substances:—

Potash, . . . . .	13
Carbonic acid, . . . . .	15
Acetic acid, . . . . .	10
Malic acid, . . . . .	45
Lime, . . . . .	69
Alcohol, . . . . .	240
Extractive, . . . . .	120
Mucilage, . . . . .	240
Saccharine matter, . . . . .	315
Gluten, . . . . .	480
Water, . . . . .	13,595
	<hr/>
	15,142
Loss, . . . . .	218
	<hr/>
Total, . . . . .	15,360

As yeast may be reduced to a dried state without depriving it of the power of acting as a ferment, it is clear that the carbonic acid, acetic acid, alcohol, and water, are not essential to it. We cannot suppose that either potash, lime, or malic acid, is essential. The saccharine matter, we know, is capable of fermenting of itself; but if it were the essential ingredient, it would be quite unnecessary to add yeast to wort at all, as we know that the wort contains abundance of saccharine matter in solution. We

know likewise, from experiment, that neither extractive, mucilage, nor gluten, possesses the property of exciting fermentation. Thus, none of the substances found by Westrumb in yeast, can be considered as the true fermenting principle. Dobereiner found, that, when yeast is steeped in alcohol, it loses the property of acting as a ferment. This may be owing to the alcohol dissolving and carrying off the true fermenting principle. But we are rather disposed to ascribe it to the presence of a portion of alcohol in the yeast. We know that a certain portion of alcohol destroys fermentation. Thus, we have found, by a great many trials, conducted on rather a large scale, that the stronger a wort is made, the greater is the quantity of unaltered saccharine matter which remains in it after the fermentation has been carried to the greatest possible length. Hence the present mode of levying the duties on spirits upon the wash is not only very injurious to the goodness of the spirits manufactured, but is attended with a positive and very heavy loss to the community. Distillers' wash may be fermented a second time, and would, in this way, yield a considerable additional quantity of spirits. We have frequently seen it made into good small beer. The proper mode of levying the duty would be on the quantity of saccharine matter in the wash. This might easily be determined by a good saccharometer. A certain part of the duty might likewise be levied upon the spirits produced. This would act as a sort of check upon the first esti-

mate, and would considerably diminish the risk of fraud. Indeed, the mode of determining the duty by the quantity of saccharine matter, would not be more liable to evasion than the present mode. It could be evaded in no other way than by concealing a portion of the wash, which would be equally efficacious according to the present mode.

We conceive, therefore, that when yeast is mixed with alcohol, it may retain so much of that liquor as to prevent it from acting as a ferment. When we attempt to wash away the alcohol, we may destroy the yeast by washing away that portion of it which really acts as a ferment, which is probably small in quantity.

It seems to us not unlikely, that the portion of yeast which really acts as a ferment, is a quantity of saccharine matter which it contains, that has begun to undergo the decomposition produced by fermentation, but has not yet completed the change. For nothing more seems to be necessary than to begin the fermentative process in wort; the process then goes on of itself. It would be curious to know whether a high temperature ( $96^{\circ}$  or  $100^{\circ}$ ) might be substituted in distilleries for the great quantities of yeast at present employed. We believe that the reason why such great quantities of yeast are necessary in distilleries, is the very great strength of the wash employed; as they are obliged by law to produce a quantity of proof spirits, amounting nearly to one-fifth of the whole bulk of the wash. Nothing can be

more preposterous than such a method, nor more contrary to the real interest of the community, which obviously must be to produce the greatest quantity of good spirits from a given quantity of grain.

The quantity of yeast mixed with the wort in the fermenting-tuns by brewers is very small, amounting, at an average, to a gallon of yeast for every three barrels of wort. The following table will give the reader an idea of the quantities of yeast really mixed by the Edinburgh brewers with their strong-ale worts in different brewings. It is obvious, however, that the quantity of yeast must be regulated in some measure by its goodness.

Quantity of Wort in Barrels.	Specific Gravity.	Lbs. per Barrel of Saccharine Matter.	Quantity of Yeast added in Gallons.
10·611	1·106	99	3·5
10·83	1·104	97½	4
14·944	1·096	89½	2·5
14·8055	1·093	86½	3·75
14·6388	1·093	86½	2·83
14·722	1·082	76½	2·83
10·201	1·091	86½	1
9·75	1·091	86½	1
11·478	1·098	91½	1
9·25	1·096	89·67	1

The last four brewings, in which the quantity of

yeast added was smaller than in the first six, took place during the month of May, when the heat is apt to make the fermentation run to excess. The variation in the quantity, so conspicuous in the first six brewings, is partly to be ascribed to differences in the goodness of the yeast, but chiefly to the carelessness and want of method which distinguished the brewer in question beyond any one we ever met. But we have taken his quantities to shew, that differences in the quantity of yeast are not material; for all the preceding brewings, except the first, furnished very good ale. The wort in the first brewing had been cooled too much; the consequence was, that it fermented very badly, and finally ran into acidity.

Soon after the yeast has been mixed with the wort, an intestine motion begins to appear in the liquid; air-bubbles separate from it, and a froth collects slowly upon the surface. This froth is of a yellowish-grey colour. At first it has the appearance of cream; but in a few days it collects in considerable quantities, especially if the weather be warm. At the same time the temperature of the wort increases, and a very considerable quantity of carbonic acid gas is given out by it. The increase of temperature which takes place during the fermenting of ale may be stated, at an average, to amount to 12° or 15°. Sometimes it amounts to 20°, and sometimes does not exceed 5°. But in such cases there is generally some fault in the skill of the brewer.

But the following table, exhibiting the highest temperatures of different ales during their fermentation, will satisfy the reader of these changes of temperature better than any general explanation :

Quantity of Wort fermented in two Tunns, in Barrels.	Date at which it was let into the Fermenting-Tunns.	Temperature at that time.	Temperature when at the highest point of Fermentation.	Date at which this Temperature took place.	Strength of Wort when let into Fermenting-Tunns, in lbs. per Barrel.	Quantity of Yeast added, in Gallons.
10-83	March 10.	50°	63°	March 17.	88-75	4
14-944 in 1 tun.	March 17.	55°	61°	March 21.	85-62	2½
14-8055	March 24.	46°	68°	April 2.	78-125	3½
14-6388 in 1 tun.	March 29.	57°	70°	April 2.	80-625	2-83
14-722	March 31.	56°	71°	April 3.	73-75	2-83
17-43 in 1 tun.	April 4.	51°	64°	April 10.	65-00	2-83
8-72 in 1 tun.	April 6.	50°	65°	April 13.	93-75	3½

We shall now give some examples of the change of temperature by fermentation, when the brewings were conducted in summer, and of course assisted by the heat of the weather.

Quantity of Wort fermented in Barrels.	Date of letting it into the Fermenting-Tun.	Temperature at that time.	Temperature when at highest.	Date of ditto.	Strength of Wort, in lbs. per Barrel.	Yeast used, in Gallons.
975	May 24.	51°	71°	May 30.	95·93	1
11·1782	May 28.	49°	72°	June 2.	91·56	1
9·25	May 31.	45°	67°	June 6.	89·37	1
10·2777	June 4.	46°	67½°	June 13.	105·82	1
10·5	June 7.	44°	71°	June 15.	102·187	1
10·2222	June 11.	55°	82°	June 15.	110·0	1
10·694	June 18.	53°	80°	June 24.	96·4	1
13·5	June 21.	53°	67½°	June 25.	61·25	1

We shall likewise give the result of two brewings with raw grain, made also during the summer.

Quantity of Wort fermented in Barrels.	Date of letting it into the Fermenting-Tun.	Temperature at that time.	Temperature when at highest.	Date of ditto.	Strength of Wort, in lbs. per Barrel.	Yeast used, in Gallons.
10·5555	June 26.	48°	62°	July 1.	56·25	1
14·3055	July 6.	58°	68°	July 8.	72·5	1½

From the preceding tables we see that the length of time which elapses before the fermentation reaches its acme, supposing this to be measured by the temperature, varies very considerably. The shortest in-

terval in the table is three days, and the longest nine days; the average of the whole is very nearly six days, which is exactly the mean between the longest and the shortest times. If the reader will glance his eye over the tables, he will perceive that, in general, the higher the temperature of the wort is when let down into the fermenting-tuns, the more rapidly does the fermentation come on. As the worts were cooled by exposure to the greatest cold of the night, and as the coolers were screened from the radiation of heat, the temperatures given to the third column of the preceding tables may be considered as measuring very nearly the greatest degree of cold which took place in Edinburgh at the dates contained in the second column. It follows, as might have been expected, that the warmer the weather the more rapid is the fermentation. And hence the advantage of letting down the worts rather warm in cold weather, and cooling them down as much as possible in warm weather. For this purpose we cannot too much recommend coolers which can occasionally be uncovered altogether, and exposed to the unclouded sky. A roof, perhaps, might be contrived, composed of very light materials, which might be easily slid off, or which might turn upon a pivot. For a roof would be occasionally necessary to screen the worts from rain. In warm weather, brewing should be confined to clear and unclouded days, when the cooling process could be carried farthest of all. We have little doubt that wort might easily be cooled down to the

freezing point, if requisite, in our warmest summer weather.

Little can be said about the length of time during which the fermentation of the ale lasts, because it varies very much according to the heat of the weather, and the degree to which the wort has been cooled down. The following table will give some idea of the length of time which elapsed during the fermentations contained in the preceding tables :

FIRST TABLE.

1st, . . . . .	8 days.
2d, . . . . .	10
3d, . . . . .	10
4th, . . . . .	8
5th, . . . . .	9
6th, . . . . .	9
7th, . . . . .	10

SECOND TABLE.

1st, . . . . .	6 days.
2d, . . . . .	8
3d, . . . . .	9
4th, . . . . .	15
5th, . . . . .	10
6th, . . . . .	7
7th, . . . . .	7
8th, . . . . .	7

THIRD TABLE.

1st, . . . . .	9 days.
2d, . . . . .	5

The theory of fermentation has occupied the attention of chemists ever since the manufacture of ale began to be attended to by men of science, but it is only

of late that much light has been thrown upon the subject. Lavoisier was the first person who attempted to give any thing like a theory of this intricate process. He attempted to determine the composition of common sugar, a substance which may be fermented just as well as the soluble part of malt, and which yields similar products. He endeavoured, likewise, to determine the constituents of alcohol, the substance formed by fermentation. With these data, and with a knowledge of the composition of water and carbonic acid, he formed a plausible theory, which was valuable as a first approximation, though there can be little doubt that it was erroneous in every particular. Since that time, several experiments on the subject have been made by Thenard. Gay-Lussac and Thenard, and Berzelius, have determined the constituents of sugar with much care; and Theodore de Saussure has made very elaborate, and we believe accurate, experiments on the composition of alcohol. These facts will enable us to form a conception of what takes place during fermentation. We shall first state the general theory, as resulting from experiments on common sugar, and then give some experiments which we ourselves have made on the saccharine matter of malt.

• If a weak solution of sugar in water be kept in a warm place, it will ferment of itself, and be converted into a spiritous liquor. This we have tried more than once, and always successfully, provided the weather was warm. A solution of sugar of grapes in

water ferments still more speedily. This is said likewise to be the case with sugar of starch, and, of course, with the saccharine matter of malt. In our general view of fermentation, then, we may leave out of view the small quantity of yeast; because it is not absolutely necessary, but seems merely to render the effect more rapid, and, consequently, prevent the change of the liquid into acidity, which almost always takes place when the fermentation is slow.

When the fermentation is complete, the sugar disappears altogether, and two new substances are found in its place, namely, carbonic acid and alcohol. All that happens, then, is the resolution of sugar into the two new substances, carbonic acid and alcohol. It is requisite to know how much of each of these substances is formed from a given weight of sugar.

According to Lavoisier's experiments, 100 parts of sugar yielded, when fermented,

Alcohol, . . . . .	57·70
Carbonic acid, . . . . .	35·34

He does not give us the specific gravity of his alcohol, but it could scarcely be less than 0·825; for when his experiments were made, alcohol of greater strength was scarcely known. Now, such alcohol contains at least 11 per cent. of water, for that quantity has been actually extracted from it. From Saussure's experiments, it is probable that the real quantity of water contained in alcohol of the specific gravity 0·825, is 18·387 per cent., or almost a fifth. On

this supposition sugar, according to Lavoisier's experiments, yields

Alcohol, . . . . .	47·1
Carbonic acid, . . . . .	35·34
	<hr/>
	82·44

or, per cent.,

Alcohol, . . . . .	57·1
Carbonic acid, . . . . .	42·9
	<hr/>
	100·0

Thenard mixed 60 parts of yeast with 300 parts of sugar, and fermented the mixture at the temperature of 59°. He informs us that, in four or five days, all the saccharine matter had disappeared. The quantity of carbonic acid evolved amounted by weight to 94·6 parts. It was perfectly pure, being completely absorbed by water. The fermented liquid being distilled, yielded 171·5 parts of alcohol of the specific gravity 0·822. When the residue of the distillation was evaporated, 12 parts of a nauseous acid substance remained, and 40 parts of the yeast still continued unaltered in appearance, though Thenard assures us that it had lost the whole of its azote. Thus the products of the fermentations were,

Alcohol of 0·822, . . . . .	171·5
Carbonic acid, . . . . .	94·6
Nauseous residue, . . . . .	12·0
Residual yeast, . . . . .	40·0
	<hr/>
	318·1
Loss, . . . . .	41·9
	<hr/>
Total, . . . . .	360·0

• But as the nauseous residue and residual yeast nearly make up the quantity of yeast employed, let us consider only the products of decomposed sugar, supposing the loss to be proportionally divided between the carbonic acid and alcohol. Now, alcohol of the specific gravity 0·822 contains one-tenth of its weight of water, which can be separated from it; and if we suppose, with Saussure, that absolute alcohol contains 8·3 per cent. of water, then the products of sugar decomposed by fermentation, according to Saussure's experiments, are as follow :

Alcohol, . . . . .	47·70
Carbonic acid, . . . . .	35·34
	<hr/>
	83·04

or, in 100 parts,

Alcohol, . . . . .	57·44
Carbonic acid, . . . . .	42·56
	<hr/>
	100·00

This result approaches so nearly that of Lavoisier, that there is reason to suspect that the coincidence is more than accidental.

According to the experiments of Thenard and Gay-Lussac, sugar is composed of

Carbon, . . . . .	42·47
Oxygen and hydrogen, in the same proportion as in water, . . . . .	57·53
	<hr/>
	100·00

According to one analysis of Berzelius, it is composed of

Hydrogen, . . . . .	6·802
Carbon, . . . . .	44·115
Oxygen, . . . . .	49·083
	<hr/>
	100·000

and, according to another, of

Hydrogen, . . . . .	6·891
Carbon, . . . . .	42·704
Oxygen, . . . . .	50·405
	<hr/>
	100·000

Alcohol, according to the analysis of Saussure, is composed of

Hydrogen, . . . . .	13·70 or 3 atoms.
Carbon, . . . . .	51·98 or 2 atoms.
Oxygen, . . . . .	34·32 or 1 atom.
	<hr/>
	100·00

And carbonic acid is composed of

Carbon, . . . . .	27·3 or 1 atom.
Oxygen, . . . . .	72·7 or 2 atoms.

Hence it is obvious, that sugar can be resolved into alcohol and carbonic acid only on the supposition that it contains three atoms of oxygen, three atoms of carbon, and three atoms of hydrogen; proportions which do not accord with any of the analyses stated above. Supposing its composition to be so, the weight of each of the constituents per cent. is as follows:—

Hydrogen, . . . . .	6·66
Carbon, . . . . .	40·03
Oxygen, . . . . .	53·31
	<hr/>
	100·00

On this supposition, an integrant particle of sugar contains nine atoms, namely, three of oxygen, three of carbon, and three of hydrogen; which are capable of arranging themselves differently, so as to form an integrant particle of alcohol containing six atoms, and an integrant particle of carbonic acid containing three atoms.

An integrant particle of sugar is composed of

	Oxygen, 3 atoms.	Carbon, 3 atoms.	Hydrogen, 3 atoms.
A particle of alcohol of . . .	1	2	3
A particle of carbonic acid of	2	1	0
	3	3	3

The weight of a particle of alcohol is . . . 2·877

The weight of a particle of carbonic acid . . . 2·751

According to these numbers, 100 parts of sugar ought, by fermentation, to be decomposed into

Alcohol, . . . . .	50·76
Carbonic acid, . . . . .	49·24
	<hr/>
	100·00

or it ought to form very nearly equal weights of each of these constituents.

This explanation of fermentation, though in some points hypothetical, must be admitted to approach pretty near the experiments made upon the subject. These experiments are attended with so much difficulty, that rigid accuracy cannot be expected. In all likelihood, we can never arrive at the truth by

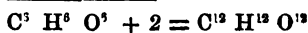
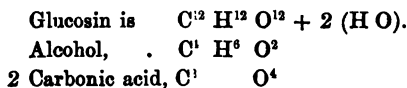
any other method than that which we have followed upon this occasion. Nor will this method be any longer doubtful, as soon as it is ascertained with precision, that sugar can be resolved into alcohol and carbonic acid, and as soon as we know the proportions of the two substances evolved. We conceive that both Lavoisier and Thenard have stated the quantity of carbonic acid too low, from not being aware that the whole of the sugar is never decomposed by fermentation. This we conclude from some experiments of our own, made on a large scale, of which we shall now proceed to give an account.

We have given the preceding details to make the reader aware of the chemists to whom the discovery of these important facts is owing. But the following mode of stating the case, for which we are indebted to Liebig, will probably be more easily understood.

1. Glucosin or starch-sugar is composed of 12 atoms carbon, 12 atoms hydrogen, 12 atoms oxygen, and 2 atoms water. Let us represent these atoms by  $C^{12} H^{12} O^{12} + 2 (H O)$ .

2. Alcohol is composed of 4 atoms carbon, 5 atoms hydrogen, 1 atom oxygen, and 1 atom water, represented by  $C^4 H^5 O + H O$ .

3. Carbonic acid is composed of 1 atom carbon and 2 atoms oxygen, represented by  $C O^2$ .



Thus, every atom of glucosin decomposed, is resolved into 2 atoms alcohol and 2 atoms carbonic acid.

Nine different brewings of pure malt were made. The worts were weak, and they were fermented as strongly as possible by means of large quantities of yeast, added at intervals, as is practised by the distillers. The following table exhibits the specific gravity of these worts before and after the fermentation was over:—

Specific Gravity of the Wort.	Specific gravity of Wort after fermentation.
1·040 . . . . .	1·0014
1·056 . . . . .	1·0016
1·050 . . . . .	1·000
1·0492 . . . . .	1·0012
1·0465 . . . . .	1·0045
1·045 . . . . .	1·0047
1·0465 . . . . .	1·0007
1·051 . . . . .	1·0007
1·0524 . . . . .	1·0004

From this table we see, that only one of the worts was reduced by fermentation so low as the specific gravity of pure water. As a good deal of alcohol was evolved in each by the fermentation, it is obvious that they must have all contained a certain portion of saccharine matter undecomposed, notwithstanding the violence of the fermentation, which elevated the temperature of the worts more than 50°. On evaporating a portion of the worts of each of these brewings, we obtained a quantity of undecomposed saccharine matter, which amounted, at an average, to

H

one-fifth of the quantity originally present. At first they contained, on an average, 45 lbs. per barrel of saccharine matter. The *spent wash*, after distillation, contained still 9 lbs. per barrel. This liquor was capable of being fermented a second time, and of yielding more spirits.

But as these worts were very weak, and as they were fermented in very advantageous circumstances, and in much greater quantities than either Lavoisier or Thenard could have employed in their experiments, we do not conceive that more than four-fifths of the sugar which they employed in their experiments could have been decomposed. Now, if to the carbonic acid actually developed in their trials we add a fifth part, the number will approach very nearly to the one which we have deduced from the supposition that sugar is decomposed by fermentation into an integrant part of alcohol and an integrant part of carbonic acid.

On comparing the quantity of alcohol of 0.825 obtained in our experiments from the quantity of saccharine matter actually decomposed by fermentation, the result was, that 100 parts of saccharine matter yielded almost exactly 50 parts of such alcohol. This would amount to about 40.9 parts of real alcohol. There can be no doubt that a portion of the alcohol was lost during the distillation, which was conducted in the rapid way followed some years ago by the distillers in Scotland. If we suppose one-fifth to have been lost, which is probably not much beyond the

truth, the real produce of alcohol from the saccharine matter of malt would be almost exactly one-half of its weight, which it ought to be, according to the preceding supposition that it is decomposed into alcohol and carbonic acid.

When the fermentation is languid, it is customary to beat in the yeast which has collected on the top; that is to say, the whole is stirred till the wort and yeast are thoroughly mixed.

In practice it may be observed, that the two methods of fermentation in brewing ales by putting the worts to the yeast at high and low heats, is worthy of the brewer's attention who desires to produce ales of the finest quality.

In slow fermentation, the degree of heat at which the wort is pitched is from  $50^{\circ}$  to  $55^{\circ}$ . When the gyle comes to a head, the yeast that forms on the surface is beat in, and this process continues from nine to twelve days. When the ale is judged to be sufficiently attenuated, it is run from beneath the yeast into barrels.

In quick fermentation, the wort is mixed with yeast at from  $60^{\circ}$  to  $65^{\circ}$  of heat. The yeast is allowed to form on the head of the gyle, and gives out carbonic acid until it begins to turn viscid, and tends to sink down through the wort. This takes place in from thirty-six to forty-eight hours. It is then mixed well in the gyle, and run into barrels, where it ferments, and works over for forty-eight hours, requiring to be regularly filled up at first every two hours,

for the first twelve hours, then every four hours, until it gradually comes to yeast, and ceases working out of the barrels.

Thus there are two distinct methods of fermentation. The quick fermentation is that by which porter is made, and ale generally, throughout England. The slow fermentation is the practice in brewing ale in Edinburgh and in Scotland. In both methods, the decomposition of the glucosin, and the formation of alcohol, go on until the ale is finished, and either run into barrels, as in Edinburgh, or until the fermentation ceases in the barrels, as in England. This latter is the proper term for *cleansing*. English brewers, in general, know nothing about attenuation. Their practice of fermenting at a high heat forces on the gyle so rapidly, that as soon as ready, which is within 48 hours, they must run the wort into barrels, to check the heat and bring it to cleanse into yeast, which does not begin to form until 12 or 14 hours after the wort is first run into barrels. The repeated filling of the barrels as the wort flows out, being equivalent to the beating in of the head of the yeast for some days by the Scotch brewers.

Edinburgh brewers attenuate their high-priced bottled ales as low as they can carry it with safety, for the purpose of making it keep. The weak draught ale is not attenuated so much. This gives it a fullness to the taste.

In the year 1835, a practical treatise on brewing and storing of beer was published by Mr William

Black. This book, as Mr Black informed us, was the result of forty years' experience as a practical brewer. It contains many sensible observations. His theory of fermentation is imperfect, from the state of our knowledge. The souring of ale during its fermentation, which sometimes takes place, he ascribes to electricity. I have never had an opportunity of verifying or refuting this opinion. Should it be true, the souring ought to be prevented by forming a communication between the fermenting beer and the moist ground, by means of a copper, brass, or iron wire.

Mr Black considers, that when the first mash is judiciously made, the temperature of the water for the second mash is of very little consequence. He says of the heat of the worts, as they flow from the first mash, any temperature between  $138^{\circ}$  and  $152^{\circ}$  will answer, and recommends, as a good mean for pale beer,  $145^{\circ}$ . For brown beer the temperature should be from  $138^{\circ}$  to  $145^{\circ}$ , and to obtain these heats, that  $175^{\circ}$  for the first mash of pale malt will generally make the worts flow within the given range; and  $160^{\circ}$  to  $165^{\circ}$ , for brown beer, will do the same.

5. The last step of the process of brewing is called *cleansing*. When the violence of the fermentation is over, the head of yeast which covers the top of the fermenting-tun diminishes in height by the gradual escape of the carbonic acid gas, which heaved it into bubbles. If the wort were allowed to remain in the gyle-tun after this has happened, the yeast would again mix with it; and the consequence would be a disagreeable bitter taste, known among brewers by

the name of *yeast bitter*. The fermentation would likewise continue, though in a languid manner, and the ale would soon run into acidity. These accidents are prevented by drawing off the ale into small casks. And this is called *cleansing*. The casks are filled quite full, and left with their bungs open. The drawing off of the ale from the gyle-tun lowers its temperature, and, of course, checks the fermentation. On this account the cleansing is sometimes practised in summer when the elevation of temperature in the wort is at its height.

We have repeatedly observed a curious circumstance during the cleansing, not very easily accounted for. If we take the temperature of the ale at the upper surface of the gyle-tun, and then observe the temperature of the ale when it flows from the stop-cock at the bottom of the tun, we shall generally find it one or two degrees hotter in this latter place than at the former. We ought naturally to expect the highest temperature at the top of the gyle-tun.

The ale still continues to ferment after it is put into the small casks; but as these casks are always kept full, the yeast, as it comes to the surface, flows out at the bung, and thus separates altogether from the beer. It is this separation that has induced brewers to distinguish it by the name of *cleansing*. In these casks, then, the yeast divides itself into two portions. The greatest part rises up with the carbonic acid evolved, and flows out at the bung-hole; while another portion subsides to the bottom, and constitutes what is called the dregs of the beer. It

is essential to the cleansing that the casks should be always full, otherwise the yeast will not run off, and the beer will not become transparent. This object is accomplished in small breweries by a man constantly going round, and filling up the casks as they *work down*. But in the London breweries there is an ingenious mechanical contrivance which answers the purpose perfectly.

When the fermentation has subsided, the beer will in general be found transparent. It is bunged up in the casks, and preserved for sale; or in London, where the quantity is too great for this, the beer is removed into large stone vats, capable of holding several thousand barrels, from which it is gradually distributed to the consumers.

In London, where the beer is usually sent to the public-houses as soon as the fermentation is over, and before it has had time to become fine, it is usual to send along with it a quantity of *finings*, as it is called, that is, a solution of isinglass in weak sour beer, made from a fourth mash of the same malt. The publican puts a certain quantity of this into every cask. It forms a kind of web at the surface of the liquid; and, gradually sinking to the bottom, carries with it all the flocculent matter, and leaves the beer transparent.

We shall terminate this chapter with a table exhibiting the results obtained by brewing with malt made from a considerable number of different varieties of barley and big.

GRAIN. <i>First Quality.</i>	Weight per Bushel. lbs.	Bushels of Malt used.	Weight of Malt per Bushel. lbs.	Wort in Barrels.	Specific Gravity of Worts.	Lbs. per Barrel of Dry Ex- tract.	Total Quantity of Dry Extract.	Solid Ex- tract from a Bushel of lbs. Avoir- dupois.	Solid Ex- tract from a Bushel of Raw Grain.	Solid Ex- tract from 1 lb. of Raw Grain.
<b>ENGLISH.</b>										
Norfolk.....	50-375	60	36-58	{ 10-611 7-305	1-106 1-039	{ 99-2 35-25	1364-89	22-748	24-91	0-485
Norfolk.....	50-375	47-5	36-58	{ 11-131 9-176	1-104 1-108	{ 97-25 101.	1071-36	22-588	24-70	0-4843
Norfolk.....	50-375	55	36-58	{ 9-166 14-77	1-029 1-084	{ 25-5 78-125	1153-23	20-976	22-96	0-4563
Norfolk.....	50-375	60	38-4	{ 7-972 8-566	1-106 1-030	{ 99-06 26-56	1368.	22-8	23-84	0-4733
Norfolk.....	50-375	55	38-4	{ 3-38 10-583	1-014 1-1197	{ 11-25 112-5	1220-7	22-19	23-20	0-4406
Suffolk.....	50-508	72	40-56	{ 8-527 3-55	1-044 1-0124	{ 40-6 10-0	1798-46	24-98	25-39	0-5027
Kent.....	49-750	60	34-88	{ 10-733 7-417	1-104 1-033	{ 97-25 29-25	1325-84	22-095	24-58	0-4941
Kent.....	49-914	50	35-76	{ 4-465 8-954	1-018 1-106	{ 14-75 99-2	1139-52	22-79	24-22	0-4863
Kent.....	49-032	81-875	35-44	{ 7-305 2-717	1-032 1-019	{ 28-25 15-5	2037-86	24-889	27-06	0-5431
				{ 11-488 16-222	1-117 1-049	{ 110. 45-25				
Average.....	50-208		37-02	{ 2-673	1-008	{ 6-5		22-894	24-54	0-4803







GRAIN. Second Quality.	Weight per Bushel. lbs.	Bushels of Malt used.	Weight of Malt per Bushel. lbs.	Wort in Barrels.	Specific Gravity of Worts.	Lbs. per Barrel of Dry Ex- tract.	Total Quantity of Dry Extract.	Solid Ex- tract from a Bushel of Malt in lbs. A voidu- pols.	Solid Ex- tract from a Bushel of Raw Grain.	Solid Ex- tract from a 1 lb. of Raw Grain.
<i>Big.</i> Kirkcudbright.....	46-875	60	36-40	15-621 { 9-934 9-611	1-082 1-109	76-4 102	1210-62	20-177	20-428	0-4368
Kirkcudbright...	46-875	72	36-40	{ 13-388 4-138	1-047 1-075	{ 43-25 70	1441-37	20-019	20-268	0-4324
Ayr.....	47-937	50	37-83	{ 14-5 10-694	1-011 1-105	{ 9-37 98-44	1062-66	21-283	21-483	0-4481
Ayr.....	47-937	98	37-83	{ 11-111 7-277	1-041 1-1028	{ 37-5 96-9	2111-22	21-543	21-560	0-4497
Angus.....	47-392	72	38-57	{ 10-083	1-006	5	1565-06	21-737	20-552	0-4337
Average.....	47-408		37-40					20-946	20-868	0-4399



GRAIN. Second Quality.	Weight per Bushel. lbs.	Bushels of Malt used.	Weight of Malt per Bushel. lbs.	Wort in Barrels.	Specific Gravity of Worts.	Lbs. per Barrel of Dry Ex- tract.	Total Quantity of Dry Extract.	Solid Ex- tract from a Bushel of Malt in lbs. Avoirdu- pois.	Solid Ex- tract from a Bushel of Raw Grain.	Solid Ex- tract from a l. lb. of Raw Grain.
<i>Big.</i> Kirkcudbright.....	46.875	60	36.40	15.621 { 9.934 9.611	1.082 1.109	76.4 102	1210.62	20.177	20.428	0.4358
Kirkcudbright.....	46.875	72	36.40	13.388 { 4.138 14.5	1.047 1.075	43.25 70	1441.37	20.019	20.268	0.4324
Ayr.....	47.937	50	37.83	10.694 { 11.111 7.277	1.011 1.105	9.37 98.44	1062.66	21.253	21.483	0.4481
Ayr.....	47.937	98	37.83	10.083 { 10.083	1.041 1.1028	37.5 95.9	2111.22	21.543	21.560	0.4497
Angus.....	47.392	72	38.57		1.006	5	1565.06	21.737	20.552	0.4337
Average.....	47.403		37.40					20.946	20.868	0.4399



GRAIN. Third Quality.	Weight per Bushel. lbs.	Bushels of Malt used.	Weight of Malt per Bushel. lbs.	Wort in Barrels.	Specific Gravity of Wort.	Lbs. per Barrel of Dry Extract.	Total Quantity of Dry Extract.	Solid Extract from a Bushel of Malt in lbs. Avordupois.	Solid Extract from a Bushel of Raw Grain.	Solid Extract from a 1 lb. of Raw Grain.
<b>SCOTCH.</b>										
Haddington .....	48-969	72	36-816	$\left\{ \begin{array}{l} 10-123 \\ 8-028 \\ 3-441 \end{array} \right.$ $\left\{ \begin{array}{l} 10-012 \\ 8-916 \\ 0-995 \end{array} \right.$ $\left\{ \begin{array}{l} 14-000 \\ 5-916 \\ 4-75 \end{array} \right.$	1-103 1-047 1-021 1-112 1-071 1-011 1-086 1-039 1-0088	$\left. \begin{array}{l} 96-4 \\ 43-25 \\ 17-4 \end{array} \right\}$ $\left. \begin{array}{l} 105 \\ 66 \\ 9 \end{array} \right\}$ $\left. \begin{array}{l} 80 \\ 35-3 \\ 6-9 \end{array} \right\}$	1390-45	19-311	19-617	0-4008
Haddington .....	48-969	72	36-816				1647-08	23-014	23-378	0-4774
Berwick .....	48-854	72	37-312				1490-51	20-802	20-233	0-4141
Average .....	48-930		36-98					20-976	21-076	0-4307
<i>Big.</i>										
Kirkcudbright.....	44-722	67-75	35-031	$\left\{ \begin{array}{l} 13-083 \\ 6-25 \\ 8-472 \end{array} \right.$ $\left\{ \begin{array}{l} 13-048 \\ 5-125 \end{array} \right.$ $\left\{ \begin{array}{l} 10-083 \\ \dots \\ 3-12 \end{array} \right.$	1-1037 1-037 1-0047 1-0865 ... 1-004	$\left. \begin{array}{l} 99-68 \\ 33-43 \\ 3-75 \end{array} \right\}$ $\left. \begin{array}{l} 80-025 \\ \dots \\ 3-12 \end{array} \right\}$	1481-78	21-871	20-688	0-4621
Kirkcudbright.....	44-722	68	35-031				1306-86	19-219	18-161	0-4061
Average .....	44-722		35-031					20-545	19-414	0-4341

## CHAPTER V.

## OF ALE AND BEER.

The English word *ale* is obviously the same with the Swedish word *öl*, which is applied to the same kind of fermented liquor; while the word *beer* is synonymous with the German *bier*. These two words in Great Britain are applied to two liquors obtained by fermentation from the malt of barley; but they differ from each other in several particulars. Ale is light-coloured, brisk, and sweetish, or at least free from bitter; while beer is dark-coloured, bitter, and much less brisk. What is called *porter* in England is a species of beer, and the term *porter* at present signifies what was formerly called *strong beer*. The original difference between these two liquids was owing to the malt from which they were prepared. Ale malt was dried at a very low heat, and consequently was of a pale colour; while beer or porter malt was dried at a higher temperature, and had of consequence acquired a brown colour. This incipient charring had developed a peculiar and agreeable bitter taste, which was communicated to the beer along with the dark colour. This bitter taste rendered beer more agreeable to the palate, and less injurious to the constitution, than ale. It was consequently

manufactured in greater quantities, and soon became the common drink of the lower ranks in England. When malt became high priced in consequence of the heavy taxes laid upon it, and the great increase in the price of barley which took place during the war of the French revolution, the brewers found out that a greater quantity of wort of a given strength could be prepared from pale malt than from brown malt. The consequence was, that pale malt was substituted for brown malt in the brewing of porter and beer. We do not mean that the whole malt employed was pale, but a considerable proportion of it. The wort, of course, was much paler than before, and it wanted that agreeable bitter flavour which characterised porter, and made it so much relished by most palates. The porter brewers endeavoured to remedy these defects by several artificial additions. They prepared an artificial colouring matter, by heating a solution of coarse sugar in an iron boiler till it became black, and was reduced to the consistency of treacle. The smoke issuing from it was then set on fire, and the whole was allowed to burn for about ten minutes, when the flame was extinguished by putting a lid on the vessel. This substance was mixed with a certain quantity of water before it was cold. The porter is coloured by adding about two pounds of this colouring matter for every barrel of wort while in the copper. Some brewers make their colouring matter with infusion of malt instead of sugar; and, in 1809, M. de Roche took out a patent for preparing the colouring

matter from the husks of malt, by burning them like coffee, and then infusing them in water. We believe that all these colouring matters are of the same nature; of course the brewer ought to employ that one of them which is cheapest.

To supply the place of the agreeable bitter which was communicated to porter by the use of brown malt, various substitutes were tried. Quassia, cocculus indicus, and we believe even opium, were employed in succession; but none of them were found to answer the purpose sufficiently. Whether the use of these substances be still persevered in we do not know, but we rather believe that they are not, at least by the London porter brewers.

It was this change in the use of the malt which occasioned the great falling off in the London porter, which has been so much complained of, and ascribed to so many causes. We do not believe that the schemes of Mr Jackson, of notorious memory, though they enriched himself, produced the injurious effects upon the London breweries that have been ascribed to them. This man, whose character was notorious, kept an apothecary's shop on Tower-Hill; and speculating on the means of amassing a speedy fortune, he hit upon the idea of brewing beer from various drugs instead of malt and hops. But instead of commencing practical brewer himself, he struck out the more profitable trade of teaching his process to the London brewers. Mrs Piozzi informs us, that even from one great brewer he contrived to realise an

ample fortune. His methods must have been practised upon a considerable scale for some time ; but we have no doubt that they have been all abandoned long ago. It was the French war, and the enormous tax upon malt, that was the real cause of the deterioration of the quality of London porter, nor will it ever recover its former good qualities, till the tax on malt is reduced to its former rate ; or unless the price of porter be greatly enhanced, which is not likely to happen. We have sometimes thought that if quassia were reduced to powder, and burnt like coffee, it might probably be employed with great advantage, both as a colouring matter of porter, and as likely to furnish the agreeable bitter, at present considered as peculiar to brown malt.

The quantity of malt employed annually in Great Britain, in brewing ale and beer, may be easily deduced from the annual statements of the amount of the malt-tax, printed by order of the House of Commons.

The following tables will shew the quantities of malt made in England and Wales, Scotland, and Ireland, from the year 1833, with the amount of revenue received thereon, and the rates of duty in each year ; also the amount of duties on malt and hops, and the quantities used in the United Kingdom from 1843, with the number of licensed brewers, and amount of duties thereon for the year 1846.

*Account of the Quantities of Malt charged with Duty in England and Wales, of the Revenue received thereon, and of the Rates of Duty, in each year, from 1833.*

Years.	Number of Bushels of Malt.	Amount of Duty.		Rate of Duty per Bushel.	
		£	s. d.	s. d.	
1833	33,789,010	4,364,413	15 10	2 7	
1834	34,449,646	4,449,745	0 0	.....	
1835	36,078,855	4,660,185	0 0	.....	
1836	37,196,998	4,804,612	0 0	.....	
1837	33,692,356	4,351,929	8 3	.....	
1838	33,823,985	4,368,931	8 8	.....	
1839	33,826,016	4,369,193	14 8	.....	
1840	36,653,442	4,841,229	18 0	2/7 and 5 per cent.	
1841	30,956,394	4,198,460	18 4	.....	
1842	30,796,262	4,176,742	19 0	.....	
1843	30,891,000	4,189,592	0 9	.....	
1844	31,856,563	4,320,546	8 4½	.....	
1845	30,508,942	4,137,774	12 11½	.....	
1846	35,723,774	4,845,050	7 2½	.....	

*Account of the Quantities of Malt charged with Duty in Scotland, of the Revenue received thereon, and of the Rates of Duty, in each year, from 1833.*

Years.	Number of Bushels of Malt.	Amount of Duty.	Rate of Duty per Bushel.	
			From Barley.	From Big.
		£	s. d.	s. d.
1833	4,302,036	530,358	2 7	2 0
1834	4,491,292	553,567	.....	.....
1835	4,459,553	551,096	.....	.....
1836	4,903,187	611,910	.....	.....
1837	4,583,045	578,515	.....	.....
1838	4,419,141	557,913	.....	.....
1839	4,360,363	552,107	.....	.....
1840	4,397,304	572,544	{ 2/7 and 5 per cent.	{ 2s. and 5 per cent.
1841	4,058,249	539,572	.....	.....
1842	3,786,476	503,829	.....	.....
1843	3,618,606	481,310	.....	.....
1844	3,889,442	516,053	.....	.....
1845	4,353,036	577,497	.....	.....
1846	4,584,666	609,165	.....	.....

*Account of the Quantities of Malt charged with Duty in Ireland, of the Revenues received thereon, and of the Rates of Duty, in each year, from 1833.*

Years.	Number of Bushels of Malt.	Amount of Duty.	Rate of Duty per Bushel.	
			From Barley.	From Big.
		£	s. d.	s. d.
1833	1,984,849	245,987	2 7	2 0
1834	2,204,653	272,291	.....	.....
1835	2,353,645	288,602	.....	.....
1836	2,287,635	283,357	.....	.....
1837	2,275,347	286,470	.....	.....
1838	2,262,440	284,954	.....	.....
1839	1,744,550	218,508	.....	.....
1840	1,406,116	178,703	{ 2/7 and 5 per cent.	{ 2s. and 5 per cent.
1841	1,149,692	151,210	.....	.....
1842	1,268,656	168,009	.....	.....
1843	1,184,278	157,048	.....	.....
1844	1,441,173	190,461	.....	.....
1845	1,684,110	222,700	.....	.....
1846	1,788,643	236,939	.....	.....

Since the repeal of the beer-duties in 1830, no regular return has been given of the quantities of beer manufactured by the great London houses; but we may form an estimate approaching nearly to the truth, from the quantities of malt annually consumed. Taking thirty-six of the largest breweries of London and vicinity, we find the annual returns to be 700,000 quarters of malt; and, calculating that  $2\frac{1}{2}$  barrels of strong beer are produced from each quarter, the quantity of porter and ale will amount to 1,925,000 barrels. Averaging 7 lbs. of hops for each quarter of malt, the quantity of the former amounts to 4,900,000 lbs. These numbers will afford the general reader some idea of the immense trade of the London breweries.

*Amount of Duties on Malt and Hops charged in England and Wales, and in Scotland and Ireland, on Malt and Bear, or Big, from the Year 1843 to the Year 1846.*

	Quantities Charged.				Amount of Duty.			
	1843.	1844.	1845.	1846.	1843.	1844.	1845.	1846.
	Lbs. Bushels.	Lbs. Bushels.	Lbs. Bushels.	Lbs. Bushels.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
<b>ENGLAND.</b>								
Hops.....	27,862,730	29,285,093	32,974,750	50,704,029	243,796 8 1½	256,243 0 5½	288,526 10 5½	443,657 9 6
Malt from Barley,	30,891,000	31,866,563	30,508,942	35,723,774	4,189,592 0 9	4,320,546 8 4½	4,137,774 12 11½	4,845,050 7 2½
<b>SCOTLAND.</b>								
Malt from Barley,	3,309,610	3,515,463	3,932,363	4,172,256	448,865 18 3½	476,784 19 6½	535,326 17 7½	565,862 8 6½
Malt from Bear } or Big.....	308,996	373,979	420,673	412,410	32,444 13 3½	39,267 18 4½	44,170 16 9½	43,303 3 9½
<b>IRELAND.</b>								
Malt from Barley,	1,067,717	1,277,975	1,497,735	1,604,311	144,809 7 8	173,325 13 8½	203,130 11 6	217,584 16 7½
Malt from Bear } or Big.....	116,561	163,198	185,375	184,332	12,239 0 4½	17,136 0 5½	19,569 9 5½	19,354 16 4½
<b>UNITED KING- DOM.</b>								
Hops.....	27,862,730	29,285,093	32,974,750	50,704,029	243,796 8 1½	256,243 0 5½	288,526 10 5½	443,657 9 6
Malt from Barley,	35,268,327	36,650,001	35,939,040	41,500,341	4,783,267 6 8½	4,970,657 1 7½	4,874,232 2 1	5,525,497 12 4½
Malt from Bear } or Big.....	425,557	537,177	607,048	596,742	44,683 13 8	56,403 18 10½	63,740 6 2½	62,658 2 2½

*Number of Licensed Brewers in the United Kingdom in 1846, with annual extent of the Number of Barrels of Strong Beer Brewed, and amount of License Duty thereon.*

	Number of Licensed Brewers in 1846.			Amount of License Duty.		
	England.	Scotland.	Ireland.	England.	Scotland.	Ireland.
	Brewers of Strong Beer, not exceeding 20 barrels.....	7,501	61	15	£3,938 0 6	£32 0 6
Exceeding 20 and not exceeding 50, .....	7,909	8	...	8,304 9 0	8 8 0	.....
..... 50 .....	9,229	26	2	14,535 13 6	40 19 0	3 3 0
..... 100 .....	16,518	136	21	34,687 16 0	285 12 0	44 2 0
..... 1000 barrels.....	1,589	100	74	15,868 2 6	953 13 3	1116 13 6
Brewers of Table-Beer.....	195	31	3	151 4 0	44 2 0	3 13 6
Retail Brewers under the Act 5th Geo. IV, c. 54.....	17	24	2	93 14 3	132 6 0	11 0 6

The usual limits of the wort of strong ale in this country may be stated at from 60 to 120 pounds per barrel, or from the specific gravity 1·064 to 1·11275 at the temperature of 60°. The highest-priced ales also are not always the strongest, because the price depends in a great measure on the reputation of the brewer. The fermentation of ale is not carried far; and the consequence is, that a considerable portion of the saccharine matter still remains in the liquid, apparently unaltered. By means of the infusion of nutgalls, too, traces of starch may be still detected in strong ale, even after it has been kept for some time in bottles. The following table exhibits the original strength of the wort before the fermentation began, and likewise the diminution of specific gravity produced by the fermentation, or the *attenuation*, as this diminution is termed by brewers and distillers.

No arbitrary rule, however, can be laid down for the attenuation of the wort during the process of fermentation, as that must depend on the views of the brewer. Within the last five years, the Edinburgh brewers have not carried the attenuation of their ales, especially of that made to be used as draught, so far down as formerly. But, in all cases, regard must be had to the time the ale is intended to be kept, and the season of the year.

Original Specific Gravity of the Wort.	Lbs. per Barrel of Saccharine Matter in it.	Specific Gravity of the Ale.	Lbs. per Barrel of Saccharine Matter in it.	Attenuation or proportion of Saccharine Matter decomposed.
1-095	88-75	1-050	46-25	0-478
1-0918	85-62	1-042	38-42	0-552
1-0829	78-125	1-0205	16-87	0-787
1-08625	80-625	1-0236	20-00	0-757
1-078	73-75	1-028	24-25	0-698
1-070	65-00	1-0285	25-00	0-615
1-10025	93-75	1-040	36-25	0-613
1-1025	95-93	1-042	38-42	0-6
1-0978	91-56	1-03075	27-00	0-705
1-0956	89-37	1-0358	32-19	0-640
1-113	105-82	1-0352	31-87	0-661
1-1092	102-187	1-0302	26-75	0-605
1-1171	110-0	1-040	36-25	0-669
1-103	96-4	1-0271	23-42	0-757
1-066	61-25	1-0214	17-8	0-709

As a certain quantity of alcohol is evolved in the ale by the fermentation, it is obvious that the last column is not quite accurate. The real quantity of saccharine matter in each of these also must be greater than what is indicated in that column, because the effect of the saccharine matter, in increasing the specific gravity of the ale, is counteracted by the alcohol, which tends to diminish that specific

gravity. By casting the eye over the preceding table, it will be seen that the attenuation does not follow the ratio of the strength. It was greatest of all in the third, and least in the first brewing. These brewings being the same with those given in the fourth chapter, in order to illustrate the quantity of yeast used in fermenting, the reader, by comparing the two tables together, will be able to form some conclusions respecting the effect of different quantities of yeast, and different temperatures, upon the attenuation of strong ale.

Porter is much weaker than strong ale. The average specific gravity of porter wort, according to Shannon, as deduced by the saccharometer, is 1.0645, which indicates 60 lbs. per barrel of saccharine extract. Hence the reason why it is so much less glutinous and adhesive than strong ale. The fermentation which porter undergoes is, we believe, much less than that of ale; but we have no very accurate information on the subject. According to the experiments of Mr Brande, brown stout, which is the strongest porter made in London, contains 6.8 per cent. by measure, of alcohol of the specific gravity 0.825. If he had given us the specific gravity of this porter before distillation, it would have enabled us to determine in some measure the error in the attenuation, as indicated by the saccharometer.

The porter brewers in London use three kinds of malt; namely, pale malt, amber malt, and brown malt. These three are mashed separately, and the

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worts from each are afterwards mixed together in the same fermenting vessel. In some breweries, as in that of Barclay and Perkins in the Borough, there are three separate mash-tuns. In other breweries, the custom is to mash one kind of malt the first day, another kind the second day, and a third kind the third day. The first day's wort is put into the fermenting-vessel, and mixed with yeast; and the other two worts are added to it successively as they are formed. Hence it is very difficult to determine with accuracy the strength of the worts in the London breweries. It could only be done by knowing the quantity of wort from each mash, and its specific gravity when let into the fermenting-vessel. We have had an opportunity of determining the strength of the porter wort in all the principal breweries in London. The average specific gravity of brown-stout wort is 1.0624. The wort of the best common porter is of the specific gravity 1.0535, that of the worts of the weakest is as low as 1.0374. The average specific gravity deduced from twenty brewings was 1.0500. Such wort contains about 46.4 lbs. per barrel of saccharine matter. Judging from the taste of some of the worts, quassia seems to be employed in considerable quantity by some of the brewers, and much more sparingly, if at all, by others. The fermentation of porter is carried on with considerable rapidity, so that it is over in two or three days. The specific gravity of the porter is usually brought down to 1.013 or 1.017. The specific gravity of the best

brown stout, after standing some months in the bottle, is 1·0106. The proportion of pale and brown malt used in the different houses varies. One of the best brewers in London uses nearly two parts pale malt to one part brown.

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## EXPLANATION OF THE PLATES.

Figs. 1 and 2, Plates I. and II., explain the arrangement of the utensils and machinery in a porter brewery, on the largest scale; in which, however, it must be observed, that the elevation, fig. 1, is in a great degree imaginary as to the plane upon which it is taken; but the different vessels are arranged so as to explain their uses most readily, and at the same time to preserve, as nearly as possible, the relative positions which are usually assigned to each in works of this nature.

The malt for the service of the brewery is stored in vast granaries or malt-lofts, usually situated in the upper part of the buildings. Of these, we have only been able to represent one at A, fig. 1; the others, which are supposed to be on each side of it, cannot be seen in this view. Immediately beneath the granary A is the mill, in the upper floor of which are two pairs of rollers for bruising or crushing the grains of the malt. (An enlarged representation of the rollers is given in Plate III., figs. 3 and 4.) In the floor beneath the rollers are the mill-stones *b b*, where

the malt is sometimes ground, instead of the simple bruising which it receives by passing between the rollers.

The malt, when prepared, is conveyed by a trough into a chest *d*, from which it can be elevated by the action of a spiral screw *e* (see also Plate III., figs. 5 and 6) into the large chest or bin B, for ground malt, situated immediately over the mashing-tun D. The malt is reserved in the bin till wanted, and it is then let down into the mashing-tun, where the extract is obtained by hot water supplied from the copper G.

The water for the service of the brewery is obtained from the well E, by a lifting-pump, worked by the steam-engine; and the forcing-pipe *f* of this pump conveys the water up to the large reservoir or waterback F, placed at the top of the engine-house. From this cistern iron pipes are laid to the copper G, and also every part of the establishment, where cold water can be wanted for cleaning and washing the vessels. The copper G can be filled with cold water by only turning a cock; and the water, when boiled therein, is conveyed by the pipe *g* into the mashing tun D. It is introduced beneath a false bottom, upon which the malt lies, and, rising up through the holes in the false bottom, it extracts the saccharine matter from the malt; a greater or less time being allowed for the infusion, according to circumstances. The instant the water is drawn off from the copper, fresh water must be let into it, in order to be boiled,

ready for the second mashing; because the copper must not be left empty for a moment, otherwise the intense heat of the fire would melt the bottom. For the convenience of thus letting down at once as much liquor as will fill the bottom of the copper, a pan or second boiler is placed over the top of the copper, as seen in Plate V., fig. 10; and the steam rising from the copper, communicates a considerable degree of heat to the contents of the pan, without any expense of fuel. This will be more minutely explained hereafter.

During the process of mashing, the malt is agitated in the mash-tun, to expose every part to the action of the water. This is done by a machine contained within the mash-tun, and put in motion by the horizontal shaft H, leading from the mill. The mashing-machine is shewn in Plate IV., fig. 8: When the mashing is finished, the wort or extract is drained down from the malt, into a vessel I, of similar dimensions to the mash-tun, and situated immediately beneath, from which it is called the underback. Here the wort does not remain longer than is necessary to drain off the whole of it from the tun above. It is then pumped up by the three-barrelled pump *k*, into the pan at the top of the copper, by a pipe which cannot be seen in the plate.

The wort remains in the copper pan until the water for the succeeding mashes is discharged from the copper. But this waiting is no loss of time, because the heat of the copper, and the steam arising

from it, makes the wort, which had become cooler, ready for boiling. The instant the copper is empty, the wort is let down from the pan into the copper, and the second wort is pumped up from the under-back into the copper pan. The proper proportion of hops is thrown into the copper through the near hole, and then the door is shut down, and screwed fast, to keep in the steam, and cause it to rise up through pipes into the pan; and by bubbling up through the wort in the pan, it communicates so much heat that it is soon ready for boiling in its turn; for it is to be observed, that the different worts follow each other through all the different vessels with the greatest regularity, so that there is no loss of time, but every part of the apparatus is constantly employed. When the boiling of the wort has continued a sufficient time to coagulate the grosser part of the extract, and to evaporate part of the water, the contents of the copper are run off through a large cock into the jackback K, which is a vessel of sufficient dimensions to contain it, and provided with a bottom of cast-iron plates, perforated with small holes, through which the wort drains, and leaves the hops. The hot wort is drawn off from the jackback through the pipe *h* by the three-barrelled pump, which throws it up to the coolers L, this pump being made with different pipes and cocks of communication, to serve all the purposes of the brewery, except that of raising the cold water from the well. The coolers L are very shallow vessels, built over one another in seve-

ral stages; and that part-of the building in which they are contained is built with open lattice-work on all sides, to admit the free current of air. When the wort is sufficiently cooled to be put to the first fermentation, it is conducted in pipes from all the different coolers to the large fermenting-vessel or gyle-tun M, which, with another similar vessel behind it, is of sufficient capacity to contain all the beer of one day's brewings.

When the first fermentation is concluded, the beer is drawn off from the great fermenting-vessel M into the small fermenting-casks or cleansing-vessels N, of which there are a great number in the brewery. They are placed four together, and to each four a common spout is provided, to carry off the yeast, and conduct it into the troughs *u* placed beneath. In these cleansing-vessels the beer remains till the fermentation is completed, and it is then put into the store-vats, which are casks or tuns of an immense size, where it is kept till wanted, and is then drawn off into barrels and sent away from the brewery. The store-vats are not represented in the plate, but are of a conical figure, and of different dimensions, from fifteen to forty feet diameter, and usually twenty feet in depth. The steam-engine which puts all the machinery in motion is explained by the figure. On the axis of the large fly-wheel is a bevelled cog-wheel, which turns another similar wheel upon the end of a horizontal shaft, which extends from the engine-house to the great horse-wheel, which it turns by

means of a cog-wheel. The horse-wheel puts in motion all the pinions for the mill-stones *b b*, and also the horizontal axis which works the three-barrelled pump *k*. The rollers *a a* are turned by a bevelled wheel upon the upper end of the axis of the horse-wheel, which is continued for that purpose; and the horizontal shaft *H*, for the mashing-engine, is driven by a pair of bevelled wheels. There is likewise a sack-tackle, which is not represented. It is a machine for drawing up the sacks of malt from the court-yard to the highest part of the building, whence the sacks are wheeled on a truck to the malt-loft *A*, and the contents of the sacks are thrown in.

The horse-wheel is intended to put in horses occasionally, if the steam-engine should fail; but these engines are now brought to such perfection that it is very seldom any accidents occur with them.

Fig. 2, Plate II., is a representation of the fermenting-house at the brewery of Messrs Whitbread and Company, Chiswell Street, London, which is by far the most complete in its arrangement of any work of the kind, and was erected after the plan of Mr Richardson, who conducts the brewing at those works. The whole of fig. 2 is to be considered as devoted to the same object as the large vessel *M* and the casks *N*, fig. 1. In fig. 2, *r* is the pipe which leads from the different coolers to convey the wort to the great fermenting vessels or squares *M*, of which there are two, one behind the other; *ff* represents a part of the great pipe which conveys all the water from the

well E, fig. 1, up to the water-cistern F. This pipe is conducted purposely up the wall of the fermenting-house, fig. 2, and has a cock in it, near *r*, to stop the passage. Just beneath this passage a branch-pipe *p* proceeds and enters a large pipe *xx*, which has the former pipe *r* withinside of it. From the end of the pipe *x*, nearest to the squares M, another branch *nn* proceeds, and returns to the original pipe *f*, with a cock to regulate it. The object of this arrangement is to make all or any part of the cold water flow through the pipe *xx*, so as to surround the wort-pipe *r*, which is only made of thin copper, and lower the temperature of the wort passing through the pipe *r*, until, by the thermometer, it is found to have the exact temperature which is desirable before it is put to ferment in the great square M. By means of the cocks at *n* and *p*, the quantity of cold water which shall pass in contact with the surface of the pipe *r* can be regulated at pleasure, so as to have a command of the heat of the wort when it enters into the square.

When the first fermentation in the squares M is finished, the beer is drawn off from them by pipes marked *v*, and conducted by its branches *w* to the different rows of fermenting-tuns marked NN, which fill all the building. Between every two rows are placed large troughs to contain the yeast which they throw off. The plate shews that the small tuns are all placed on a lower level than the bottom of the great vessels M, so that the beer will flow into them,

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and, by standing in them all, will fill them to the same level. When they are filled, the communication-cock is shut; but as the working off of the yeast diminishes the quantity of beer in each vessel, it is necessary to fill them up again. For this purpose the two large vats O O are filled from the great vessels M before any beer is drawn off into the small casks N, and this quantity of beer is reserved at the higher level for filling up. The two vessels O O are in reality placed between the two squares M, but we have been obliged to place them so that they can be seen. Near each filling-up tun o is a cistern t, with a pipe of communication from the tun O, and this pipe is closed by a float-valve. The small cisterns t have always a communication with the pipes which lead to the small fermenting-vessels N, and therefore the surface of the beer in all the tuns and in the cisterns will always be at the same level; and as this level subsides by the working off of the yeast from the tuns, the float sinks and opens the valve, so as to admit a sufficiency of beer from the filling-up tuns o to restore the surfaces of the beer in all the tuns, and also in the cistern t, to the original level. In order to carry off the yeast which is produced by the fermentation of the beer in the tuns O O, an iron dish or vessel is made to float upon the surface of the beer which they contain; and from the centre of this dish a pipe o descends and passes through the bottom of the tun, being filled through a collar of leather so as to be tight, at the same that it is at liberty to slide

down as the surface of the beer descends in the tun. The yeast flows over the edge of this dish, and is conveyed down the pipe to a trough beneath.

Beneath the fermenting-house are large arched vaults P, built with stone and lined with stucco. Into these the beer is let down when sufficiently fermented, and is kept till wanted. These vaults are used at Mr Whitbread's brewery instead of the great store-vats of which we have before spoken, and are in some respects preferable, because they preserve a great equality of temperature, being beneath the surface of the earth.

Figs. 3 and 4, Plate III., represent the malt-rollers, or machine for bruising the grains of malt. A is the hopper into which the malt is let down from the malt-loft above, and from this the malt is let out gradually through a sluice or sliding-shuttle *a*, and falls between the rollers B D. These rollers are made of iron, truly cylindrical, and their pivots are received in pieces of brass let into iron frames, which are bolted down to the wooden frame of the machine. A screw E is lapped through the end of each of these iron frames; and by these screws the brasses can be forced forwards, and the rollers made to work closer to each other, so as to bruise the malt in a greater degree. G is the shaft by which one of the rollers is turned, and the other receives its motion by means of a pair of equal cog-wheels H, which are fixed upon the ends of the pivots, at the opposite ends of each of the rollers; *d* is a small lever, which bears upon

the teeth of one of these cog-wheels, and is thereby lifted up every time a cog passes. This lever is fixed on the extremity of an axis, which passes across the wood frame, and in the middle of it has a lever *c*, fig. 3, bearing up a trough *b*, which hangs under the opening of the hopper A. By this means the trough *b* is constantly jogged, and shakes down the malt regularly from the hopper A, and lets it fall between the rollers: *e* is a scraper of iron plate, which is always made to bear against the surface of the roller by a weight, to remove the grains which adhere to the roller.

Fig. 5, Plate III., is the screw by which the ground or bruised malt is raised up, or conveyed from one part of the brewery to another. K is an inclined bar or trough, in the centre of which the axis of the screw H is placed; and the spiral iron plate or worm, which is fixed projecting from the axis, and which forms the screw, is made very nearly to fill the inside of the box. By this means, when the screw is turned round by the wheels EF, or by any other means, it raises up the malt from the box *d*, and delivers it at the spout G.

The screw is equally applicable for conveying the malt horizontally in the trough *k* as inclined, and similar machines are employed in various parts of breweries for conveying the malt wherever the situation of the works require.

Fig. 8, Plate IV., is the mashing-machine. WW is the tun, made of wooden staves, hooped together.

In the centre of it rises a perpendicular shaft NN, which is turned slowly round by means of the bevelled wheels KI at the top. RR are two arms projecting from the axis, and supporting the short vertical axis S at the extremities, so that, when the central axis is turned round, it will carry the axle S round the tun in a circle. The axis S is furnished with a number of arms T, which are shewn in fig. 9, and have blades placed obliquely to the plane of their motion. When the axis is turned round these arms agitate the malt in the tun, and give it a constant tendency to rise upwards from the bottom.

The motion of the axis S is produced by a wheel Q on the upper end of it, turned by a wheel P fastened on the lower end of the tube O, which turns freely round upon the central axis N. On the upper end of the same tube O is a bevelled wheel M, receiving motion from a wheel L, fixed upon the end of the horizontal axis F, giving motion to the whole machine. This same axis has a pinion G upon it, giving motion to the wheel H, fixed upon the end of a horizontal axle, which, at the opposite end, has a bevelled pinion I, working the wheel K, before mentioned. By this means the rotation of the central axis N will be very slow compared with the motion of the axis S, for the latter will make seventeen or eighteen revolutions on its own axis in the same space of time that it will be carried once round the tun by the motion of the axis N. At the beginning of the operation of mashing, the machine is

made to move with a slow motion; but, after having wetted all the malt by one revolution, it is made to revolve quicker. For this purpose the ascending shaft A, which gives motion to the machine, has two bevelled wheels BC fixed upon a tube X, fitted upon the shaft. These wheels actuate the wheels D and E upon the end of the horizontal shaft F; but the distance between the two wheels B and C is such that they cannot be engaged both at once with the wheels D and E; but the tube X, to which they are fixed, is capable of sliding up and down on the axis A sufficiently to bring either wheel B or C into action with its corresponding wheel E or D upon the horizontal shaft; and as the diameters of BE and CD are of very different proportions, the velocity of the motion of the machine can be varied at pleasure by using one or other: *b* and *c* are two levers, which are forked at the ends, and embrace collars at the ends of the tube X; and the levers being united by a rod, the handle *b* gives the means of moving the tube X and its wheels BC up or down to obtain the action of the different wheels.

Figs. 10 and 11, Plates V. and VI., represent a large close copper. AA is the copper, and B the pan placed over it. The copper has a large tube E rising up from the dome of it, to convey the steam; and from the top of this, four inclined pipes R descend, the ends being immersed beneath the surface of the water or wort contained in the pan. By this means the steam which rises from the copper issues

from the ends of the pipes R, and rises in bubbles through the liquor in the pan, so as to heat it. In the centre of the copper is a perpendicular spindle *a*, which, at the lower end, has arms *dd* fixed projecting from it, and is turned round by a cog-wheel *b* at the upper end. From the arms *dd* chains are hung in loops, which drag round upon the bottom of the copper when the axis is turned; and this motion stirs up the hops to keep them from burning at the bottom: *fg* is a chain and roller to draw up the spindle *a* when the rowser is not wanted; and *ee* are iron braces proceeding from the outside of the copper, to retain the axis *a* firmly in the centre of the copper. D is the waste-pipe for carrying off the steam into the chimney when it is not required to heat the liquor in the pan. The copper represented in the drawing is made in the same manner as usual; but the fire is applied beneath it in a manner very different from the common brewing-coppers. The method was devised with a view to the burning or consuming of the smoke, and was employed in the brewery of Messrs Meux and Company, London, about the year 1803.

The fire-place is divided into two by a wall extended beneath the bottom of the boiler, as shewn by Z in the plan, fig. 11, Plate VI., where the dotted circle A represents the bottom of the copper, and the circle X its largest part. The section in fig. 3 shews only one of these fire-places, of which C is the fire-grate. The raw coal is not thrown in through the

fire-door in the manner of common furnaces, but is put into a narrow inclined box of cast-iron *h*, built in the brick-work, and shaped like a hopper. The coals contained in this hopper fill it up, and stop the entrance of the air so as to answer the purpose of a door; and the coals at the lowest part or mouth of the hopper are brought into a state of ignition before they are forced forwards into the furnace, which is done by introducing a rake or poker at *i*, just beneath the lower end of the hopper *h*, and forcing the coals forwards upon the grate-bars *C*. Immediately over the hopper *h*, a narrow passage is left to admit a stream of fresh air along the top of the hopper to pass over the surface of the fuel which is burning at the lower end of the hopper *h*. By this means the smoke rising from that portion of fuel is carried forwards over the burning coals upon the grate *C*, and is thereby consumed. Beyond the grate-bars *c*, a breast-wall *S* is erected, to direct the flame upwards against the bottom of the boiler *A*, and thence descending under the bottom, the flame is received into the flues, which make each a half turn round the lower part of the copper, as shewn in the plan at *tt*, and then enter the chimney or perpendicular flue *W* at the same point; the entrance being regulated by a damper to make the draught more or less intense. There is also a sliding-door or damper *E*, which closes up the lower part of the chimney; and by means of these two dampers the fire under the copper can be regulated to the greatest precision; for by opening

the damper F it admits the cold air to enter immediately into the chimney W, and thus take off the rapidity of the draught; and at the same time, by closing the dampers from the flues into the chimney, the intensity of the draught through the fire is checked, which is very necessary to be done when the contents of the copper are drawn off. Immediately over the fire-grate *c*, an arch of fire-bricks or stone *s* is placed beneath the bottom of the copper, to defend it from the intense heat. The chimney is supported on iron columns R R. - Behind the fire-grate *c* is a cavity *r*, for the reception of the masses of scoriae which are always formed in so large a fire. They are pushed back off the grate into this receptacle with an iron hook as fast as they accumulate. The bottom of this cavity is formed of sliding iron doors, which can be opened by drawing them out, and in this way the clinkers are discharged; or the whole of the fire may be driven back off the grate into this cavity, and will then fall through into the ash-pit and be removed from the copper, which is very necessary to be done when the copper is to be cooled, so that men may descend into it to clean out the sediment which is left after boiling the wort. For a more particular description of this method of setting boilers, see *Philosophical Magazine*, vol. xvii.

Fig. 13, Plate VI., represents one of the sluice-cocks which are used to make the communications of the pipes with the pumps or other parts of the brewery. BB represents the pipe in which the cock

is placed. The two parts of this pipe are screwed to the sides of a box C C, in which a slider A rises and falls, and intercepts at pleasure the passage of the pipe. The slider is moved by the rod *a*, which passes through a stuffing-box in the top, the box which contains the slider, and has the rack *b* fastened to it. The rack is moved by a pinion fixed upon the axis of a handle *e*, and the rack and pinion is contained in a frame *d*, which is supported by two pillars. The frame contains a small roller behind the rack, which bears it up towards the pinion, and keeps its teeth up to the teeth of the latter. The slider A is made to fit accurately against the internal surface of the box C, and it is made to bear against this surface by the pressure of a spring, so as to make a perfectly close fitting.

Fig. 12, Plate VI., is a small cock to be placed in the side of the great store-vats, for the purpose of drawing off a small quantity of beer, to taste and try its quality. A is a part of the stave or thickness of the great store-vat; into this the tube B of the cock is fitted, and is held tight in its place by a nut *aa* screwed on withinside. At the other end of the tube B a plug *c* is fitted, by grinding it into a cone, and it is kept in by a screw. This plug has a hole up the centre of it, and from this another proceeds sideways, and corresponds with one made through the side of the tube when the cock is open; but when the plug *c* is turned round, the hole will not coincide, and then the cock will be shut. D is the handle

or key of the cock, by which its plug is turned to open or shut it; this handle is put up the bore of the tube (the cover E being first unscrewed and removed), and the end of it is adapted to fit the end of the plug. The handle has a tube or passage bored up it to convey the beer away when it is opened, and from this the passage *f*, through the handle, leads to draw the beer into a glass or tumbler. The hole in the side of the plug is so arranged, that when the handle is turned into a perpendicular direction with the passage *f* downwards, the cock will be open. The intention of this contrivance is, that there shall be no considerable projection beyond the surface of the tun; because it sometimes happens that a great hoop of the tun breaks, and, falling down, its great weight would strike out any cock which had a projection; and if this happened in the night, much beer might be lost before it was discovered. The cock above described being almost wholly within-side, and having scarcely any projection beyond the outside surface of the tun, is secure from this accident.

Fig. 14, Plate VI., is a small contrivance of a vent peg, to be screwed into the head of a common cask when the beer is to be drawn off from it, and it is necessary to admit some air to allow the beer to flow. A A represents a portion of the head of the cask into which the tube B is screwed. The top of this tube is surrounded by a small cup, from which project the two small handles C C, by which the peg is turned

round to screw it into the cask. The cup round the upper part of the tube is filled with water, and into this a small cup **D** is inverted; in consequence, the air can gain admission into the cask when the pressure within is so far diminished that the air will bubble up through the water, and enter beneath the small cup **D**.

ADDITIONAL OBSERVATIONS  
ON THE  
PRACTICAL METHODS  
OF  
BREWING.

BY

W. STEWART.

ERRATA.

- Page 88, line 13, commencing "We have" down to "carbonic acid," p. 89, line 2, and containing Liebig's analysis of sugar, should have been placed within brackets, thus [ ]
- 191, line 15, *for affects read effects*
  - 289, line 6 from bottom, *for 30 lbs. of hops read 50 lbs.*
  - 294, line 7 from bottom, *for Seven hogsheads read Six hogsheads*



## INTRODUCTION

TO

### PRACTICAL METHODS OF BREWING.

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THE design of the following observations is to describe, in a plain and concise manner, the practical methods of brewing Scotch and English Ales.

To convert barley into malt, and, by brewing, to extract ardent spirits from it by distillation, or to manufacture the various sorts of ales, beer, and porter, must be considered complicated processes of chemistry. Each process, indeed, in these arts, is an experiment which turns out successful and profitable in proportion to the skill and economy with which it is conducted, and the brewer and distiller must ever watch each operation with much care and anxiety to produce the best results. To describe the various phenomena which occur in practice,—to demonstrate the theories which govern each operation, and to connect the whole on sound principles of science, is the province of practical che-

mistry, and those who have the management of maltings, breweries, and distilleries, cannot give too much attention to this branch of knowledge, which is so intimately connected with their whole operations.

But there are many points in these operations that the eye of science is apt to overlook, and which even practical brewers who have published works on the subject have too much neglected; and these are the methods of working the processes, so as to produce malt liquors differing so much in quality and flavour, as to give them a distinctive character in the market of consumpt. Of this description, the kinds of malted liquors that have acquired what may be termed national distinction, are, London porter, Edinburgh and English home-brewed ale,—common brewery and victuallers' ales being produced by the same methods of brewing all over England. It is the system of making Edinburgh ale, and the descriptions made generally in England, that will form the subject of this treatise.

It will readily occur to the reader, that a practical detail of the two methods of brewing, as adopted in England and Scotland, with something like a fair estimate of the advantages arising from working out the system of either country must be desirable. The opportunity too, is favourable. There is neither any danger of getting entangled in questions of science, nor of provoking controversy: all that I shall attempt, is to give that general informa-

tion on the subject, with such observations, derived from practical experience, as may be deemed useful to the operative brewer, in conducting his processes towards obtaining the most beneficial result.

Before entering on these subjects, however, it may be of some importance to take a glance at the progress of the malting and brewery business since the commencement of the laws of excise.

During the reign of Charles I., and the succeeding government of Cromwell, maltings, breweries, and distilleries were greatly increased in England, without any impost on their productions, with the exception of temporary duties, raised by the conflicting parties during the Civil War. Under the councils of Cromwell, the navigation law, which laid the foundation of the future maritime supremacy of Great Britain, was passed. The temporary occupation of Scotland and Ireland, caused that unity of interest in the three kingdoms so favourable for the extension of commerce; and the destruction of the Dutch fisheries, and humiliation of that power gave to English enterprise an impetus which promised to develop the resources of the country. The restoration of Charles II. changed the whole aspect of affairs. The nobility had become impoverished,—the crowd of needy adherents who returned with Charles, or rose up to support him when all danger was past, clamoured for money; and the expedient was devised of establishing a permanent Excise, or cutting out a part of the capital of maltsters, brewers, and distil-

lers, and increasing the national revenue by levying a duty on the productions of their establishments, with a protecting duty, at the same time, on all spirits and malt liquors imported from foreign countries.

The first Act of Parliament which constitutes the Excise system was passed 12th Char. II., c. 23. By this act, thirty-six gallons was declared to be the measure of a barrel of beer, and thirty-two gallons that of a barrel of ale. The duty on beer and ale was enacted to be 1s. 3d. on each barrel above the value of 6s. per barrel, and 3d. per barrel if valued at 6s., and under that sum. A duty on malt and hops was not exacted until the reign of Queen Anne, forty years afterwards. By the above act, a duty was charged of 1d. for every gallon of strong water or aqua vitæ, made and sold; and 4d. per gallon of strong water or brandy imported. By another act, 12th Char. II., c. 25, these duties were doubled; and up to the accession of George I., the duties altogether on strong beer and ale were raised to 5s. per barrel, and small beer 1s. 4d. per barrel.

The Malt Act was passed 12th Anne, 1713, which levied a duty of 6d. per bushel on all malt made in England and Scotland, and prohibited brewers "from brewing beer and ale with sugar, honey, foreign grains, Guinea pepper, or with a late invented liquor or syrup made from malt and water, boiled up to the consistency of molasses, and very much resembling the same, and commonly called *Essentia Bine*, or with other unwholesome materials."

By 9th Anne, c. 12, the first duty on hops was levied, being 1d. per lb. on hops, the growth of Great Britain, and 3d. per lb. on hops imported.

The liquor called *essentia bine*, described in 12th Anne, leads to the conclusion, that this was the period when porter was first made, in any great quantity, by the brewers of London. The species of malt liquors before this time was denominated beer and ale. The latter was made from pale malt, with the finest quality of hops; and the beer from amber-coloured or high-dried malt, and with hops of a stronger bitter, or coarser quality than those used for ales, and in a larger proportion. It is familiar to those acquainted with brewing ales by the quick method of fermentation, that, during the heats of summer, the vinous speedily gives way to the acetous fermentation; and when this occurs, brewers are accustomed to check it by putting down the ale with raw hops; and publicans very often do this of their own accord. This hopped ale, when mixed half and half with fresh mild ale, forms a very agreeable beverage, which is much used during the summer months in England. There cannot be a doubt that it was the increased popularity of this mixture of beer that first gave rise to the brewing of porter, in the beginning of the eighteenth century. The brewers would soon find out a method of brewing their beer entire, to supply the demand of their customers; and by using the *essentia bine* described in the Act, and storing the fresh beer in vats, mixed with a propor-

tion of old ale, well hopped, they could produce at once to their customers an article high-coloured, and of that peculiar bitter taste and flavour which was so much relished by the public. The name of Half-and-half would be given to this species of beer at first; but after it began to be regularly consumed by those accustomed to hard work, it would receive the name of Porter, which it has retained. It is not, however, recognised by this name in any Act of Parliament.

The revolution of 1688 gave a powerful impulse to the commercial enterprise of England. The consumption of malt, and the annual amount of beer manufactured, increased to such a degree, that, by the end of the reign of Queen Anne, the quantity of malt charged with duty averaged 24,000,000 of bushels, while 3,500,000 barrels of strong beer were annually produced.

Before the Union of Scotland and England, the national drink of the former was strong ale, beer, and a species of ale called Twopenny, from being sold at 2d. per pint, equal to two quarts English measure. By the 7th Article of the Union, this sort of ale is valued at 9s. 6d. per barrel of twelve gallons Scots measure, equal to thirty-four gallons English, on which a duty of 2s. per barrel was in future to be paid; and by 8th Anne, cap. 7, an additional duty of 1½d. In the year 1760 the duty was raised to 3s. 4½d., in consequence of which, and the increasing consumpt of whisky, the brewing of twopenny gra-

dually diminished, and was finally discontinued altogether before the end of the century. The particular time when whisky was first distilled in Scotland, and publicly sold as an article of consumpt, is involved in some obscurity. The name of whisky is derived from the Gaelic *uisge beatha*, pronounced *uiske bea*, or water of life, which identifies it with the aqua vitæ of the English distillers. Corn-brandy was made in England in the reign of Charles the First from pure malt, and received the name aqua vitæ from French brandy. Spirits from raw grain were also extracted by the English distillers of that period. It was compounded and rectified into strong waters or gin, and consumed to considerable extent, when the excise was first partially levied during the Civil War. The duties on these spirits were consolidated by the permanent laws of excise at the restoration of Charles II. At the Union, the spirits aqua vitæ, strong water, and rectified compounds of the English, had not found their way to Scotland. But it is more than probable that the art of distilling had been introduced by the soldiers of General Monck's army, stationed, during the rule of Cromwell in the north of Scotland; that it had gradually extended through the Highlands; and that the production during the early part of last century had been brought down from these districts and sold to the Lowlanders, as *uiske bea*, from which the Scottish term of whisky is derived.

By the Articles of the Union, the English excise-laws were extended to Scotland, and henceforward

the two countries were to bear alike all taxation for public exigencies. In a few years the malt and hop taxes were imposed, and the country was regularly placed under surveyance of the officers of excise. The unpopularity of these taxes, and the vexatious prosecutions which soon involved all who brewed their own ale and infringed on the fiscal regulations by which they were bound, soon put a stop to brewing on a small scale, which was gradually given up, as whisky and beer came into general use. The brewing of strong ale was thus thrown into the hands of common brewers; and private families, as well as the inns and public houses, obtaining supplies from these sources, of ales of an excellent description, the making of home-brewed ale has never been renewed to any extent.

Of the progress of malting, brewing, and distillation in Ireland, no satisfactory account has ever been published, by which anything like authentic information can be obtained previous to the extension of the excise-laws to that part of the empire. The duty on malt was first imposed in England in 1697; in Scotland, in 1713; and in Ireland, in 1785. The quantities of malt made in Ireland, of spirits from malt and grain, and of ale and strong beer, have varied so much, according as the rates of duty have been occasionally increased or diminished, that it is difficult to form a correct estimate of the annual average production and consumpt. From 1790 to 1794, when the duty on malt was 7d. per bushel, the average

quantity annually made may be stated at 4,500,000 bushels; when the duty was increased successively during the war to 4s. 5d., the quantity of malt diminished to 2,000,000; and, although the duty was reduced to 2s. 7d., the average is now under 1,500,000 bushels. The repeal of the corn-laws, however, must have a decided influence on the future distillery operations in Ireland; and it may be confidently expected, that a large increase in the manufacture of raw grain-spirit for exportation will take place.

The high and low duties on spirits extracted from barley and malt, when made for home consumption, in England, Scotland, and Ireland, has either encouraged or suppressed the consumpt, in these different parts of the United Kingdom, so as to have had a decided influence on the habits and manners of the people, and in forming their tastes and desires for the drinks within their reach. In England, the high duties on home-made spirits, and the prohibitory duties on brandy and Geneva have kept the mass of the people to the consumption of beer and ale; while, in Scotland and Ireland, the alternate low and high duties on spirits, and the war duties on malt, have encouraged the consumption of whisky and small-beer in preference to malted liquors. The quantity of malt which has paid duty annually for the last three years, exceeds 40,000,000 of bushels for the United Kingdom; and when to this is added 6,400,000 bushels of raw grain used in distillation, and the prospective increase which must inevitably follow from

the extension of commerce and manufactures, when the repeal of the corn-laws and the principles of free trade get room to work, the malt and corn that in all probability will be used in brewing and distillation will amount to 6,000,000 of quarters, which are equivalent to the manufacture of 25,000,000 gallons of spirits, 1 to 10 over hydrometer proof, 12,000,000 barrels of strong beer and ale, and 3,000,000 barrels of small beer.

The consumpt of the United Kingdom, therefore, may be estimated, on an average, as follows:—

	Barrels Strong Beer and Ale.	Barrels Small Beer.	Gallons Spirits.
England, . . .	11,520,000	2,300,000	13,000,000
Ireland, . . .	200,000	300,000	7,000,000
Scotland, . . .	280,000	400,000	5,000,000
	12,000,000	3,000,000	25,000,000

Taking the population, at the present time, to be

18,000,000	in England,
8,200,000	Ireland,
2,800,000	Scotland,
<hr/>	
29,000,000	

they consume less, by 50 per cent., than the population of 1793, in proportion to numbers, and 100 per cent. less than the population of 1765. It must be seen, at a glance, that the quantities of strong beer and

ales, and home-made spirits, consumed by the inhabitants are now moderate in proportion to their increased numbers and wealth, and to the manners and customs of the respective countries.

It would be of immense benefit both to Ireland and Scotland were the malt-duty reduced so as to encourage the consumpt of malted liquors in preference to whisky; but the task of equalising duties, to benefit the community, without immediately impairing the revenue of the country, is certainly one of difficulty. The reduction of the malt-tax would at first cut both ways. It would cause at the same time a loss of duty both on malt and on spirits, in proportion to the amount of their reduction; and this loss could only be recovered by an increased consumption of malt at the reduced rate, such as took place when the duty on coffee was reduced; and by laying an equivalent tax on home-made spirits in England, Scotland, and Ireland,—that is, to raise the duty in Scotland and Ireland, and to lower it in proportion in England. This last plan would answer the purpose better were the system of licensing grocers in England to sell ales and British spirits, not to be consumed on the premises, adopted at the same time. Private families could thus purchase from their grocers strong beer, ale, or the best spirits, as required; and the increased consumpt would ultimately compensate for the reduction of duties.

The revisal and modification of the excise-laws, must be a subject of the deepest interest to malt-

sters, brewers, and distillers. I shall take the opportunity of offering a few observations on these important matters.

1. On the reduction of the duties on malt, and equalisation of the spirit-duties.

2. Restriction of materials used in brewing and distillation.

3. Removal of the vexatious fiscal regulations, which injure the operations of the maltster and distiller, without benefiting the revenue.

1. *Malt-duties*.—It must be at once conceded, that the present ministry, however liberal in principle, cannot part with so large an amount of revenue as the malt-tax produces, without substituting some other taxes, to make up the deficiency; and as such an arrangement is altogether hopeless, the question at once arises, were the reduction of the duty on malt effected to one-half of its present rate, and an equalisation of the duties on British spirits established, would the revenue arising from the increased consumption of malt and spirits compensate for the amount of malt-duty reduced? Experience of the effects of reducing the duties on other articles of consumpt, completely proves that such an equivalent would be returned to the Government, and that a low duty on a large consumpt of malt would produce more revenue than a high duty on a small one.

The equalisation of the spirit-duties admits of as

little doubt. The rate in England is 7s. 10d. per gallon, and in Scotland and Ireland 3s. 8d. and 2s. 8d. per gallon. Were the duties on home-made spirits lowered to 5s. per gallon, and the Scotch and Irish spirits raised in fair proportion, and licenses at the same time granted to the grocers of England to sell by retail, there cannot be any doubt whatever that the increased consumpt would be more than equivalent for the tax reduced.

But it might be urged that this additional duty in Scotland and Ireland would raise a host of smugglers, with all concomitant evils. The fear is visionary. The Highland smuggler could not compete with the improved spirits which would soon appear in the market at a lower price than he could possibly afford to sell his own production; for unless he could obtain at least 14s. per gallon, he would not risk the adventure. Smuggling might take place to some extent in Ireland, as it does at all times, but not to such a degree as to hurt the fair trader.

2. *Restriction in the use of materials.*—In brewing ales and porter, neither molasses nor sugar, nor any other material, is cheaper than malt and hops. The equivalent to a quarter of malt is 200 lbs. of sugar. Even without a reduction of the malt-tax, no brewer can profitably use it. It is only when malt is very high in price, that sugar can be used in brewing, and that with no great advantage. Glucosin or starch-sugar differs in its fermenting principle from cane-sugar. When boiled with malt-wort, and cooled

down to the point of fermentation, the difference still exists. In the process of fermentation, the glucosin or sugar-starch has the capacity of being first resolved into alcohol, leaving a great part of the former in a state of solution; and although the fermentation, or attenuation, as it is called, is carried down as far as the brewer thinks desirable, and the ale appears in fine condition in the gyle, yet in a short time after being sent into the customer's cellar, it springs rapidly into the second fermentation. With distillers the process is different; but unless the sugar is cheap, raw grain and malt distillation will be found to be the most profitable.

Were the reduction on the malt-duties to take place, it is evident, that to restrict the use of raw grain to a certain extent would be the best means for producing a larger consumpt of malt; and distillers could not object to this, because they would be remunerated by the higher price, and by enlarged consumption of finer spirits. To the agricultural interest, it is indifferent whether barley is used malted or unmalted at present; but the advantage would be very great by the additional demand for barley, which would immediately follow the reduction of the tax. Nor could any valid objection be urged, that such reduction would increase intemperance amongst the working-classes. It is too moderate to have any such effect. The increase in the consumpt, of a fine quality of spirit would extend to all classes in large commercial cities and towns; and it may be

calculated, that from five to six millions of gallons additional would, in this manner, be annually consumed.

3. The removal of the vexatious restrictions and formalities which still encumber the operations of the maltster and distiller by the excise-laws, would be of very great importance to them, without in any manner endangering the revenue, or preventing the officers from doing their duty ; but so many grievances exist in other manufactories, subject to excise surveyance, that it would be necessary to have the whole brought before Parliament, and an effectual remedy provided, by striking off from the code of excise-laws so many vexatious restrictions, which injure the fair trader, without any benefit to the revenue whatever.

The revisal and modification of the excise-laws are rendered more imperative by the influence which free trade and the repeal of the corn-laws have already manifested on the trade and commerce of the country. For more than a century, the consumpt of malt has stood nearly at one point, notwithstanding the rapid increase of the population, the immense growth of wealth, commercial prosperity, and agricultural improvement. Taking a glance at the quantity of malt made, and the population of Great Britain and Ireland since the reign of Queen Anne to the present time, the truth becomes apparent, that the use of all sorts of liquors and ardent spirits manufactured from barley has declined as the popu-

lation advanced, and that, in proportion to numbers, the balance is so decidedly in favour of the population of the present time, that the fact ought to quiet the fears of those who suppose that intemperance has gained ground amongst the working-classes of the present day, notwithstanding the light of knowledge and the influence of education. In round numbers, the account stands thus :—

	Population of Great Britain and Ireland.	Quantity of Malt made.
In the Year 1720, . .	7,000,000	Quarters. 3,500,000
.....1765, . .	10,000,000	3,700,000
.....1793, . .	14,000,000	3,800,000
.....1820, . .	21,000,000	3,600,000
.....1849, . .	29,000,000	5,000,000

The decrease in the consumption of productions brewed and distilled from malted barley, has undoubtedly arisen from a variety of causes. *1st*, The increased use of tea and coffee since 1765, by all classes of society. *2d*, The high duties imposed on malt and spirits during the wars of the French revolution; and, *lastly*, The influence which knowledge and education have so powerfully exerted on the customs, manners, and tastes of the great mass of the population.

The national consumpt of liquors which the customs and manners of the inhabitants demand; the increase suitable to the increase of population; and

the imposing of taxes on these liquors, either for the purpose of creating revenue, or for the spread of such beverages as have the least injurious effects on the morals and temperate habits of the people,—are all questions belonging to the government, and altogether different from the views of temperance societies, and of the humane and philanthropic exertions of individuals, who go the length of condemning the drinking-usages of society altogether, or of well-intentioned magistrates, who ascribe to the multitude of public houses all the evil effects of intemperance. The duty of the government is imperative. Drink, in all its variety of refreshing or exciting qualities, is a luxury, and may be taxed moderately, without impairing the necessaries of life; and local public functionaries may feel called upon by a sense of public duty, or private individuals by moral obligations, to check the evils of intemperance by the restriction or prevention of public houses; but experience has completely proved, that all excessive taxation and official interference are alike unavailing, and cause the very evil which they are said to cure. High duties and fiscal oppression cause smuggling to an extent beyond all calculation; and those who attribute intemperance to the great number of public houses, reason under pure fallacy. It is not public houses that cause drinking, but it is drinking that causes the public house. It is other causes operating on the dispositions of the people, as Adam

Smith observes in his *Wealth of Nations*, that give employment to a multitude of publicans.

The question of the revival and modification of the excise-laws is, therefore, practical ; and it resolves itself into this,—whether or not a reduction of the malt-duty to one-half of its present rate, with an equalisation of the spirit-duties, and extension of licenses to all grocers in the United Kingdom, would be of any loss to the revenue ; for it is not disputed that such a reform of the excise would be of immense benefit to the community. This is the real view of the question. Those who argue that the malt-duty ought to be totally repealed, have no foundation whatever for their reasoning. The ministry who govern the country can neither do without this tax, nor can they supply its place. The best that can be accomplished is to moderate the duty, and rely on the rapid increase of consumption for making up the deficiency.

But there is another point which not only deeply interests all who have capital embarked in malt-ing, brewery, and distillery establishments, but the proprietors of land in every district of the empire. The malt-tax is a land-tax ; it is a duty levied on the production of land ;—there can be no dispute about this. The total repeal of this tax, therefore, would benefit landlords, in the long-run, to nearly the amount of duty which is levied on barley in the shape of malt. And so it would, could other parties be satisfied ; but the principles of free trade are

abroad. The country is pressing forward in mercantile and manufacturing industry and enterprise.

The great truth, that a nation can only manufacture up to its supply of food, propounded by Colonel Thomson, and so ably demonstrated in theory, is now being in process of realisation in practice. The repeal of the corn-laws must eventually push on the manufacturing districts into full employment, and this in turn will cause a demand for other species of labour,—the increase of manufactures keeping pace with the supply of food, or, in other words, with wages to purchase it.

Now, in this state of matters, it is essentially necessary that government should have a revenue to pay the interest of the debt of the country ; for it is mainly on the punctual discharge of this great national obligation that the whole future commercial prosperity of the British empire depends ; to pay also the expense of civil government, and of keeping in an efficient state all the various means of defence, not only of the United Kingdom, but of her vast colonial empire. Were the government to give up the malt-tax without an equivalent, an additional property-tax would soon become inevitable ; because, without a malt-tax, the duties on home-made spirits could not be sustained, and there is no branch of industry that can afford to bear further taxation. For the sake of revenue, and, perhaps, by the demand of public opinion, the wines and brandies of France, and gin of Holland, might be permitted to be imported at

low rates of duties, and the consumpt of British corn-spirit would diminish in proportion. The cultivation of barley, which is carried on so extensively in Great Britain, not so much for food to the inhabitants, as to supply the breweries and distilleries, would gradually decline; and this, operating with other causes relative to free trade in agricultural productions, would permanently injure the landed interest more than any temporary benefit they might reap from the repeal of the malt-tax.

In every point of view in which the subject can be taken, the reduction of the malt-tax, and consequent production of a finer and purer spirit for home consumption, with other modifications already enumerated, would be satisfactory to all parties, and would increase the revenue of the country.

The practical methods of brewing Scotch and English ales, now become connected more immediately with this Introduction. In England, porter and ales may be truly said not only to be luxuries, but part of the necessaries of life, and are justly considered to be the national drink of the people. Any reduction of the spirit-duties would not materially affect the consumpt of malted liquors, more especially in the provinces, where the inhabitants generally prefer good ale (and in numerous districts it is excellent) to any ardent spirit whatever. But in Scotland and Ireland the case is very different. The brewing of ale by private families is almost given up, and very few publicans brew their own ale. The term *home-brewed*,

which, in England, is idiomatic of something excellent of itself, as applicable to drink, is unknown; but still, in various districts, ale of very fine quality is manufactured, and Edinburgh and Dublin are celebrated for making very fine descriptions of ale and porter. The ardent spirit generally used at present in Scotland and Ireland is whisky; but it would be folly to imagine that the inhabitants of these countries are more partial to whisky than any other description of liquor. Were the excise-laws relaxed, and the brandies and wines of France, and gin of Holland, imported at low duties, the use of whisky would gradually diminish. Previous to the middle of last century the consumpt of whisky in Scotland was very trifling. The national drink was strong beer, ale, and twopenny, a sort of intermediate drink between strong ale and small beer. The liquors of better description were the wines and brandies of France and Portugal. The operation of the excise-laws, and the heavy duties imposed on every species of foreign wines and spirits, forced the making of strong ale into the hands of the common brewers, and raised up distilleries in various quarters to supply ardent spirits to the market, and thus whisky became the prevalent drink of all orders of society, not from choice but from cheapness. In Ireland the case at present is similar. In Queen Anne's reign, and that of George I., we find Acts of Parliament relative to the exportation of hops to Ireland for the use of her breweries; and there cannot be any rational doubt

but that the national drink of the Irish would, at this day, have been ale and porter, with a finer quality of malt spirits, had they had their own choice. In both countries, but more especially in Ireland, the temperance societies have had a decided influence in spreading the principles of temperance among the people, and the consumpt of raw grain whisky is on the decline; but, with improved commerce, and better employment of labour, the consumpt of every species of the better qualities of liquor must increase; and the object most desirable is, that Her Majesty's Government would revise the laws of excise, so as to encourage the domestic brewing of ale all over the United Kingdom, and, by putting the malt and spirit duties on a moderate and equitable footing, enable brewers and distillers to produce the best possible qualities of drink to the public.

The following details of brewing, will be divided into five chapters. 1. Of the practical methods of brewing in England and Scotland. 2. Of the Scotch method of brewing ale. 3. Of the English method. 4. Of the method of brewing porter on a small scale, and of English home-brewed ale. And lastly, conclude with a short summary of malting and brewing;—affording throughout these divisions of the subject such information to the practical brewer as may be useful to him in the prosecution of his profession.

## CHAPTER I.

## OF THE PRACTICAL METHODS OF BREWING.

The business of brewing is divided into two great branches: The manufacture of ale by the common brewers of Great Britain and Ireland; and of porter, which is chiefly confined to the brewers of London. The method of brewing ale in Scotland differs from that pursued in England so much, that, in order to give a practical detail of the process, it will be necessary to divide the subject into separate heads, to afford a distinct description of the operations, so that the methods of working may be clearly understood.

The difference of the English and Scotch methods of ale-brewing consists—1. In mashing, the English brewers run the water at a temperature of 170° Fahrenheit through the malt from the bottom of the mash-tun, and stir each mash. The Scotch brewers fill the mash-tun with a sufficient quantity of water for the first mash, at a temperature of 175°, into which they run down the malt; they stir the first mash, preferring the use of oars to the mashing-machine, which latter they think taints the wort. The succeeding mash is effected by sparging or sprinkling at 180°, which commences at the time the first mash is drawn by the taps; and this sparging goes on constantly until they obtain the full quantity of worts

required for the brewing. 2. In boiling the worts, the English brewers, having drawn a sufficient quantity of worts from the mash, boil down to strength generally about two or two and a-half hours. The Scotch draw a shorter quantity of worts, and boil down to strength generally in one hour and a-half. 3. In fermenting the worts. The English pitch at a high temperature, from  $62^{\circ}$  to  $65^{\circ}$ , and bring the gyle forward to cleanse into barrels within forty-eight hours. The Scotch ferment at a low temperature, from  $50^{\circ}$  to  $55^{\circ}$ , and work the gyle from eight to ten days, beating in the head of yeast occasionally, until the attenuation is judged completed, when they run the ale from beneath the yeast into barrels, where no more fermentation takes place. 4. The English brewers, in cleansing, mix the yeast on the head of the gyle with the wort, and run the whole brewing into barrels to cleanse; which is done by keeping them regularly filled up until the fermentation ceases, and as much yeast as possible separated from the ale. The Scotch cleanse in the gyle, as already described. In both methods of fermentation, which may be distinguished by the quick and slow method, the judicious brewers of both countries never wish to carry the degree of heat more than ten degrees higher than that at which the wort has been set to fermentation.

It will thus be readily perceived, that, to give a practical detail of both processes of brewing, the object will be much better accomplished by carrying

through a description of a single brewing of ale by each of these methods. Before doing so, it may not be unacceptable to take some notice of matters connected with both modes of brewing, and of such previous steps, on preparing and judging of materials, as may be thought conducive towards producing ales of the finest flavour and quality.

The first question that occurs, and indeed such a question has often been asked, since so much difference exists in the methods of brewing Scotch and English ales, by which mode can that of the finest quality be produced? The question is of considerable importance, and, in fact, is one of difficulty to answer. With common brewers, local prejudice and taste must be so much studied, that in most places it is hazardous for them to alter their established system. In large towns this may be got over, where the advantage of improvement is so decided and the sale quick, that the change in the system of brewing cannot affect the regular production sent out. The adoption of the Scotch system by brewers, in such circumstances, may be very advantageous; but to small provincial brewers, who brew perhaps to the extent of 20 barrels two or three times per week, the adoption of the Scotch system presents so many difficulties, that its introduction into England, to any great extent, is dubious.

To the intelligent brewer, whose eye meets the sketch already given of the difference in the methods of brewing, it must at once be obvious that the chief

point lies in the fermentation of the worts. Now, in many parts of England, brewers mash two or three times weekly almost all the year round. Were such to adopt the Scotch mode of brewing, they must have eight or nine gyles constantly in operation. The danger of so large a stock running into the second fermentation during the summer months presents a formidable objection. There are parts, however, of the Edinburgh mode of brewing ale, which may be profitably adopted in England, without, in any degree, deranging their usual methods of working, such as the method of sparging the mash, and in shortening the time of boiling the worts; a judicious application of these parts of the Scotch method to the quick system of fermentation, would be of importance both towards economy, and improving the quality of the ale.

The Edinburgh system of brewing is decidedly the best that can be adopted, when the ale is intended to be bottled and kept for any time without the addition of hops; but when intended for draught, and when the run is constant, and the demand instantly to be supplied from the brewery all the year, the English system is greatly preferable; so much so, indeed, that some of the Edinburgh brewers have rather followed the English method in brewing their ales to be drawn from the butt, and have found the alteration of much advantage. It will be admitted, therefore, that both methods possess superior points to each other, and that to a brewer who studies

improvement, a knowledge of both systems in practice may become valuable, according to the circumstances in which he may be placed.

The best ale produced in Great Britain is that which is brewed by private families in England. With such, *home-brewed* is made and kept in a state of perfection which ale of no other country can equal.

When the best malt and hops are selected, the first mash drawn of sufficient strength, and the second mash so regulated as to make up the quantity of worts required for the brewing, the boiling of the worts with the hops only continued so long as necessary to extract their aromatic bitter, and the fermentation managed with judgment, ale is produced approaching to wine in quality, which may be kept in fine condition and pure flavour for years. This *home-brewed* is always made by the process of stirring the mashes, and of quick fermentation, so that it is quite evident that the superiority of one ale to another is not to be attributed either to mashing or fermentation. One thing is certain, however, that both in Scotland and in England, ales of inferior quality are produced, even where the best materials are within reach of the brewer. This ought never to arise where fine malt and hops are employed; but in brewing as in other arts, want of skill and judgment make a wreck of the best materials.

Still, it is undeniable, that a marked difference exists in the quality of ale made in the same locali-

ties, where the brewers use equal quantities of malt and hops, the same kind of water, and work out the process by similar methods. In London and Edinburgh, where the best materials are in the choice of brewers, with a quick sale and consumpt of the production, with a large amount of capital, and where every means of improvement have been keenly studied, and, when practicable, adopted, it is not surprising that a superior quality of liquor should be made to that produced by provincial brewers; but even in London and Edinburgh, the qualities of the production of brewers differ so much as to be distinguished by the consumer. It is not unimportant to the practical brewer to investigate the cause of this difference. The process of brewing admits of different methods of working, and there are few brewers but have some secret with regard to heats of mashing or fermentation, by which they conduct their operations. The distinctive character of a brewer's ale may, therefore, be accounted for by his observing the same unvarying method throughout the whole process of his manufacture, using the same proportions of materials, and drawing the supply of water from the same source. There are many important truths, however, in brewing malted liquors, which, being discovered incidentally, are regarded by the practitioner as secrets. Hence the many pretended discoveries which appear in the works on brewing during the course of last century, and which have disappeared before the truths of scientific investiga-

tion. Properly speaking, there are no secrets in brewing, either for the production of alcohol or malted liquors. Should a practical brewer possess knowledge on any particular part of the processes of these arts, he may perhaps treasure it as a secret, and imagine that he alone is reaping the advantage of the discovery, while others have, in all probability, acquired the same knowledge from observation or practical experience, and are in the constant practice of acting upon it like himself, and of believing, like him, that they are the sole possessors of the secret.

In brewing, there are many methods of working out the various processes, and brewers differ much in practice in conducting their operations; but the theories now established by scientific demonstration, incontestibly prove that it is only by working as closely as possible to the principles of chemical science, that the best and most profitable result can be produced, whether affecting the strength, or flavour, or preservation, of the various productions of malted barley. By a knowledge of chemical science, I mean that general knowledge of chemistry which any person of common education may acquire who wishes to improve himself in his profession, and which, to a brewer or distiller, is of the greatest value. With this knowledge, the process of brewing, whether for distillation or making ale, appears in a new light. The brewer works with confidence, and no difficulty occurs in the processes for which he is

not prepared with a remedy. From the time of laying on the first mash, and obtaining the worts of a known quantity and strength, he is enabled to regulate the whole future process, so as to preserve the advantage acquired from working with fine malt, and obtain that richness of flavour which distinguishes malt liquors, when skilfully and judiciously made. But there is another advantage. This knowledge enables him to carry economy through the whole process from beginning to end;—a most important matter in brewing, where so much waste occurs.

There are a few points in malting and brewing which may be brought under the notice of the reader, and upon which the successful production of ales of the best quality much depend.

1. In malting, after the process of artificial germination has been carried to that particular stage sufficient to secure the greatest outcome of starch, to kiln-dry the malt by regularly increasing heat, from 100° to 150°. When the kiln-heat is too low at first, the malt renews its growth, and begins to spring; when too high it will blow or expand, and when the heat is then rapidly increased get scorched. Much depends on kiln-drying; and brewers who have maltings cannot give too much attention to this branch of their business, nor to the next point, which is to regulate their making of malt by the quantity they employ in brewing, so as to contrive always to work with as fresh-made malt as possible. With fine, recent made malt, hops of good quality,

and common care and skill in conducting the process of brewing, ales of the richest flavour are sure to be the result. 2. In mashing, to regulate the mash by heats suitable to the age and quality of the malt in operation, and the state to which it is crushed or ground. 3. Never to draw the second mash to a greater length than can be boiled down to strength within that particular time necessary to cut the worts; and secure to the brewing the fine aromatic bitter principle of the hops. 4. In fermentation, if by the slow method, to regulate the heat of the gyle with such precision that the attenuations and increasing heat of the worts should be commensurate, slow, and progressive. This is accomplished by the use of the refrigeratory tube or worm, with which every gyle ought to be fitted up; and if by the quick method, to watch the favourable time for beating in the yeast, the cleansing not to be too hurried, but the worts allowed full time to strengthen the yeast before it slackens; and in both methods, to work the gyle so as not to allow the worts to rise more than  $10^{\circ}$  or  $11^{\circ}$  of heat higher than when first pitched. 5. Cleansing. The fermentation of the worts, either by the quick or slow method;—their attenuation, or, in other words, the partial resolution of the starch-sugar of the malt into alcohol;—and the preparation or cleansing of the yeast from the liquor,—are all processes which require the brewer's skill and experience to bring to a successful result. By the slow method of fermentation, the ale is cleansed in the gyle, and when all

is right, and the attenuation brought down to the point desired, it is run into the same casks which are sent out to the customer. Little or no more fermentation takes place, and ale is never racked into other casks by the Edinburgh brewers; but in Alloa, Stirling, and Perth, which are the best districts for brewing ale next to Edinburgh, they run the finished ale into butts, and afterwards *rack* into barrels, as orders are executed. These two methods of cleansing the gyle, in the Scotch system of brewing, are particularly worthy of the notice of the reader: both methods are the best suitable to the respective localities. The Edinburgh brewers pursue their method because their ale is sent out at once to the customers' cellars. The Alloa district brew large quantities, which are sent to Glasgow, and other parts, generally for immediate use. In *racking*, the Alloa brewers prepare what they term fillings, which are worts of the same brewing, set at the quick fermentation heat, 60° or 62°, and use part of this store in racking, putting an English pint into each barrel. The Edinburgh brewers rely on the fine condition of their ale, and add nothing whatever before sending out the stock. I have been thus particular, that English brewers may understand precisely the two methods of finishing the gyle by the Scotch system. Brewers sometimes overturn it into a clean tun or square, to check too rapid fermentation and cool the whole brewing, or to prepare for exportation; but for home consumption, the two methods above described are adopted. In cleansing by

quick fermentation or the English method, one point may be particularly brought to notice, that is, when the working of the wort in the barrels has nearly ceased, to fill and keep them filled up, with ale of the same brewing, from a barrel which has been regularly worked forward with the rest, and not to draw the troughs or plus-tub too close, for the sake of getting as much wort scraped together as finish the filling up of the barrels. Many brewers pay attention to this necessary precaution, but many do not; and whatever is useful in brewery practice should be put on record.

In such a complicated process as brewing, of course there are many different opinions as to the best methods of carrying on the operation, but the whole art resolves into this:—From a given quantity of malt and hops required the greatest possible quantity of ale of equal strength, and of the finest flavour. One man may produce twenty hogsheads of ale of excellent quality from a given quantity of malt and hops, and be esteemed accordingly; but he who can produce twenty-one hogsheads of as good ale from the same quantity and quality of materials must be regarded as much more successful.

Since the beginning of the present century, great progress has been made by practical chemists, who have turned their attention to investigating this most difficult art, both on the Continent and in this country. Their valuable researches have placed it on the ra-

tional foundation of science. The true theories of the whole process is wellnigh established ; and practical brewers may, with common industry and research, very readily give a good reason for every part of the process. The art of varying the operations of brewing, so as to produce ale of distinctive character, such as Edinburgh or English home-brewed, or common ale, must be of advantage to every practical brewer. I shall therefore carry through a description of making twenty barrels of ale from eighty bushels of malt, and eighty pounds of hops, and continue the same proportion in both methods of brewing, as practised in Scotland and England, with such information connected with the various processes as may be reckoned useful.

In the present preliminary remarks, I shall not take up time in describing the utensils used in brewing, as these will be noticed during the description of the operations. It may be shortly stated, however, that the copper is built so high as to command all the other utensils of the brewery. The mash-tun is placed as near it as convenient, and beneath is the underback, large enough to contain the whole worts of the mash. In every brewery of magnitude, there are several boilers for boiling the worts together, or separately, and preparing water for all other purposes. When all the utensils are judiciously placed, and are in good proportion to each other, it is almost unnecessary to say that the working of the brewery

is rendered more easy and economical, and the various processes are carried on with greater ease and satisfaction.

The capacity or size of the utensils should always exceed the calculated quantity of beer they are intended to make. A boiler to brew 20 barrels of ale, should be large enough to hold from 35 to 40 barrels of water: it requires all that capacity to hold the worts drawn from the mash, and which must be so reduced by evaporation, in boiling and cooling down to strength. The boilers employed to boil the worts ought to regulate the size of all the other utensils. Fanners are sometimes placed over the coolers to assist in cooling the wort. Where the roof of the cooling-room is low, or the situation confined, fanners are of necessity advantageous; but where it is high, and the apartment spacious, with the windows sufficiently open, they are prejudicial. They must be considered to supply a defect in the construction of the cooling-room, because they disturb the worts in the process of depositing the coagulated fecula, and other vegetable sediment, which, when retained, helps on the acetous fermentation afterwards. I know very well that some intelligent brewers are of opinion, that the worts get rid of this sediment or precipitated fecula during the process of the vinous fermentation, and adduce the practice of the distillers, who run these vegetable remains into their gyles to increase their attenuation; but I have ever found, that the purer I got the wort cooled

down and pitched, the better and purer was the ale ; and that where fanners were used, the damage they occasioned was greater than the risk of time lost in cooling by atmospheric influence alone.

The process of malting is well known, and has been often described ; but it may be remarked, that as the artificial germination of barley, and kiln-drying to stop that growth, which makes it into malt, is often part of the brewer's business, he ought, at the commencement of each brewing, to be a judge of the malt in operation to regulate his future proceeding. It is a mistake of some writers who have stated, that the hordein or starch of barley is converted into sugar by the process of malting ; neither is it correct to say that this process either destroys vegetable life or effects a change in its constituent principles ; the only change that takes place is, that barley, during the process of artificial germination, loses part of its gluten and mucilage, which are taken up by the rootlets and acrospire, with a small portion of sugar, which is developed at the same time as nourishment for these parts of the corn.

Malt, when crushed or coarsely ground, and treated with twice its weight of water at a temperature of 160° to 180°, and allowed to digest or infuse for two or three hours, is converted into glucosin or starch-sugar, and held in solution. This is simply the process of mashing to make strong ale.

In preparing malt, therefore, to undergo this pro-

cess, the brewer must judge from its appearance in colour and quality, how far it may be most profitable to grind it rough or small, to obtain the strongest wort. During the course of the year, he may have various qualities to operate with, and it requires skill and judgment to manage this part of his business. Recent made malt requires care in grinding. When of fine quality, the rollers of the mill should be slackened a little, not to crush it too fine. Malt of this description always yields worts of the richest flavour. When old, pale malt ought never to be ground small, nor mashed at a high temperature. It is liable partially to set, and yield turbid wort. Amber and brown malt bear a high temperature in mashing,  $185^{\circ}$  to  $190^{\circ}$ ; but it is neither safe nor prudent to go beyond  $185^{\circ}$  with any malt whatever in the first mash. With average malt of all descriptions,  $175^{\circ}$  is the best and safest heat that can be used. High heats in mashing certainly produce the strongest, but not the finest worts. When ales are brewed by mashing at a high temperature of water, vegetable extract comes over with the starch-sugar, and, not being got rid of during the succeeding processes of boiling and fermentation, remains in solution in the finished ale, and disposes it prematurely to assume the acetous state. In all cases when the brewer has the control of these matters, experience must be his guide.

Of hops to be used in the manufacture of ale, every brewer may be held to be a judge. But the use of

them in boiling the wort, the nature of the bitters they impart, and the best method of extracting the essential aroma of the plant are very different matters, and merit particular investigation by those whose aim is to make ales of very fine quality. Next to their choice, is their preservation. Fine Kent hops are sometimes bought, and, on arrival at the brewery, conveyed to the loft, and kept until worked up. If kept in stock for any great length of time they get winded, and lose all their most valuable properties. Now, when hops first arrive at the brewery, each pocket or bag should be subjected to the screw-frame pressure, which compresses it to two-thirds of its size; it is then corded, and the hops will keep all the season sound and fresh. For the methods of extracting the aroma and bitter principles, I must refer to the proper place in the order of brewing.

Much of the fine condition and keeping quality of malted liquors depends on the water with which they are made. Brewers who are scantily supplied, or have occasion, as scarcity or drought occur, to use water inferior to that which they commonly work with, cannot be too much on their guard in this respect. In some instances I have observed brewers and victuallers, both in Scotland and England, using brackish water supplied by wells on their own premises, or from some neighbouring rivulet, which contained too much vegetable remains, in both cases injuring the fermentation and damaging their ales, where springs of pure water were not far distant.

In these cases the expense of bringing such into the work must be compared with the prospective benefit to be derived from their use, and guide decision ; for, both in malting and brewing, it is of the greatest importance to possess a constant supply of the best water. Pure soft spring water, such as rises from chalk or limestone formations, is the best. River water that flows in a hilly district, is also generally good ; when its course is through moss or level districts of country, it holds vegetable remains in solution, and the yeast takes a character from its use as well as the extract from the malt. Ale made with it is always soft, rarely in very good condition, and apt to be readily influenced by atmospheric change and run into acidity.

The choice of materials is in the power of every brewer. The preparatory steps to be taken in bringing them into operation to the best advantage, and in carrying through the various processes with skill and economy, so as to secure a production of the best possible quality commensurate with the quantity of material employed, must now engage his attention.

- The whole art of brewing ale is comprehended in the six following divisions : 1. Malting, and preparation of malt ; 2. Mashing ; 3. Boiling ; 4. Cooling ; 5. Fermentation ; 6. Cleansing. Storing and management of vats, and racking and mixing of stock for delivery, may be reckoned another division ; but the six enumerated combine the art of making ale and bringing it forward to its first finished state. A

brewer, to be proficient in his business, must examine each of these processes by itself; he must study each in all its bearings, and endeavour to find out a reason, founded on sound principles, for the action of the matter before him, for the cause of that action, and for the successive changes which are produced on the malt and water by the agency of caloric, as he combines one part of the process with the next, until the whole experiment is successfully carried through to the desired result.

The investigations into the various processes of malting and brewing by Dr Thomson of Glásgow have led to a better knowledge of these arts, which it may be necessary shortly to notice.

During the course of last century, from the time that the art of manufacturing strong beer and ale underwent a decided change by the gradual substitution of porter in London for public consumpt, there are no authors whose works can be referred to as affording any thing like a rational theory of the art of brewing malted liquors. Chemists had not yet advanced so far in analytical research, as to investigate the intricacies of the decomposition of barley,—to follow up the action of caloric on its constituent substances,—to discover the principle of fermentation, and to illustrate the formation of sugar, carbonic acid, and alcohol, by demonstrative experiment. At a very early period, Mr Combrune, a London brewer, found out that in the mashing process malt had the property of taking in water at a high

degree of temperature, in proportion to its high dried colour, and resolving into sugar without setting, or being converted into glutinous paste; and although his experiments in the drying of malt, and the colour which it assumes by exposure to certain degrees of heat, have been proved by Dr Thomson to be altogether erroneous, arising from the improper manner of conducting his experiments, it cannot be doubted, that his writings had for many years a decided influence on the practice of English brewing.

Towards the latter end of the century, Mr Richardson, a brewer of Hull, constructed the first saccharometer, by weighing a barrel of water and converting it into malt wort. By weighing it again, he ascertained the weight of saccharum held in solution. The idea was ingenious, but, like Mr Combrune's experiment, was not founded on correct principle. This subject, now become of infinite importance to distillers and brewers, fell also under the investigation of Dr Thomson about the year 1805, who discovered that the capacity of water to hold sugar in solution differed at different degrees of heat; and that to construct a saccharometer on a true principle of science, it was necessary, using his own words, "to dissolve determinate weights of the solid extract of malt in given quantities of water." Dr Thomson afterwards constructed the saccharometer, now so well known as Allan's, the name of the instrument-maker in Edinburgh who manufactured it. "It indicates the specific gravity of the wort, from which,

by means of a sliding rule, which accompanies the instrument, the weight of saccharine matter contained in it is at once determined."

The utility of this instrument is now universally appreciated. With this invaluable guide, the brewer is enabled to work out his process with confidence. Whatever may be his knowledge derived from experience, this checks all erroneous calculation, and always proves the present weight of saccharum in hand,—a most important point in brewing economy.

Dr Thomson had made numerous experiments on barley, malted and unmalted; and during these investigations, he discovered the law, that malt preserves its pale colour on the kiln at a very high temperature, in proportion as the heat is gradually increased; a most important discovery, because it follows, that this high-dried pale malt will stand a higher mashing heat, and afford a stronger and richer extract, besides turning out a better keeping malt than that kiln-dried at a lower temperature.

Mr Combrune's rule, that the heat of the water in mashing ought to be regulated by the colour of the malt, and, therefore, that the paler the malt, the lower ought to be the temperature of the mashing water, and the browner the colour, the higher temperature it will bear without setting, should thus be taken with reservation. It is only true when the malt has been properly kiln-dried, and when heat, at a very high temperature, judiciously applied, is the cause of the colour of the malt. Mr Combrune's experiments on

the heats at which it changed colour from pale to brown and black, were founded in error. They were not conducted on a maltster's kiln, but, as Dr Thomson observes, by placing a sample of undried malt in an earthen pan, and setting it in a stove, and, by stirring it as the malt deepened in colour, ascertaining its increased heat by the thermometer, the malt at the bottom of the jar next the fire probably being exposed to 200° or 300° of heat.

The experiments of Dr Thomson not only proved the fallacy of Mr Combrune's conclusions; but they brought out the valuable truth—that malt has the capacity of bearing a very high temperature on the kiln, without losing either its pale colour or the power of germination. When the heat is gradually increased from 100°, it may be raised to 175°, without loss of colour, and with a capacity of bearing a high degree of heat in the process of mashing, without setting the mash.

Pale malt, dried at a high temperature, keeps a much longer time, without imbibing so much moisture as to injure the future extract, than when dried at the heats which maltsters generally employ; and it will invariably be found, that when dried by this law of Dr Thomson, the saccharine extract will not only be of greater weight, but of finer flavour, than when dried at low temperature, and preserve its qualities for a much longer time when kept in stock.

Very great care, however, is necessary, in kiln-

drying malt at a high temperature, to preserve its colour and mellowness. It must be gradually brought up from  $90^{\circ}$  or  $100^{\circ}$ , with this especial observance, that the kiln requires to be previously tempered to these heats before the malt is spread on its floor. The malt being turned after it has been on the kiln two or three hours, the heat is gradually raised to  $120^{\circ}$ . During this increase of heat it is turned again, and the temperature gradually raised to  $140^{\circ}$  and  $150^{\circ}$ ; now precisely at this period it may be continued and finished on the kiln, as is the present general practice, or the heat may be increased further up to  $170^{\circ}$  or  $175^{\circ}$ , according to Dr Thomson's law, the maltster watching its colour, and trying its condition. It must be pale and mellow, the ends of the grain not having the least appearance of being dried brown, or scorched, and having preserved this condition at these increased heats, the furnace or fire-grate is drawn, and the kiln is finished, by allowing the malt to remain on the floor until the comings (rootlets) are trodden or screened off before removing it into stock.

The third investigation is the theory of fermentation; a subject so important and valuable to brewers and distillers, as leading them in safety to the practical methods of securing the best fermentation in their respective processes of brewing and distillation.

It is evident that the theory of fermentation could only be established by the knowledge of the consti-

tuent principles of sugar by chemical analysis. During the eighteenth century, chemical science had not advanced so far as to enable the best chemists to be equal to the task. Lavoisier was the first who attempted the solution of this intricate investigation; and he was followed by the most distinguished philosophers in Europe who turned their attention to the subject. Dr Thomson, having examined and combined the various experiments of these eminent chemists with his own researches on the subject, has arrived at the important conclusion, that glucosin, or the sugar of starch, is resolved, by decomposition, into equal parts of alcohol and carbonic acid.

The fermentation, therefore, of malt wort is the action which accompanies its resolution into these substances. It is necessarily either spontaneous or artificial. It is well known, that when wort or any other solution of sugar, at a temperature above  $70^{\circ}$ , is allowed to remain in a warm atmosphere, it begins spontaneously the process of fermentation; and that when treated with a proportion of fresh yeast, this process immediately commences. But yeast cannot be said to be the fermenting principle. Yeast is a combination of various substances derived from malt, which are agglutinated and separate from the pure wort during fermentation. Dr Thomson has shewn that none of the substances which compose yeast has the power of commencing fermentation; and comes to the only conclusion that can, perhaps, ever possibly be arrived at,—that it is sugar in a state of partial

decomposition that acts as the fermenting principle, and which is brought over from the wort along with the other substances contained in yeast. Intelligent brewers will instantly corroborate this important fact. They know when fresh wort is thrown upon yeast, and stirred together, how strongly and rapidly it springs into fermentation, and how useful it is in bringing forward the languid gyle; and that when the head of yeast on the gyle-tun is beat in, and sent down, holding sugar in partial decomposition, to react on the worts beneath, how effectually the process is renewed. The same principle works in the English method of cleansing, when the barrels are kept regularly filled up with half-fermented worts, until the yeast assumes the agglutinated form, and separates from the ale altogether.

The repeated doses of fresh yeast which distillers are obliged to use to work down their worts to as great attenuation as possible, also prove that sugar, in a partial state of decomposition, is the true fermenting principle, and that it is only by viewing it in this light that any approximation can be made in forming an estimate of the equivalent values of different yeast in the process of fermentation.

The investigations of Dr Thomson are so important, that they may be justly placed before the reader as the foundation of many improvements in the art of brewing.

1. That the capacity of water to hold sugar in so-

lution differs at different degrees of temperature, and that the specific gravity of malt wort can only be proved by dissolving determinate quantities of the solid saccharine extract of malt in given quantities of water.\*

2. That malt at a high temperature, in kiln-drying, maintains its pale colour and quality of producing the richest ale-worts, in proportion as the heat is gradually raised; and that in proportion to the high temperature at which it is dried, it bears a high degree of heat in the process of mashing without setting the goods.

3. That the theory of fermentation is resolved by the decomposition of sugar into equal parts of alcohol and carbonic acid; and that the principle of fermentation in yeast is sugar in a state of partial decomposition.

I shall conclude this chapter with some observations on the proportion of materials, and degrees of heat, used in the processes of brewing. These observations of facts, made in the course of practical experience, may afford the reader a general knowledge of the art; and, taken in connection with Dr Thomson's investigations, already explained, draw the attention of brewers and distillers to such parts of the

\* This discovery was immediately followed by the construction of the saccharometer on correct principles, which was made under Dr Thomson's directions, by Mr Allan, a mathematical instrument-maker, Edinburgh.

process as, in the present methods of working, admit of improvement.

*Rules, Proportions of Materials, and Heats used  
in the Process of Brewing Malt Liquors.*

1. Barley, when dried on the kiln, possesses the same constituent principles as when artificially germinated, and converted into malt. In either state, when crushed or ground, and treated with water raised to the temperature of 150° for raw grain, and 175° for malt, and allowed to digest three hours, the starch they contain is changed into glucosin or starch-sugar.

2. The quantity of water employed for the first mash may be averaged as twice the weight of the malt. The quantity for the second and third mash is proportioned to the required strength of the ale, and the time and manner of boiling and cooling the worts.

3. The capacity of malt to retain the wort of the first mash is 28 gallons for every quarter of malt in operation. This capacity decreases in proportion to the increase of pressure from increased quantities of malt in operation.

4. Boiling the worts combines four actions, which affect the saccharine extract. (1.) The process of boiling, which cuts the wort, and coagulates part of the starch of the malt, and other vegetable matter

which comes over in solution from the mash. (2.) Condensation, the amount of the weight of which is equal to what was contained in the wort driven off by evaporation. (3.) Escape of the wort by evaporation. (4.) Destruction of part of the saccharine extract by evaporation during the time of boiling.

5. One and a-half hour's rapid boiling is sufficient for any wort whatever. The additional time of boiling being necessary only to condense the worts to a required weight of saccharine extract, called boiling down to strength.

6. Worts boil down in an open boiler 5 lbs. saccharine extract per barrel in one hour, when their weight, as indicated by Dr Thomson's saccharometer, is 50 lbs. per barrel; and this rate increases one to ten every hour they are subjected to the boiling temperature. Thus worts of 60 lbs. per barrel, boil down 6 lbs. per hour; 70 lbs. per barrel, 7 lbs. per hour; and so on in regular proportion, up to the greatest weight saccharine extract is obtained for making ales.

7. Hops give out, first, their fine aromatic bitter principle; and, second, their empyreumatic bitter, in proportion to the time and manner of boiling the wort.

8. Hops take up four times their weight of wort; but this capacity to retain worts diminishes in proportion to the length of time of boiling.

9. Worts, from the time of being spread on the coolers at a boiling temperature, until cooled down to

60°, lose one-eighth part of their bulk by evaporation, and condense in proportion to the quantity of water driven off,—deducting that portion of saccharum which escapes during evaporation. This amount of condensation on the coolers, added to that which takes place in boiling, may be calculated by the brewer when he first ascertains the quantity of worts he has obtained from the mash, and their weight, as indicated by the saccharometer. By such a calculation he is enabled to shorten or vary his future process, so as to take advantage of the superior strength of the mash from working fine malt, and increase his production of ale in proportion.

10. Attenuation, or resolution of brewer's wort into alcohol, when carried a certain length, decreases in proportion to the strength of the wort. As the carbonic acid escapes, by the process of fermentation, the alcohol increases, until it acquires strength gradually to destroy the fermenting principle. In strong wort for ale, this attenuation must be carried down according to its weight of saccharum. When the worts range from 90 to 120 lbs. per barrel, the attenuation may be regulated with precision. When they range from 60 to 90 lbs. for weaker ales, the attenuation increases in proportion to the weakness of the wort, and is apt to work down more than the brewer desires. Weak ales, over-attenuated, lose in value, and are injured in proportion to the saccharum taken up, which ought to have been

left in sufficient quantity to give a fulness of taste to the ale in consumpt.

11. In pitching the worts, or setting them to yeast,  $52\frac{1}{2}^{\circ}$  is the mean heat for the slow method of fermentation, with an increase of  $10^{\circ}$  for the process of attenuation;  $62\frac{1}{2}^{\circ}$  is the mean for the quick method, with an increase of  $10^{\circ}$  for being finished in the gyle;  $7\frac{1}{2}$  per cent. of the worts may be calculated as the quantity taken up by the formation of yeast, and loss and waste by the slow, and 10 per cent. by the quick, method of fermentation. In the slow method, one gallon of yeast to four barrels of wort, and in the quick method, two gallons of yeast to five barrels of worts are good proportions to form the onset. In summer, a third less in the slow method is sufficient for the purpose; in the quick method, the same proportion is nearly preserved throughout the year.

12. *Maximum Extract of Starch-Sugar from Malt.*—As this is a question of very great importance to brewers, and as no arbitrary rule can possibly be laid down on the subject, I shall endeavour, in a concise and explicit manner, to offer a few remarks founded on practical experience.

It is evident that the productiveness of malt in yielding saccharine matter, depends on the quality of the barley from which it is made, and on the skill by which it has been artificially germinated and dried on the kiln. About this there cannot be any dispute; and there is no occasion whatever for

entering into the question, at present, of the best methods for making malt.

To understand the matter properly, barley must be divided into three or four qualities, which, supposing it to be of English growth, and manufactured by English workmen in the most approved and skilful manner, places the question at once on a fair footing.

By what standard are we to determine either the produce of each of the qualities of barley, or the average of the whole? If the evidence of individual brewers generally is taken, the accounts are so conflicting and erroneous, that no dependence whatever can be placed on such testimony; that these erroneous and conflicting opinions are the result of ignorance, no one can imagine for a moment. They spring simply from the brewer never having made a number of trials of the worts, as obtained from the mash, and then measuring them by the saccharometer after being boiled and cooled down to strength. It must have been from some erroneous calculation, that the officers of excise gave information to Government in 1846, that the average of brewers' worts in England contained  $22\frac{1}{2}$  lbs. saccharum per bushel; and it was upon this evidence that 180 lbs. of sugar were held equivalent to a quarter of malt, to strike the drawback upon the duty on sugar used by brewers and distillers. This estimate, it may be remarked in passing, was too low by  $1\frac{1}{2}$  lbs. per bushel, and no distinction was made betwixt brewers' worts and those of the distiller, who do not boil them, but run

them immediately into the coolers from the mash-tun, and thus save the loss which arises to the brewer in boiling by the evaporation of the wort and destruction of part of the saccharum during the process.

But this is not all. Mr Huskison, many years ago, in his place in the House of Commons, asserted, on the occasion of a question on the malt-tax, that the quantity of ale brewed from a quarter of malt was  $3\frac{1}{2}$  barrels, and that on comparing the amount of barrels of ale and beer brewed with the quantity of malt paid duties for, there appeared 500,000 quarters which had been manufactured without paying duty; and thereupon, on a charge which had no foundation whatever, the stringent and oppressive regulations on the maltsters and brewers of England were justified. The fact was asserted on erroneous calculation. The quantity of beer and ale brewed was exaggerated by half a barrel to each quarter of malt; and no outcome was allowed on malt measured when made above what is charged duty for in the process of malting, which amounts to five per cent. on the whole annual quantity made. Besides, brewers, during the whole time the tax was charged on their productions, paid duty on more beer and ale than they made. The gauge was taken from the gyle-tun; and they could never cleanse, by at least five per cent., what they were charged with. I have mentioned these matters to shew that maltsters and brewers did not complain without reason of the grievances they had

to endure under the fiscal regulations of the excise. It is not that the excise-officer overstepped his power; for, both in England and Scotland, during a long experience, I have generally found them to be fair and candid in their charging the duties. It is the system that injures the fair trader that is in fault, and the sooner it is amended the better.

To return from this digression, which, however, is not by any means foreign to the subject, the maximum quantity of saccharine extract obtained from malt may be stated as follows:—

First quality of barley, . . . .	30 lbs. per bushel.
Deduct loss of saccharum in boiling two hours, and in cooling and hop-drain, . . . . .	$3\frac{1}{2}$
Left for fermentation, . . . .	<u><math>26\frac{1}{2}</math></u>
Second quality of barley, . . . .	28 lbs. per bushel.
Deduct loss of saccharum, . . . .	$3\frac{1}{2}$
Left for fermentation, . . . .	<u><math>24\frac{1}{2}</math></u>
Third quality of barley, . . . .	25 lbs. per bushel.
Deduct loss of saccharum, . . . .	$2\frac{1}{2}$
Left for fermentation, . . . .	<u><math>22\frac{1}{2}</math></u>
Fourth quality of barley, . . . .	23 lbs. per bushel.
Deduct loss of saccharum, . . . .	$2\frac{1}{2}$
Left for fermentation, . . . .	<u><math>20\frac{1}{2}</math></u>

The reader will thus perceive the immense advan-

tage which brewers ought to derive from the purchase of the best samples of barley, and economy and skill both in malting and brewing. I shall have occasion afterwards to advert again to this subject, when such improvements will be suggested as may lead towards a saving of the saccharine extract in brewing.

These definitions and rules are offered not without hesitation. Facts derived from experience are merely approximations, and require to be confirmed by the test of strict experiment; but whatever promises to be profitable ought to be communicated. It is in art as in science, truth sometimes can only be approached by approximation; and improvement ought to be attempted, when the nearness of the approach is sufficient for the purposes of practical utility.

## CHAPTER II.

### OF THE SCOTTISH SYSTEM OF ALE-BREWING.

The system of brewing ale adopted in Scotland, exhibits superiority only in those places where justice is done in taking the previous steps of malting the finest quality of barley; in providing hops of that particular description necessary for imparting a fine aromatic flavour, and in carrying through the whole process with that care and skill which experience in making a fine quality of ale bestows. In these re-

spects, Edinburgh, or rather the Mid-Lothian district of Scotland, maintains a decided eminence in the production of ale. Its uniform good quality gives the brewers unity of character, similar to those of London in the manufacture of porter.

There are other localities, however, in which ales are made of a very fine description. The Alloa and Stirling district, including Perth eastward to Montrose, have been celebrated many years, and may justly rank with Edinburgh in their productions. In all these places the methods of working are nearly similar, differing, however, in some parts of the process so as to give the ale a character of its own, which is easily distinguished in any part of the country where it is presented for use.

In giving a detail of the methods adopted in working out the Scottish system, I shall offer such observations as may afford the practical brewer useful information in the various processes of mashing, boiling, cooling, fermentation, and cleansing, comparing, as I proceed, the English method of these operations, so far as may give an extended view of the whole art of brewing.

1. *Mashing*.—The most eminent practical chemists who have turned their attention towards investigating the processes of brewing, have not, as yet, proved by the demonstration of experiment, the theory of converting the starch of barley into sugar, or, as it is now called, glucosin. It is known, that when

starch is boiled four or five hours with dilute sulphuric acid the formation of glucosin or starch-sugar is the result ; and that when barley, either in the state of raw grain, or artificially germinated, is dried in a kiln at a temperature gradually increased from  $100^{\circ}$  to  $150^{\circ}$  or  $170^{\circ}$ , and thereafter crushed or ground, and treated with water from  $150^{\circ}$  to  $180^{\circ}$ , the starch it contains is also changed into glucosin, or sugar similar in its constituent principles to that obtained from common starch boiled with dilute sulphuric acid. In mashing of malted barley, no acid is known to exist by which the change of its starch into sugar can be effected. It must therefore be held, either that the agency of water heated up to  $170^{\circ}$  affects the change, by a portion of the water combining with the starch, or that the barley acquires in kiln-drying a new property by the action of caloric sufficient to convert its starch into sugar. In this last case, in the absence of demonstration by experiment, recourse must be had to hypothetical reasoning. It may be urged, that when barley malted or unmalted is dried on the kiln, it loses a fifth part of its original weight by the water it contains, being driven off by caloric, or, in other words, that it parts with oxygen and hydrogen in such proportions as form water. Now, in kiln-drying malt, the continued action of caloric on its substance, might produce carbon, which, uniting with the oxygen, would form carbonic acid.

In the process of mashing, the malt would thus

take up from the water the proportions of oxygen and hydrogen it lost, and give out carbonic acid. This partial decomposition of the water, and escape of carbonic acid, would render the whole sufficiently acidulous to convert the starch of the malt into sugar, and thus account for the agency that effects the change.

The subject, however, is a question of chemistry. Brewers, at present, must be satisfied with the observation of fact, which is sufficient for every purpose of practical usefulness, that water heated to  $175^{\circ}$  extracts the sugar of malt, whatever may be the agent by which the change is effected.

Supposing a brewing of twenty barrels of ale is required to be made from eighty bushels of malt and eighty pounds of hops. The utensils being all in a state of readiness, and the malt and liquor (water) prepared, three or four barrels of liquor, at a temperature of  $180^{\circ}$ , are first let down into the mash-tun, and, at the same time, the sluice of the malt-bing is opened, and the malt and remainder of the liquor, at  $175^{\circ}$ , run down together, and are immediately mixed and stirred by men with oars. The time occupied in mashing is about three quarters of an hour, according to the quantity of malt in operation. The whole quantity of liquor for the mash is twenty barrels. The head of the mash-tun is now closely covered, and the mash allowed three hours to extract.

The heat of the liquor, when let down into the

mash-tun, was  $175^{\circ}$ , that of the grist  $55^{\circ}$ . Ten minutes after the whole was run down, the heat of the mash at the surface was  $138^{\circ}$ . The water had lost  $37^{\circ}$ , but the malt had gained  $83^{\circ}$  of heat. The weight of the water was two-and-a-quarter times that of the malt; the mean heat of the mash, therefore, should have been  $142^{\circ}$ . The heat, which, contrary to the usual law, is least at the surface of the mash, must account for the deficiency in any trial the brewer makes of heats of the worts after the mash is laid on.

The mash having remained three hours to extract, the head of the tun is uncovered, and the sparger fixed. The sparger is a cylinder made of copper or other metal, about five or six inches in diameter, but, of course, made in proportion to the size of the mash-tun. It is closed at both ends, and nearly so to within a foot of the centre, which is open with a cross division, against which a run of liquor, by a spout from the copper, strikes, and sends it round the tun. An iron bar is fixed across the latter, on which the sparger is placed on a pivot. Its two arms extend the width of the tun, the under side of these are pierced with small holes similar to the mouth of a watering-pan, from which, as it revolves, the liquor escapes, and sprinkles the mash.

The liquor in the boiler being tempered to the heat required for sparging (*sprinkling*),  $185^{\circ}$ , the taps of the mash-tun are slacked (*set*), and the worts are permitted to flow slowly at first, until they be-

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come transparent. The sparger, at the same time, is put in motion, with as much liquor at  $185^{\circ}$ , as of worts which flow from the taps, care being taken that the head of the mash is never dry; and this flow from the taps, and sprinkling on the surface, go on until the required quantity of worts for the brewing is obtained.

The heat of the mash, when the taps are set, is  $140^{\circ}$  at the surface, and  $150^{\circ}$  at the bottom of the mash-tun. These are generally the degrees of heat in the Edinburgh method of mashing, and they are equivalent to the heats in the English method of mashing and stirring with machinery. The law which regulates the cooling of fluids is reversed in the worts of the brewers' mash-tun, the heat being there greatest at the bottom, instead of the surface. This arises from the malt settling down when left in a state of repose, and preventing the colder stratum of wort descending from the surface, and displacing that which is beneath. The worts, therefore, at the under part of the mash-tun are confined, and cannot ascend. The heat lost escapes through the side of the mash-tub, but this is in a very trifling degree. When the pure worts are drawn either from the taps or from the surface, they immediately obey the general law.

In sparging, when the malt swells up a little, it is a favourable sign of the extract being good. I have already observed that the head of the mash should not be run dry in sparging. The reason is, that

when such is the case, the goods sink, and the surface cracks, the liquor then percolates without extracting its due share of saccharine matter from the malt. There is another evil, should the sparging liquor be rather at a high temperature: it dissolves the starch of the malt without converting it into sugar, and escapes with it by too rapid descent through the grains, rendering the worts opaque, and endangering the future quality of the ale.

To return to the brewing in hand, the method of laying on the first mash having been described, together with the process of sparging, the strength of the first wort is ascertained by the saccharometer to be 96 lbs. per barrel. The weight should be ascertained when two or three barrels of the worts are drawn, as they are then transparent, and shew their real strength and quality, on which the brewer depends to regulate his future proceedings. The weight of the worts, when the mash is in the process of transfusion by the sparging liquor, must be carefully watched. The strength of the sparge gradually diminishes as the process advances, until the weight is down to from 10 lbs. to 15 lbs. per barrel. In the present case, the whole wort required for the brewing is 30 barrels, which, being recovered and pumped up into the wort copper, is found to be of the weight of 72 lbs. saccharine extract per barrel.

The reader will perceive that sparging or sprinkling is merely a continuation of the first mash, and that the difference of extracting the saccharine mat-

ter by this method and that of stirring the second mash by the English mode, and allowing it time to infuse, lies in drawing off all the extract the brewer desires, by the continuous sprinkling on the surface, until the whole quantity is obtained ; while the English brewer has to lay on a third mash for the same purpose, at the disadvantage of being obliged to boil down a longer time to strength. I am decidedly of opinion that a judicious application of the sprinkling method in the English system, would be highly advantageous in obtaining the full saccharine extract with a shorter quantity of wort, and thus shorten the time of boiling, the prolongation of which is so injurious to the quality of the ale. Suppose that the first two mashes were laid on and drawn at a fourth less quantity, and that, in taking off the second mash, the sparger was applied, and slowly wrought, there cannot be a doubt that a stronger wort would be obtained, so as to shorten the boiling to an hour and a half, and thus preserve a considerable portion of the wort lost by evaporation, and the fine aroma of the hops besides. The Scotch neither get a stronger nor a finer wort by sparging, than the English brewer by stirring the mashes and giving them time to infuse ; on the contrary, the former, by sparging, send down a considerable portion of the small dreg, or dissolved starch, without being converted into sugar, which descends through the grains, and escapes into the underback, rendering the wort opaque, and not unfrequently carrying a cloudiness into the finished

ale. The Edinburgh brewers are perfectly aware of this; the superior quality of material they employ, and the great care and skill with which all their operations are conducted, enable them to regulate their first mash with the sparging process, so as to afford them all the advantage the English derive from stirring and infusing the second and third mash, without any necessity for damaging the wort by long boiling.

In both methods, the first mash regulates and gives a character to the whole brewing; the second, whether by sparging or stirring, secures it with regard to strength and flavour, and is hardly of less consequence than the first.

It has been confidently asserted by authors on brewing, that the first mash determines the value of the whole wort, and that the succeeding mashes only wash out the first, which saturate the grains, and no more saccharum is formed. It is of importance that the reader should be guarded against these fallacies. The English method of mashing sets the question at rest. Suppose 72 bushels of malt treated with water, at  $170^{\circ}$ , to the extent of 27 barrels; 20 barrels of wort will be obtained, at 60 lbs. extract per barrel, making 1200 lbs. saccharum, 7 barrels being taken up by the malt, which, at 60 lbs., are 420 lbs. left in the grains; 20 barrels are laid on for the second mash at  $190^{\circ}$ , which come over at 40 lbs. extract per barrel, making 800 lbs.; so that we have a substantial proof that 380 lbs. of saccharum have been

formed in the second mash, besides what has been left for small beer.

Dr Thomson's law that malt has the capacity to maintain its quality and pale colour at a high temperature, in proportion as the heat is gradually increased in kiln-drying; and the important fact he relates, that, at a temperature of  $175^{\circ}$ , it not only preserved the pale colour, but the power of germination, have all a close relation-with the heats at which water requires to be mixed with malt, to produce the best extract of glucosin, or starch-sugar, in the process of mashing. According to intelligent brewers, when the malt is first placed in the mash-tun, and the water run down into it through the bottom,  $170^{\circ}$  is the best and safest heat that can be used. When the water is first run into the mash-tun, and then the malt shot into it from the hopper above,  $180^{\circ}$  is the best heat. From these different methods of working the first mash, these heats are equivalent; and  $175^{\circ}$ , being the mean, may be taken as the best that can be employed. Now this is precisely the degree of heat at which, according to Dr Thomson, malt had preserved its virtues in kiln-drying. The coincidence is remarkable, and leads to the conclusion, that, in proportion to the temperature at which pale malt has been finished on the kiln, the heats in mashing ought to be regulated to produce the greatest saccharine extract.

The quantity of liquor (water) required for the first mash, in the Scottish system of brewing, can-

not be determined by any arbitrary rule. One-and-a-half to two barrels of water for each quarter of malt in operation, are used by brewers according to their views and future disposal of the ale. Those of Edinburgh prefer a rich, strong extract from the first mash; and as, by the process of sparging, they can transfuse the second, or rather the continuation of the first mash to the required length, they always keep within two barrels of liquor to each quarter of malt.

To form a fair estimate of the advantage of the two methods, as practised in England and Scotland, it is necessary to have regard to the views of the brewer in the disposal and future consumpt of the ale. In Edinburgh, until within a few years back, it was generally made to be sent out to publicans and grocers for the purpose of being bottled. The methods of mashing, boiling the hop-worts, and fermentation, were the best that could possibly be adopted for brewing both their October or winter stock, and their summer or keeping ale. As the price is fixed according to the strength of the wort, and rated at a certain price per hogshead, the strength and flavour of these different priced ales required to be as equal and uniform as the brewer could possibly preserve; and thus the system of brewing became fitted for the production of such a quality of malted liquor. In England, the general consumption of beer and ale is in draught from the cask; and the English system of brewing is as admirably adapted for

the purpose as that of Edinburgh is for the consumption from bottle.

In effecting a change in their systems of brewing, therefore, it is for the brewery proprietor to judge first, whether or not such parts of the process could be adopted with advantage, without the great risk and expense of altering his utensils and general arrangements. I see no difficulty whatever in the matter. An English brewer, without any alteration of the utensils, may adopt, at any time, the Scotch modes of mashing and boiling the worts; and, according as these are judiciously carried through, it would be certainly attended with very great advantage, keeping the strength of the ales out of view altogether; because just as good ale can be brewed by one system as by the other. But economy in short boiling, and in obtaining a fine aromatic extract from the hops, are valuable considerations, and are of such easy attainment, that the subject cannot fail to attract inquiry.

The process of mashing ought to be carefully studied. It is here that the formation of glucosin, or starch-sugar, gives a character to the brewing. There is an aroma in the malt as well as in the hops, which requires to be as carefully preserved in mashing, as that of the latter in boiling the worts. It is only by extracting and preserving these virtues from the materials in the greatest degree, that malted liquors in the highest state of perfection can be produced; and it is on this, and by economy in con-

ducting each process, that many improvements in brewing depend. The best temperature of the water for mashing has been repeatedly noticed, as also the quantity to be used in proportion to the quantity of malt in operation, with the time and method of working; but a very important point is now presented to the brewer's consideration, and that is, from the state of the worts, as obtained from the mash, to determine his future proceeding.

After all the worts have been secured from the mash-tun, and being in possession of a certain quantity of proved strength, he should be able to calculate the evaporation that must take place during the process of boiling and cooling. He should know not only the amount of loss by evaporation from the boiler and coolers, but the destruction of saccharum which takes place during these operations, and thus be enabled to calculate the condensation or increase of weight down to the fermentation point.

When superior malt comes into operation, and yields an excess of saccharine extract, he confidently varies the future process to secure the advantage, and cleanse a greater quantity of ale. Should the brewer be his own master, in these matters he acts at his own discretion. Should he be acting in the employment of another, his aim will be to acquire such practical knowledge, not merely to improve himself in his profession, but for the benefit of the establishment he is engaged with.

In one point of view, the arts of distillation and

brewing are very easy matters. The Highland smuggler makes the best malt spirits that the country can produce ; and there are hundreds in England who make home-brewed ale in richness and quality superior even to that brewed in Edinburgh : all these artists trouble themselves very little about specific gravity, saccharine extract, or any chemical knowledge whatever ; they have choice and plenty of material ; but in regular establishments, where certain quantities are required from given proportions of materials, and where, indeed, from competition and expenses of business, it is requisite to work with the greatest economy throughout, it is fitting that the person who has the charge of the operative departments should have every facility of acquiring that general knowledge which will be satisfactory to himself and profitable to his employer.

I shall endeavour to illustrate this as applicable to the business of brewing.

Malt differs in quality in proportion generally to the quality of the barley from which it is made ; the weight of saccharine matter it contains, therefore, varies, according to quality, from 20 lbs. up to 30 lbs. per bushel. Now there are hundreds of brewers who have no choice whatever in selecting malt ;—they work up whatever comes to hand.

During the course of the year a variety of malt is operated with,—even made in their own malting, where good and indifferent samples are taken off the kiln and injudiciously mixed in stock. It is not every

brewer that tests his worts by the saccharometer,—many work by guess ; the same proportions of water and degrees of temperature are applied to all malt whatever, and the usual quantity of hops weighed for each brewing. The gauge of the mash-tun is known by a mark, and the time of boiling regularly kept. The worts are cooled down to the predetermined heat, and the usual pailfuls of yeast form the onset. The fermentation runs its course. The ale is cleansed, and is really good ; but it may, and often does happen, one very important *addition* is wanting,—fine malt has been in operation, and the wort has been five or six lbs. per barrel richer than usual. In a brewing of twenty-five barrels this would have made two barrels *in addition*, had the brewer had the knowledge to have weighed the worts from the mash, and worked out the process accordingly.

In describing the process of boiling and cooling, I shall notice the rate at which worts condense by evaporation from the boiler and coolers, and to which the reader is referred.

I shall close these observations on the process of mashing, by a remark on the influence of temperature of the atmosphere on that operation. Malt generally preserves an equable temperature, ranging from  $50^{\circ}$  to  $60^{\circ}$ , according to the situation in which it is kept in stock ;  $55^{\circ}$  may be taken as the heat of malt in good condition. When struck by the mashing-water at  $175^{\circ}$ , the water loses and the malt gains heat in proportion to the weight of these substances ;

and the mash, during the three hours, gains additional heat from the chemical action of the particles of matter in a state of decomposition and recomposition in the mash-tun. On these actions the temperature of the atmospheric air has little effect; so little, indeed, that there is no occasion, either in winter or summer, for changing the heats in mashing, care being taken that the water is let down in a close trough or spout, and that the head of the mash-tun is carefully covered up after stirring.

In sparging, when the thermometer is at the freezing-point, or below  $40^{\circ}$ , two or three degrees may be allowed; but it is really of little moment, the chief danger in mashing is from too high temperature. The law by which fluids are cooled when exposed to the atmosphere, does not apply to the brewer's mash, as the heat there is greatest at the bottom of the tun, and least at the surface.

Much has been written by authors on brewing, on danger, from gluten and mucilage coming over in large quantities with the saccharine extract from the malt. These dangers are visionary, and cannot possibly exist. Barley, in a state of raw grain, does not hold more than eight per cent. of gluten, mucilage, and albumen altogether; but when converted into malt, these substances almost disappear, being taken up by the rootlets and acrospire during the process of artificial germination. The danger is, that in mashing at too high temperature the starch of the vegetable becomes mucilaginous, or *sets*, in place of be-

ing converted into sugar, a circumstance which strikes the brewer with more terror than when the false bottom of the mash-tun breaks loose, and comes floating up in the mash !

2. *Boiling the Wort.*—The 30 barrels of wort, 72 lbs. saccharine extract per barrel, having been pumped up into the boiler, and brought through to boil for half an hour, 40 lbs. of the hops were added. In boiling the hops much care is requisite that they do not fry on the surface of the wort, by which is meant, that they do not come to the surface by the boiling action and froth, and give out their aroma and bitter principle with the vapour that escapes, before being incorporated with the saccharine extract. English brewers do not acknowledge this term of frying of the hops : in their method of brewing they get the better of the hops accumulating at the surface, and coming over with the boiling wort, when they use the open copper, by shutting the damper of the furnace, and beating down the head of the worts with an oar ; when an upper back is on the copper, such precautions are unnecessary. - In Edinburgh, neither upper back nor double boiler are used. A machine is now employed, which is inserted into the boiler, by which means the worts are permitted to boil through, but the hops are kept beneath the surface.

After boiling another half hour, the remainder of the hops is delivered into the boiler, and the boiling continued half an hour longer. This is sufficient both

to extract aroma and bitter principle of the hops, and to concentrate the saccharine extract by evaporation down to the required strength.

The worts in the boiler are 84 lbs. per barrel, as indicated by the saccharometer, when cooled down to 60°; but, in consequence of the evaporation which will take place on the coolers, their gravity will be in proportion to the water driven off by evaporation; and as this is an eighth part of their bulk, the increase of saccharine extract per barrel will be in the same proportion, deducting the saccharum that escapes into the atmosphere, during the process of cooling. On worts of 84 lbs. per barrel, the increase on the coolers will be 7 lbs. per barrel; their weight, therefore, when cooled down to 60°, will be 91 or 92 lbs. per barrel. For in this brewing, calculating that three barrels of wort evaporated, this leaves 252 lbs. saccharine extract, and deducting 1½ lbs. per bushel on the 80 bushels of malt in operation, as the amount of saccharum destroyed, 152 lbs. are left condensed in the wort, which is about 7 lbs. per barrel of increase to the remainder of the worts on the coolers.

The process of boiling the worts, like all the other processes in brewing, requires much attention and care to bring it through successfully with the least possible loss, and to preserve the aroma and first bitter of the hops. In the Rules on Brewing, I stated that one-and-a-half hour's boiling is sufficient for any wort whatever. I shall be glad to find that the experience of others, in the English system,

confirms this statement. From my own knowledge, I repeat, that it is not only sufficient, but more than enough to extract the virtue of the hops in the greatest perfection; although it is the practice, in many districts of England, to boil for two-and-a-half hours. By boiling so much, the fine essential aroma and first bitter are driven off, and a nauseous bitter left, injurious to ales of every description. There is much room for improvement in boiling and infusing the hops,—the subject is worthy of the best attention of those who are judicious enough to take advantage of the knowledge of the fact. The subject, indeed, is so important, that I shall recur to it again in the description of the system of English ale-brewing.

In the boiling of worts I have stated, that the process combines four actions which affect them, viz. :—

1. Boiling; 2. Evaporation; 3. Condensation; and,
4. The destruction, or escape of part of the saccharum.

The quantity of water evaporated is in proportion to the weight of saccharine matter condensed, adding to the amount of condensation 1 lb. per bushel of the whole quantity in operation, which escapes in this proportion, each hour the wort is exposed to the boiling temperature. The amount of condensation in boiling is 1 to 10 per hour, that is to say, worts of the gravity of 50 lbs. saccharum strengthen 5 lbs. per barrel in one hour's boiling; and, carrying on the same proportion, worts of 100 lbs. saccharine extract strengthen 10 lbs. per hour. Thus, worts of 100 lbs.

in one hour and a half boiling strengthen 15 lbs. ; and when to this is added the increase of strength by condensation on the coolers calculated in the same proportion as formerly, the weight of the brewing would be 124 lbs. saccharine extract per barrel, which is a sufficient approximation for practical purposes.

The brewer is thus provided with the means of shaping his processes after the recovery of the worts from the mash, to make the most of the property entrusted to him, by working with economy of materials, and to produce the greatest quantity of finished ale from a known quantity of worts.

3. *Cooling the Wort.*—The primary notion of cooling the worts after being finished in the boiler, would be to spread them in large shallow vessels, and expose as large a surface as possible to the atmospheric influence, which, by evaporation, would cool them down in the quickest manner to the temperature desired for fermentation. For it would be observed in ancient times, when the art of brewing malt liquors was first discovered, that otherwise the wort, by too long exposure, would spontaneously ferment and run into acidity. Throughout the long period since the art of brewing, and afterwards, since the fifteenth century, when the art of distilling ardent spirits from wine and vegetable sugar, were discovered, this plan seems the only one that ever has been followed until within the present century, when the British distillers found out, that

by running the worts through pipes immersed in water, they could regulate the temperature to their desired point, and avoid the waste by evaporation altogether. Whether this mode of cooling had ever been previously adopted by distillers or brewers in foreign countries, cannot be properly ascertained. There does not appear any authority extant on the subject, and it may be justly inferred, that it was first practised in England. The method is so simple, that to the general reader it may well appear surprising that it had not been followed by brewers of malted liquors, who suffer such immense loss by the evaporation of their worts, both in the processes of boiling and cooling ; but the surprise must increase when they are told, that the Legislature prohibited this important improvement by severe penalties, and obliged them to run their boiling worts direct into the coolers. It must be perfectly understood by practical men, and by those of scientific acquirement, who have turned their investigations towards these subjects, that all acts of Parliament to regulate the processes of malting, brewing, and distillation, either by the construction or size of utensils, or to work by time, and to regulate the strength of the worts extracted during the processes, are all injurious, and alike destructive to the private property of those who have capitals embarked, and to the revenue itself. Brewers have got rid of their grievances by the repeal of the beer-duties ; but maltsters and distillers still suffer by the ignorant legislation of former days.

How absurd it is to require twenty-four hours' notice before sprinkling a floor of malt, or setting yeast to the gyle-tun that is hurrying to immediate destruction for want of the artificial principle of fermentation. Were the Government to levy the duties on the finished production, making such drawback, or rather allowance for waste or necessary loss, as the nature of the manufacture demands, and allow all the processes of such manufactories as are subject to excise laws, to be worked to as much advantage as capital and ingenuity can exert, without control or hindrance, it would be nothing but what the fair trader has a right to enjoy; and it would ultimately be of immense benefit both to the manufacturer and to the revenue of the country besides.

The worts, of the present brewing, having been boiled for one hour and a half, and allowed to remain in the copper for the space of a quarter of an hour after drawing the furnace, their strength, as indicated by the saccharometer, being 84 lbs. per barrel, are then run into the hop-back, and from thence spread on the coolers. The hops are stirred when first the worts are run from the boiler, to allow as much of them to escape as possible, and lodge at the bottom of the hop-drainer. The worts thus filtrate clearer into the coolers. The brewer always regulates the time of the brewing, so as to admit of the worts being run into the coolers during the afternoon, that they may catch the coolest time of the night to go down to the fermentation degree of heat required.

The sooner they are brought down to this point the better. It sometimes happens, though rarely, that they fox, or set the backs, as it is termed, which means, that in consequence of being too long on the coolers, or from the latter not being properly cleaned, they begin to ferment, and are apt to run into the acetic state. In all cases, they should be cooled down and pitched to ferment, within twelve hours from the time of being run from the copper. When the worts are spread on the coolers, they immediately begin to condense,—to concentrate in weight by evaporation,—and to throw off part of the saccharine extract, all which go on during the time they are exposed to the influence of the atmosphere; the process of cooling, therefore, ought to be studied by brewers, so as to carry it through with the greatest possible economy and expedition, to preserve the quality of the ale in operation. The amount of condensation is ascertained by the saccharometer, which, if constructed on correct principles, indicates, at any temperature of heat down to  $60^{\circ}$ , the weight of saccharine extract the worts contain. The quantity of wort evaporated may be calculated by the increased density of that which is left on the coolers, deducting the saccharine matter destroyed during the process. When the worts are cooled down to  $60^{\circ}$ , the brewer may then gauge them, and ascertain their quantity, as also their strength by the saccharometer. By comparing the total quantity and weight with those of the mash, and striking the difference, he will ob-

serve what has been lost during the whole process. It is of importance for him to be enabled to do so. From the time of laying on the mash, until the worts are cooled down to the fermentation point, every process should be carefully watched, and the worts tested by the saccharometer. According to their quantity and strength, the process can be varied in perfect safety, so as to secure the greatest amount of finished ale. Without the utmost precaution—it cannot be too often repeated—waste occurs; and whatever may be the skill and experience of the operative, it will be readily admitted that economy is a qualification valuable in proportion to the judgment with which it is exercised. In brewing malted liquors, there is neither economy in sparing the materials, nor in using them of inferior descriptions. The best malt and hops are the cheapest, in the end, that a brewer can use who studies his own interest; and it will ever be found, that, in the manufacture of ales, their strength and richness of flavour will be something in proportion to the economy with which the process has been conducted.

Various methods of cooling the worts are practised, but that still in general use is by the open cooler. Some distillers, it has been already noticed, run them through pipes of great length, immersed in water, and thus cool them down to any required temperature; but this method does not answer brewers, who must get rid of the coagulated fecula and vegetable sediment, which distillers admit into their fer-

menting-tuns without hesitation, as these promote the fermenting process. I shall mention several new methods of cooling, which are worthy the immediate attention of brewers.

When the worts are first run from the copper, they are sent through a tube immersed in water, lodged in a receiver, and which is capable of holding one or two hogsheads; after being subjected to the influence of the water a sufficient time, they are displaced by another charge, and the first spread on the cooler adjoining; and this process goes on until the whole contents of the copper are subjected to refrigeration. This method saves part of the wort, which otherwise would be driven off by evaporation, and permits the deposit of the sediment on the coolers, during the whole time they remain afterwards until they go down to the fermentation heat.

Another method is to fix a flat, water-tight receiver round the inside of the whole cooler, the bottom of which dips an inch into the wort. Cold water being run through this receiver, its influence strikes the worts beneath, and cools them down rapidly.

Or the worts, after being cooled in the usual manner to  $75^{\circ}$ , are let down from the coolers, through a worm placed in a large cask filled with water, and are cooled down to the temperature the brewer requires.

In practice, I have used the latter occasionally in summer brewing, and found it always to answer the purpose. In all methods of cooling, where the eva-

poration of the worts is prevented, they must be first boiled down to strength in proportion.

The iron cooler, adopted by some brewers, is also very useful, when, from the warmth of the atmosphere in summer, the worts are slow of going down to the temperature required. A quantity of water from the brewery-well is pumped into the cooler; the water is generally at  $40^{\circ}$  to  $44^{\circ}$ ; the iron soon acquires this temperature, and the water being let off, and the cooler quickly mopped dry, the worts are run into it to the depth of an inch, and thus go down successively to the required heat, to be run into the gyle.

I have noticed these methods as being very useful. They are worthy of consideration, because they are at once simple and effective, and any brewer can adopt them without much expense.

But a regular method of cooling down the whole worts of a brewing on a correct principle, to bring them to the temperature of fermentation, and at the same time to admit them to deposit their sediment, and flow pure into the gyle, and this on a scale of magnitude sufficient for large establishments, is still wanting.

I am decidedly of opinion that this great improvement in the art of brewing will be speedily effected. Were a utensil so constructed as to hold the entire quantity of the brewing (or, when on a very large scale, it may be divided), and a supply of water kept constantly run on the surface, this utensil at the same time being kept full from the hop-back,

which, on an improved construction, would require to be used both as a drainer and reservoir, the worts could thus be cooled down sooner than by the open method of evaporation; the action of refrigeration being vertical, would carry down the sediment, and no loss of wort, nor of the saccharine extract whatever, would be sustained. I have proved this method on a small scale, and have no reason to doubt but that it would prove successful on the largest, and become a valuable acquisition to brewers and distillers.

It has been calculated that worts, in cooling, lose one-eighth of their bulk by evaporation; but they do not acquire a density in proportion to the quantity driven off; a part of the saccharine extract escapes at the same time, which must be deducted, and the difference shews the increase of weight they acquire when cooled down to 60°. The saccharum that escapes I have found to be about 1½ lbs. per bushel on the whole malt in operation; but this is merely a rough calculation made during practical operation, and requires confirmation by experiment. It sometimes happens that the worts of the same brewing are boiled down in separate coppers, and that the hops are used in different proportions in the process, the weaker wort being reserved until the stronger is run through the hop-back, and the hops left in it. The weaker wort is now run into the hops and carries off the strength which was left in them. In these cases, the stronger and weaker worts are cooled down

separately, and are mixed in the gyle-tun. The form of the hop-back is of some importance. They are of various constructions. Sometimes they are a square wooden frame pierced full of small holes in the bottom and round all the sides. This kind is tedious to work, as the hops fill up the holes, and the worts come through slowly but very pure. A second kind is close at the sides, and has open spars across the bottom, over which a hair-cloth is spread, through which the worts rapidly escape into the coolers. The best construction is that with a false bottom, like the mash-tun, with a stopcock to regulate the flow of the worts. This is the best kind in use, and ought to be adopted by all who would obtain a pure wort, and wish to manage the hops with the greatest economy.

The cooling of the worts, towards effecting the greatest possible saving, is of so much importance, that I shall again advert to the subject in the English method of brewing.

4. *Fermentation.*—The explanation of the theory of fermentation, attempted to be given in last Chapter, renders a repetition of the subject at any length unnecessary. It has been proved by chemical analysis, that glucosin, the starch-sugar of malt, is resolved by decomposition into equal parts of alcohol and carbonic acid; and the conclusion has been arrived at, after the strictest examination of yeast, that it is sugar in a state of partial decomposition that acts as

the fermenting principle. The appearance, therefore, which brewers' and distillers' worts assume while under the process of decomposition, is caused by the escape of the carbonic acid, and the arrangement of the particles of vegetable matter, and other acids and substances which the worts contain, and agglutinate and separate from the solution in the shape of yeast, carrying over with it a portion of the sugar partially decomposed, and which, when applied to fresh worts, commences the same action of fermentation. The theory of fermentation, therefore, is no longer a matter of conjecture. The decomposition of sugar establishes a law in chemical science,—by which, in all time coming, brewers and distillers may regulate their processes without working in ignorance.

I shall now proceed to describe the fermentation and attenuation of the brewing in hand; and, as it is during this process that the ale acquires a character for flavour and keeping, I propose to enter with some minuteness into the subject.

The worts having been cooled down to 53°, and six gallons of yeast prepared, the first part of the process is to pitch the gyle; that is to say, to mix the onset of yeast and the worts together in the gyle-tun, to commence the process of fermentation, the weight of saccharine extract being 94 lbs. per barrel. One barrel of wort is first run into the gyle, to which the six gallons of yeast are added, and thoroughly mixed; the remainder of the worts are then pitched

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in full flow from the coolers, at the temperature, as already mentioned, of  $53^{\circ}$ . The quantity of yeast, and the heat of the worts, must be varied a little, according to the season of the year, both in the slow and quick methods of fermentation. In the slow method, one gallon for every four barrels of wort during the winter, and two-thirds of that quantity for the warmer spring and summer months, may be taken as the average quantities used.

The degree of heat of the worts at which the yeast store is added, is of the utmost importance, as it regulates the time of the process of fermentation.

In the Scottish system of brewing, it ranges from  $50^{\circ}$  to  $55^{\circ}$ , according to the season of the year, or, more particularly, according to the existing state of the atmosphere. In the English system of quick fermentation, the range of heat is from  $60^{\circ}$  to  $65^{\circ}$ ; in both cases being the best that can possibly be used for carrying through the respective processes, and obtaining the desired combination of alcohol and solution of starch-sugar to constitute strong ale.

These precise heats require to be completely understood, several writers having given latitude to a much larger range, which is apt to lead into error. When the heats are lower than  $50^{\circ}$  in the slow, and  $60^{\circ}$  in the quick methods, the fermentation is languid, and recourse must afterwards be had to heat the worts in the gyle by artificial means. When above  $55^{\circ}$ , or  $65^{\circ}$  in these methods, in the first instance, the worts are apt to spring from the slow into the quick

fermentation, and endanger the brewing; and if the heat is above  $65^{\circ}$  in the latter method, the fermentation runs too quickly up, and renders the ale liable to commence the acetic fermenting process.

The mean heat for commencing fermentation I have formerly stated as  $52\frac{1}{2}^{\circ}$  in the Scottish, and  $62\frac{1}{2}^{\circ}$  in the English, system; and it cannot be too earnestly urged, that in both, the chemical principle is the same, although the action differs in manner and time,—the result required being the resolution of part of the starch-sugar into alcohol in such proportion as to bring out the ale in the highest state of richness of flavour, and fit for keeping until required for use.

The quality of the yeast, it need hardly be mentioned, must be of the best description. The rule in Edinburgh is always to work with yeast obtained from ale of equal strength to that which is in operation, and stronger, if possible, but never with weaker. The effect is obvious in practice, though the reason is not generally understood. The principle of fermentation in yeast being sugar in a state of partial decomposition, yeast made from weak wort contains less of the fermenting principle than that obtained from worts of greater strength, and acts accordingly.

There is another point which requires explanation. Store yeast for onset requires to be changed occasionally in both systems, or, to be more explicit to the general reader, the process of fermentation re-

quires to be commenced by a change of yeast from another brewery, as when too long continued in use in the same brewery, it is found to work languidly, and become deficient in strength and quantity. It may be said to work in-and-in to weakness, until it loses the capacity of carrying over a due proportion of the sugar in a state partially decomposed, and thus loses the power of acting with energy when applied to fresh wort. The brewer should be very much on his guard as to the district or brewery from whence the fresh onset comes. He should know the kind of water which is used, as the yeast acquires a character from its quality, and affects another fermentation accordingly. In practice, I found it useful to have a change of onset every four months. Much depends, however, on the care taken in keeping the yeast from one brewing to another as strong as possible.

Mr Black, in his Treatise on Brewing, observes, that there is no occasion for a change in the fermenting principle at all, and that he never attempted to make it; but there cannot be any doubt whatever that it is requisite. The utility of the practice is universally acknowledged, care being ever had that the yeast is from ale made from worts as strong as that to which it is applied, and that it is as strong and fresh as can be procured.

After the worts are pitched, and the yeast has struck, for the first ten or twelve hours a decided alteration takes place, and they are turbid and unsettled in appearance; and a scum of a greyish

colour has gathered on the surface. In twelve hours more a white circle, narrow and regular, appears round the edge of the gyle, the surface begins to chip, and shew irregular patches of white breaking through; then these unite and shoot up in little pyramids,—a proof that the yeast is beginning to form on the surface, and that carbonic acid is escaping from the worts. This is the first stage of the fermentation, which the brewer looks upon as an assurance that his gyle is in a healthy state. The whole head of the worts is now covered with froth, which the brewer watches, and, as soon as he judges that the yeast is sufficiently formed, the head on the surface of the worts is beat down, and the process of fermentation allowed to go on for twenty-four hours.

At this part of the process, the Alloa district brewers have a method of quickening the fermentation, which is very serviceable. They prepare a half-fermented wort, which is termed fillings. Reserving half a hogshead from the coolers, they put this to quick fermentation at  $62^{\circ}$ , and by the second day of the gyle's age these fillings are ready. They throw into the gyle ten or twelve Scotch pints,—about five gallons English measure,—the effect of which is to make the fermentation lively and healthful. These fillings serve another purpose, for which they are chiefly intended. By the Alloa method of fermentation, the contents of the gyle, when finished, are cleansed or run into butts, from which the ale is racked into casks as required, and the fillings are

added, to preserve its keeping quality. This method, however, is incidental, as their chief markets for consumpt are too distant to admit of their following the Edinburgh mode of cleausing into barrels at once, and sending out to customers. The Alloa ale, from this cause, is liable to become a little hard. In my opinion, when judiciously ordered by the customer, and used in time, it is all the better for this, the Edinburgh ale being sometimes complained of as being rather soft; but this is no fault of the brewers,—their customers cannot endure the least taste of the bitter principle of hops. The Edinburgh trade, therefore, use particular care to extract the aroma, without permitting the bitter to be much infused, except in their summer keeping ale. When ale is exposed to heat, either in a warm apartment, or by a change from very cold to mild weather, the aroma of the hops held in it escapes, and, not having sufficient bitter for support, sometimes acquires a soft, weak taste. But brewers must study the public demand; and such occasional condition, even of the best kind, cannot be avoided.

To return to the process of fermentation of the brewing. Twenty-four hours after the head of yeast has been beat in the renewed yeast comes thicker to the surface of the worts, of a light cream-colour, and of a firmer appearance. The progress of the heat and attenuation, or resolution of the starch-sugar into alcohol, must be carefully ascertained. The increase of heat altogether, to the finishing of

the ale, must not exceed  $10^{\circ}$  or  $11^{\circ}$ ; but the attenuation required, being according to the future views of the brewer, cannot be fixed by any arbitrary rule. In the present case, 94 lbs. saccharine extract is the strength of the wort, and the attenuation required is, that it shall be carried down to 45 lbs. per barrel. The duration of the process, therefore, depends on regulating the heat until the attenuation is accomplished. The heat should advance progressively, and is either kept in check or encouraged by the use of the tube, which is fixed round the inside of the gyle, taking five or six turns from top to bottom, through which hot or cold water can be run at the pleasure of the brewer. In eight days the heat has increased  $10^{\circ}$ , and the attenuation, as indicated by the saccharometer, is down to 50 lbs. per barrel, the head of yeast on the worts having been plunged occasionally during that time.

There cannot be any rule established for beating in the yeast, sometimes it is requisite twice in one day, sometimes not for two days together; neither can time be fixed on to determine the duration of the process of fermentation. Much depends on the quality and quantity of yeast employed to commence the process, and the heat of the worts when set to ferment.

The appearance of the gyle gives the brewer a good notion, during the process, of its healthy state; the head of yeast should have a broad rolling appearance, full to the sides of the gyle, and swelling a

little to the centre. The yeast is of a close texture, not glassy, nor studded with bubbles of carbonic acid, nor of a flat surface. When it assumes that appearance, either in the slow or quick method of fermentation, it is more than time that it should be cleansed.

The brewer must determine when the gyle is ripe, and when all is well, relative to heat and attenuation, —to cleanse. In Edinburgh, this is done by running the clear ale from beneath the yeast into the same barrels in which it is sent out to customers. No farther fermentation takes place, sufficient to render it necessary to put the barrels on troughs; they are placed on open stillions, or on the floor of the cellar. In Alloa, as previously explained, the ale is cleansed into butts, and afterwards racked into casks to be sent out. It sometimes happens that the gyle, in spite of the brewer's care, runs up to a high temperature, and the fermentation becomes rather unmanageable. In this case, the contents of the gyle are run as clear as possible into a square or clean tun. The ale cools down a little, and, in twenty-four hours, it is racked into casks; but this method of tunning ought never to be had recourse to, except the state of the gyle requires it, as it flattens the ale, and injures its quality.

I must call the reader's attention to the progressive state of the gyle during the process of fermentation, as explanatory, in some measure, of the dif-

ferent action which takes place in the quick and slow methods of working.

In the slow method of fermentation, when the yeast first gathers on the head of the worts, it gives out carbonic acid, and in proportion as it allows this to escape, and feels the influence of the atmosphere, it becomes viscid, and, were it not beat in, it would sink down through the wort, and leave it almost clear. Before it approaches this state, it is beat down into the worts. The principle of fermentation it still contains is thus mixed with the worts, and resumes its action. The more viscid part of the beat-down yeast disunites from that which holds the fermenting principle, and attaches itself to the bottom and sides of the gyle. As each successive formation of yeast comes to the surface, and is in turn beat in, the same process takes place. The viscid portion thickens at the bottom and round the sides of the gyle, until the alcohol begins to overpower the fermenting principle, and gradually would destroy it altogether. This is the time for checking the farther process of fermentation by cleansing, by which term the general reader will perceive, that it means the separation of the ale from the yeast-formation in the gyle-tun.

Dr Thomson made numerous experiments, both on a large and small scale, to determine the value of brewers' and distillers' worts holding alcohol and starch-sugar in combination, and clearly demon-

strates that they hold more of the latter than can be calculated by saccharometer proof,—making every allowance for the different specific gravities of the substances combined. To brewers, but more especially to distillers, these investigations are of great consequence; and were some judicious experiments made to determine the strength of yeast in distillery fermentation, some standard might be arrived at to ascertain how far the attenuation could be carried down with safety to the wort.

The reader, however, on comparing the above description of the nature of fermentation in the Scottish system of brewing with the English method, which will be afterwards described, will perceive that both these processes have one chemical principle in common, which, although differently wrought out, are equivalent in the production of malted liquor.

By the quick method of fermentation, the English brewer pitches his worts at  $62^{\circ}$ , with a larger quantity of yeast. From these causes, they arrive at the full fermentation standard in thirty-six hours, and, during that time, run up  $10^{\circ}$  to  $12^{\circ}$ , leaving the attenuation behind. The yeast is, therefore, beat in to the wort, and mixed thoroughly together, and tunned immediately into barrels set on close troughs, to hold the worts that immediately flow into them.

Now, being repeatedly filled up, the yeast begins to assume the viscid state precisely on the same principle as that described in the Scottish process of slow fermentation; but, in place of lodging in the barrels,

it settles down on the bottom and sides of the troughs just in the same manner as in the Scottish gyle, until the formation of alcohol checks the fermentation, and gradually stops it altogether.

In this latter process the repeated overturning of the ale, and filling up the barrels, diminishes its temperature, and preserves it from the acetic fermenting heat, but it is better guarded against that danger by the formation of alcohol, which now goes rapidly forward, until sufficiently powerful to arrest farther fermentation.

I have thus endeavoured, as shortly as possible, to give the reader a distinct notion of the nature of both these methods of fermentation; and it remains to say a few words of the proper degree to which ale should be brought down by attenuation so as to preserve the richest flavour of malt and hop, and to afford the greatest satisfaction to the consumer.

The attenuation of the wort so as to combine the exact proportion of alcohol and the sugar of malt to constitute ale of the richest description, has ever been the study of the Scottish brewers; and although every part of the process of manufacturing malted liquor may be said to be of importance, the successful attenuation of the worts in the Scottish system of brewing ale may justly be deemed one of the most essential requisites to establish the character it has acquired.

To brewers, this process must always be an object of much solicitude. When the resolution of the

starch sugar into alcohol is carried down to rather a greater length than necessary, it promotes, no doubt, the purity of the ale and its keeping quality, but it renders it too thin to the palate, and unmasks the nauseous hop-bitter, which always more or less comes over with the hop-extract. On the other hand, when strong worts have not been sufficiently attenuated, the ale has a sickly, luscious taste, and is apt to run into acidity. To avoid extremes, and to hit the exact proportion, therefore, requires all the skill of the brewer. The future disposal of the production ought to influence the process. Ales for bottling ought always to be attenuated lower than ale for draught from the cask. In making ales of this latter description, the brewers of Edinburgh have found it of advantage to keep them fuller of saccharine extract than they had formerly done. Ales for bottling would, in some instances, admit of the same improvement. I have sometimes thought that a table of attenuation, stating the specific gravity of the wort, either for bottling or to be used in draught from the cask, at the various strengths which the price indicates, might be of some use to brewers; but it is a matter of taste, for which no rule can be given with propriety.

Worts of 100 lbs. saccharine extract per barrel, which is about their strength for ale priced at £5 per hogshead, may be brought down to 50 lbs. per barrel to be used in draught, and to 40 lbs. per barrel for bottling; but when the scale is raised to £6 per

hogshead, which is about 115 lbs. per barrel, the attenuation cannot be rated in proportion to the ale at £5. To do justice to the quality of the £6 production, it must also be brought down to the same attenuation for draught as that at £5, both having sufficient saccharum to bear out their proportionate strength; but the attenuation of the £6 ale for bottling ought not to be carried down to 40 lbs., it should rather be above it in proportion to the saccharine matter it contains. Ale at £4 per hogshead contains 80 lbs. saccharum per barrel, and may be taken down to 40 lbs., to be used in draught from the cask, and the same for bottling; thus a richness and fulness to the palate are preserved in all, suitable to the general taste of the consumers.

But brewers differ so much in their ideas about attenuating their worts, that, as I have already said, no opinion can be offered on the subject without a reference to the future disposal of the ale. This subject is explained for the information of the general reader, as such an important point in brewing could not be passed over without suggesting whatever might lead to improvement.

The term *attenuation*, as applicable both to distillers' and brewers' worts, means the thinning or weakening of the saccharine extract during the process of fermentation by its resolution into alcohol. Distillers carry it down as low as possible to obtain the greatest quantity of the latter by distillation. Brewers check its progress, as previously explained,

to combine what they judge to be a good proportion of it with the starch-sugar undecomposed to constitute strong ale. The quantity of saccharum left in the wort, however, is only the apparent weight; the real weight is concealed by the quantity of alcohol evolved during the process, the specific gravity of which, below that of water, counteracts the weight of the saccharine matter in solution above it, in proportion to the alcohol formed from the starch-sugar held in the original wort. Distillers are not permitted by law to brew worts above 75 lbs. of saccharine extract per barrel; but even this, when treated with repeated doses of yeast, and attenuated until farther fermentation is prevented by the alcohol, contains from fifteen to twenty per cent. of saccharine matter above what is indicated by the saccharometer.

Brewers' worts require a different management from those of distillers. For instance, when of the strength of 120 lbs. per barrel, on being put to ferment, the decomposition of the starch-sugar is very rapid at first; but in proportion as the alcohol is evolved, the fermentation decreases, and would gradually cease altogether, were not the head of yeast beat in to renew the action, as in the Scottish system; or mixed in the gyle-tun, and run into casks to effect the same purpose, as in the English system of brewing; thus supporting the conclusion arrived at by Dr Thomson, that sugar, in a state of partial decomposition, is the fermenting principle of yeast.

Suppose these worts of the weight of 120 lbs. sac-

charine extract attenuated down so low as 40 lbs. per barrel, their real weight would be 60 lbs., from the specific gravity of the alcohol evolved adding a proportional weight of saccharum in solution, which could not be detected by the saccharometer.

It ought, therefore, to be held as a rule in brewing ale, that the stronger the worts the less is the proportional weight of alcohol produced, after a certain quantity has been evolved by fermentation sufficient to counteract its farther production.

I have been led into these remarks by the fact, that, of late, ales have been made in Edinburgh priced at £8, £9, and £10 per hogshead. As these prices would be demanded, not from any superiority of quality over the ales of other brewers, but from being made from additional malt commensurate with the prices fixed, it is of some importance to inquire how such very strong worts could be attenuated to combine a fair proportion of alcohol and starch-sugar to constitute ale of such a superior description as to warrant the price demanded.

Supposing, therefore, that these strong ales, priced at from £8 to £10 per hogshead, were manufactured with additional quantities of malt in proportion to ales made at inferior value, the question becomes one of real importance,—Can ale of such a value be manufactured, malt and hops being used, commensurate with the high price demanded? When ales are valued at £8, £9, and £10 per hogshead, the weight of saccharine extract in the worts from which they are

made should be 145 lbs., 160 lbs., and 175 lbs. per barrel of 36 gallons respectively.

Now a barrel of wort of 36 gallons containing 100 lbs. saccharine extract, may be fermented down to 40 lbs., with safety as to quality and flavour, to constitute ale sold at the rate of £5 per hogshead; while a barrel of wort containing 175 lbs. saccharine extract, could not possibly be fermented down lower than 90 lbs., and for which £10 per hogshead is demanded. The first quality at £5 contains  $6\frac{1}{2}$  per cent. of alcohol, while that for which £10 per hogshead is demanded contains only  $8\frac{1}{2}$  per cent. The large quantity of malt-sugar undecomposed which the latter contains, accounts for its strong luscious taste, having at the same time a slight putrefactive taint, which ever accompanies wort forced down to a low degree of attenuation, until overpowered by the alcohol. The attempt, therefore, to make ale at the high price of £10 per hogshead, and to combine in it alcohol and starch-sugar in the same proportion as in ales of lower value, may be considered as a failure.

It is quite evident, that, as fermentation is destroyed by the formation of alcohol in the worts, the attenuation of the latter must be in proportion to their capacity of producing it. Hence sugar in solution, at relative weights, is resolved by fermentation into alcohol in proportion to these relations; and it may be assumed, that, by the present process of fermentation in brewing, ale of the price of £8 per hogshead, made from 145 lbs. saccharine extract per

barrel of 36 gallons, is the highest that can be attempted, successfully, to produce malt liquor combining alcohol and starch-sugar in such proportions as to constitute ale of the richest description; excess of alcohol in proportion to the sugar in solution, or excess of sugar in proportion to the alcohol, being equally defects, especially in the latter, which, when it exists, renders the production liable to run into the acetic and putrefactive stages of fermentation.

The value of attenuation may be understood by the following description of ale, the secret of making which is known to few, as none of the present Edinburgh trade have attempted to make it. About thirty years since, the late Messrs Bell, Kerr, and Company, brewers in Edinburgh, manufactured a species of strong ale, which was familiarly known by the appellation of Bell's Beer. This description of ale became celebrated not only in Edinburgh, but over the kingdom, as the best that the Scottish system of brewing could produce. The method of making it was kept secret by the brewers, and when their brewery was given up, the production ceased. This ale was sold at £7 per hogshead. The manufacture of such a description of malt liquor, I think, may be easily renewed. The method consists of employing what may be termed the compound process of fermentation, in getting down the worts, and finishing the ale afterwards to the degree of attenuation required. To accomplish this, it would be necessary to brew in stock in proportion to the future demand,

and to keep it of age in sufficient quantity to supply that demand in succession. The difficulty lies, not in brewing the ale, but in establishing the business, and keeping the market supplied with it always of the same superior description.

The process of brewing ale by the Scottish system having been described until the attenuation is finished in the gyle, the heat of the wort being  $64^{\circ}$ , and the attenuation carried down to 45 lbs. per barrel, it now remains to cleanse or separate it from the yeast in the gyle, by running it into the casks which are afterwards sent out to the customer.

5. *Cleansing*.—By the term *cleansing*, English brewers comprehend the mixing of the yeast and ale together in the gyle, tunning into barrels placed on close troughs, and continuing the fermentation until the yeast forms and separates from the ale; which is accomplished by keeping the barrels repeatedly filled up, until the fermentation ceases, and the process is finished. In the Scottish system, it is applied to running the ale from the gyle into the casks after it has been judged sufficiently attenuated, and leaving the yeast behind.

There are different modes of cleansing, as stated formerly, which may be again noticed. 1st, The Edinburgh method, by which the ale is run, finished from the gyle, into the casks which are afterwards to be sent out to customers. 2d, The brewers of the Alloa and Stirling district cleanse into butts, from which

the ale is afterwards racked into casks, an English pint of fillings or prepared wort being put at the same time into each. 3d, When the ale is to be made up for exportation, it is overturned into a square or vat, capable of containing the whole brewing. In this it is allowed to remain twenty-four hours; fermentation proceeds a little, and attenuation takes place to the extent of 1 or 2 lbs. per barrel. A decoction of hops is prepared, of a strength sufficient for the intended purpose, and this, with a proportion of store, is added when the ale is racked into the casks. These additions are made to preserve it in its vinous state, calculated until its time of consumpt.

When brewers overturn their ale into squares, and rack for home consumpt, it is rather to remedy a defect than from choice. When the fermentation has run up rather too high, it may be advisable to use a square, and, if done judiciously, the ale may be brought out in a very good condition; but, after the gyle, all future racking flattens it, and injures the quality.

The practice of the Edinburgh brewers is to bring the gyle to the highest state of perfection, and tun into casks at once, where no more fermentation takes place. Neither fillings nor isinglass, in a state of finings, are used,—it being considered, that when ale is finished in fine condition, these are not requisite.

The measure of ale in hogsheads differs consider-

ably from the English standard. The Edinburgh hogshead contains 63 gallons, and the trade generally allow 15 per cent. discount on settling accounts. The reader will take the difference of measure, which is 9 gallons per hogshead above that of England, and the liberal money discount, into any calculation he may make, in forming an estimate of the comparative advantages of the English and Scottish methods of brewing.

The brewing of 20 barrels of ale, from 80 bushels of malt and 80 lbs. of hops, having been brought forward to the process of cleansing from the gyle-tun, is tunned into hogsheads and half-hogsheads. As soon as run from the gyle into the casks, it is considered finished; and, as has been already observed, no addition is made before being sent out to customers.

In the next chapter, I shall endeavour shortly to describe the English system of ale-brewing, and the method of making a given quantity, in the same order as pursued in the Scottish system.

## CHAPTER III.

## OF THE ENGLISH SYSTEM OF ALE-BREWING.

The English system of brewing, whether for making beer or ale, for public or domestic consumpt, is the best in Europe. In the art of manufacturing porter, the brewers of London stand alone; and the making of home-brewed ale by private families, admits of little farther improvement. The genial climate, the possession of materials of the finest quality, and the preference which the great mass of the people give to malted liquor, may readily account for this character being so firmly established.

But the choice of materials which enables private individuals to produce ale of the richest quality, must be borne in mind, when a comparison is made with that manufactured by common brewers and victuallers to sell with a fair profit. In the latter case, ales of every variety of character may be expected to be produced incidental to the local taste of the people who are accustomed to its use. It is here that some good may be effected, by bringing before the brewer such points in practice as admit of improvement in making ale of better quality from the same quantity of materials with which he has been habituated to work; and with this view I shall

make a few observations on the English system of ale-brewing.

In the preceding chapter, I have attempted a description of the Scottish system, making such casual remarks as might be useful to the English brewer, who desires to have some insight into practical matters. In doing this, I have neither wasted time in quotations from the works of others, nor ventured on speculative questions which admit of dispute, but rather studied to draw attention to what is practical towards economical improvement. In offering to the reader a short detail of the English mode of brewing, I shall pursue the same course, trusting to his indulgence to overlook repetitions, which, in treating such a complicated subject, are unavoidable, but not unfrequently useful in enforcing points of practical utility.

The method of brewing ale is nearly similar all over England. The malt is ground immediately before the mash is laid on, and the water, generally heated to the boiling temperature, is allowed to cool down in the copper to the heat required for mashing. The heat of the first water is  $170^{\circ}$ , and  $185^{\circ}$  for the second mash; the common practice is to take off a third for small beer. To obtain as much of the saccharine extract as possible for the ale, it is necessary to draw the first and second mash to such a length as to render it necessary to boil down to strength from  $2\frac{1}{2}$  to 3 hours. In most breweries the hops are added when the copper comes through to boil, and

are subjected to the whole time of boiling the worts. The worts are spread on the coolers, and, being cooled down to the temperature of  $60^{\circ}$  to  $65^{\circ}$ , are pitched to quick fermentation, with about two gallons of yeast for every four barrels of wort. The fermentation in the gyle comes to maturity in thirty-six hours. The ale is tunned into barrels as soon as the head of yeast is ripe and begins to sink, the latter being first plunged through the wort; many brewers, at the same time, throwing in 4 lbs. of flour and 2 lbs. of salt for every 25 barrels in operation. The worts in the gyle rise in temperature from  $10^{\circ}$  to  $12^{\circ}$ , before being run into the barrels to cleanse. One hogshead of wort is reserved to fill up with, which, with that which comes over into the troughs in tunning, is sufficient to cleanse 25 barrels of ale. Within two days the process of this additional fermentation is finished, and the ale removed into stock.

The Scottish brewer will perceive, from this short description of the English system, that it differs very much from his own, and at first view he may be inclined to form an opinion, that ale of a very superior quality could not possibly be made by it; but let him not be sure of that. In England the art of brewing malted liquor must be divided into three distinct operative employments or classes, all of which must be examined separately before the adaptation of each to its particular purpose can be appreciated.

The first class is, undoubtedly, the art of making home-brewed ale. This description of malt liquor is

carried to such perfection by private families in every district of England, that I have already said it admits of little farther improvement. It is superior to the Edinburgh production, for the reason, that it is forced, by the quantity and quality of materials used during the process of brewing, into that pre-eminence, and by the management it afterwards receives in the cellar, to maintain its flavour and acquire the quality of keeping,—both very important matters in the constitution of strong ale.

The second class is the art of brewing porter. This branch peculiarly belongs to London. Good porter has been, and is still, made out of it, but all is inferior; the causes have never as yet been satisfactorily explained, and brewers must rest satisfied with the acknowledged fact.

The third class comprehends the numerous body of common brewers,—and victuallers who brew their own ale, who are settled in every town and considerable village in England. In the production of ale in every county, a variety of causes operate to make a diversity of strength and flavour, which arises from brewers in the long run coming under the obligation of studying the tastes and customs of those amongst whom they carry on their business. Climate, quality of malt and hops, water used in brewing, and method of working out the system, all combine to impart to ale a distinctive local character, and reasonably account for that variety in condition and flavour which is everywhere to be met with.

But these causes do not operate in the manufac-

ture of the first class or home-brewed ale already mentioned. All over the country, from the nobleman's well-ordered and complete brewhouse, down to the cottager's economical contrivance, ale of the same rich flavour and strength can be made from the same quality and proportions of materials. And this fact, it may be once more remarked in passing, presents a good reason to Government for reducing the malt-duties. Whatever tends to add to the comfort and welfare of society, without impairing the revenue of the country, ought to be adopted by the Legislature. In England, malt liquor is a necessary of life, and whatever increases it in quality and quantity, without increasing the expense of procuring it, benefits the community in proportion to the advantage obtained. It cannot be too often repeated, that the settlement of the malt-tax at a reasonable rate would become a public good, without impairing the revenue, because the enlarged consumpt of malt at the lower duty would ultimately compensate Government for the reduction.

Neither do the causes which operate so decidedly in varying the productions of the common brewers and victuallers of England, affect the brewers of porter, in London. The manufacture of this species of malt liquor, as a national beverage, is confined to the metropolis by common consent, without any chance of rivalship whatever; and the character of the beer is as distinctive as that of home-brewed ale.- It does not appear that any farther improvement can

be effected in brewing porter, except in making it from pale malt altogether, and in saving the loss of the wort, which arises from the present methods of boiling, and cooling down to the temperature required for fermentation.

These different species of beer and ale are placed in three classes, according to their quality,—but not from the station or capital of those who produce them,—such arrangement being necessary, in order to fix upon that particular kind which admits of improvement in its manufacture.

It has been already mentioned, that the same method of brewing common ale generally prevails all over England, and an abstract has been given of the usual manner of its manufacture. I now propose to describe the process in detail, making such remarks on each part as may afford the reader a general knowledge of the business.

As in the Scottish system of-ale-brewing, I shall carry through a description of making 20 barrels of ale from 80 bushels of malt and 80 lbs. of hops; and having, during the course of the former, attempted to give some additional information on the theory and practice of brewing strictly applicable to both methods, such repetitions only will be made, in connection with each part of the present process, as are absolutely necessary to explain them to the general reader.

Of the water to be used in the manufacture of malt liquor of every description, it has been for-

merly stated, the best is that which springs from limestone, chalk formation, or other calcareous strata; and that the next is river or rivulet water, coming from a hilly district, which is generally free from vegetable remains in solution, so very injurious in affecting the fermentation of the worts, and the keeping quality of the ale. Every intelligent brewer is aware of the value of good water; and nothing more is required to be urged on the subject.

Of malt, and of the artificial germination of barley, and kiln-drying, by the brewer himself, who makes it for his own use, the subject is of so much importance in ale-brewing, that it may be shortly noticed again.

The process, or rather the method of conducting the process of malting, differs considerably in England from that followed in Scotland, chiefly arising from the different qualities of the barley; the climate and soil of the former country being more favourable for its growth of a fine quality than those of the latter. Of the English kinds, that cultivated in Norfolk is preferred, the better qualities of which are bought up by maltsters, brewers, and distillers, wherever they can be obtained. But in numerous districts of England very fine barley is produced. The shires of Nottingham, York, and Lincoln, produce it equal, in every respect, to Norfolk and the southern districts.

The best samples of Scottish barley are grown in the eastern shires of the country; the climate is

drier, and the soil also is better adapted for its cultivation, and that of the other cereal grain, than the western coast.

But although the arable land is highly cultivated, the colder climate and prevalence of clayey soils are, in wet seasons, unfavourable to the quality of barley, and render the Scottish production coarser and thicker in the husk than that of England. This difference in quality renders a different mode of converting it into malt necessary.

North-country barley, by which description is comprehended all that is produced in the northern counties of England, and the whole of Scotland, requires, in the process of malting, to be steeped a longer time than that of Norfolk and other southern districts. Its growth on the malting-floor requires longer duration, sprinkling with water, and to be spread thinner; and, consequently, it is different in heat during the process of germination. Fifty hours in the steep are reckoned sufficient for Norfolk barley, the heat on the floor never exceeding  $55^{\circ}$ ; while, from sixty to eighty hours are generally required for the stronger kinds of the north country, and the heat on the floors kept about  $50^{\circ}$ ; but in both countries, the heats of the malt on the floors, and on the kiln, are too often regulated rather by the guess of the maltster than by the thermometer, except in those cases where the management of the business is in the hands of a competent judge, who knows well how important a

matter it is to have the malt judiciously made, and brought off the kiln in the best possible condition. In a former part of these observations, notice has been taken of the method of kiln-drying at the high temperature of  $175^{\circ}$ , to which the maltster and brewer are again particularly referred, as a very valuable point in malting. Much of the quality of ale, in relation to strength and flavour, depends on the proper manufacture of the malt.

I shall conclude these remarks by reminding the brewer, 1. That malt, dried at the highest temperature by which its pale colour can be preserved, stands the highest degree of heat in mashing, without setting (rendering the starch of the malt mucilaginous, or converting it into a paste); 2. That malt, when ground small, yields a stronger saccharine extract, but requires the temperature of the water to range from  $165^{\circ}$  to  $170^{\circ}$ , and not above the latter heat; and, thirdly, that malt should be used as fresh from the kiln as can be conveniently arranged by the brewer, in the working up his stock of malt on hand.

In brewing by the English method, with fine pale malt a few weeks old, I have always observed that the worts flowed transparent from the mash; that, after being boiled down to strength, and spread on the coolers, little sediment remained after being pitched to ferment; that the extract was always stronger in saccharum, and richer in flavour, than

worts obtained from old malt;—and, what was a most desirable object, that the ale got sooner fine in the cask, and, when justice was done by the publican, invariably turned out well. The reason is obvious; malt recently dried possesses virtues in proportion to the quality of the barley from which it has been made. There is an aroma in it, giving a fine flavour peculiar to ale of the best quality, which is as essential to its state as the aroma of the hops. There is no brewer who has stood by a gyle on the second day of fermentation, the worts in operation having been extracted from fresh malt, but must have been sensible of their rich, grateful flavour.

Malt, when overlong kept, not only loses its aroma, but imbibes so much moisture that it gets soft and stale. The worts extracted are opaque, and deficient in strength, and the ale is apt to run into acidity.

Brewing with fresh made malt is of much importance, more especially to provincial brewers, who generally work both their breweries and maltings all the year.

It is certainly in the power of every one, who has means to command the barley and the hop markets, to brew with fresh malt and hops all the year round;—if he is judicious enough to work close to the monthly demand for ale. This, when well calculated, is one of the most valuable secrets in brewing.

Before describing the processes of brewing ale by the English system, I must remind the reader, that

in the previous chapters various remarks were made on the different methods which are applicable to both systems, and, as opportunities occurred, estimates were formed of the comparative advantages of both methods, in producing ale of superior quality.

I have now divided the English system of brewing into three branches or classes of the art. 1. Home-brewed ale; 2. Porter brewing; and, 3. Ale made by common brewers and victuallers.

It is with the third class that the art of making Scottish ale must be ranked; and, in order to obtain a fair estimate of their values, the question may be stated in this manner, all things being equal, in quality and price of material,—By which system of brewing, can ale of the best quality be made from a given quantity of malt and hops, and to sell at the same price, to afford a fair profit?

This is the only rational view the English brewer can possibly have of the matter. It is a fallacy to assert that better ale is sold to the public in Edinburgh than in England. The price is kept out of view—the class to which it belongs—and England is taken generally, instead of a particular district in it, where good ale is acknowledged to be made;—Edinburgh being merely a district which produces good ale. For there are places in Scotland—and large commercial districts too—where it is manufactured for public consumpt, of very inferior quality to what is made in many towns in England, and sold at the same price. It would be a fallacy to say, in

consequence, that English ale generally is superior to that made in Scotland.

In order to judge properly, Edinburgh ale must be placed in competition with that made in any particular county in England, noted for the goodness of its malt liquor. Suppose the kinds sold in Edinburgh at the rate of threepence and fourpence per pint, were put in competition with those sold at the same prices in Nottingham, or any other district in England noted for the goodness of production, the latter would be found equal in quality to those of Edinburgh. That it is brewed there, and priced at £6 and £7 per hogshead, is incidental to local taste and custom. In any principal town in England, could brewers obtain £6 and £7 per hogshead, ale for bottling, equal in strength and quality to that of Edinburgh, could be produced to supply the demand; but the demand does not exist, because the English prefer to use their malt liquors in draught from the butt. It may be conceded, therefore, that ales made either by the Scottish or English system are equal in quality at equal prices.

The inquiry of the English brewer, who is desirous to change his own for the Scottish system of brewing, ought to be, whether or not he could assume the best parts of the latter, and economise his process, without the expense of altering his works, or endangering his business? I have drawn his attention to this point, because much exaggeration prevails on the subject. Authors on brewing have never ex-

plained the art of manufacturing malt liquors separately, for local demand, but have mingled the whole under one general description ; hence the many conflicting statements that have been published on the subject ; and the difficulty which practical brewers still experience in obtaining from books, anything like a clear exposition of that particular branch of brewing, they carry on as a business.

The making of ale is a distinct art from that of porter. The methods of making ale by the quick and slow process of fermentation, also render them so distinct, as to require a different arrangement of utensils altogether. The making home-brewed, as generally practised in England, is also distinct from Scottish ale, and from that of the common brewers ; the excellence of its quality generally depending on a sufficient quantity of malt and hop, and judicious treatment in the cellar, for its future preservation.

These are facts which no brewer can dispute. To divide the business of brewing, therefore, into distinct classes, and to investigate the process by which these malt liquors are produced, is absolutely necessary before a competent knowledge of the whole can be acquired.

*Mashing.*—At the commencement of a brewing, it is to be supposed that every thing requisite has been cared for ;—that the utensils are all in perfect order, —that the material has been carefully measured,—

and that the water in the boilers is sufficient for the purposes intended.

The quantity of malt in operation is 80 bushels, with 80 lbs. of hops, from which it is required to make 20 barrels of ale. Every thing being in readiness, the water is let down to the mash-tun at the temperature of  $170^{\circ}$ , and ascends through the malt. By the gauge of the boiler, 24 barrels, the quantity required for the first mash, are let down ; the machine is put in motion, and the mashing proceeds. It is kept going twenty minutes, which is sufficient time ; when oars are employed, half an hour is requisite. The mash is allowed three hours to extract, the head of the tun being carefully covered.

Twenty-four barrels of water, for the first mash, for ten quarters of malt, would be considered extravagant by Scottish brewers ; but it must be considered, that, in the present operation, the worts require to be boiled one hour longer than by the Scottish method ; and that, as a quarter of malt takes up 28 gallons of wort, 17 barrels of the latter will be requisite from the first mash, 7 barrels being taken up by the malt.

The first mash having extracted for three hours, the tap is set, and the worts are permitted to flow into the underback.

The heat of the worts at the surface is  $140^{\circ}$ , and as they flow from the tap,  $148^{\circ}$  to  $150^{\circ}$ . They are run slow at first, to confine the dreg of the malt at the bottom of the tun ; as soon as they begin to fil-

trate they flow transparent. Seventeen barrels are drawn, weighing 86 lbs. of saccharine extract per barrel. The second and third mash are laid on in succession, at the temperature of  $185^{\circ}$ , the quantity of water required is 9 barrels for each mash; they are stirred for ten minutes, and allowed to extract for one-and-a-half hour for the second, and one hour for the third mash. The weight of saccharum obtained from the second is 60 lbs. per barrel, and 30 lbs. per barrel for the third mash, consisting of 8 barrels of wort from each. After the third mash, 8 barrels of water, at  $170^{\circ}$ , are laid on for small beer. When the strong worts are in the boiler, they average 66 lbs. per barrel, and are brought through to boil as quickly as possible.

The method of running the water through the malt, from the false bottom of the mash-tun, is very generally adopted in England. The best method of mashing that can possibly be followed, is to run the malt and water, simultaneously, into the tun, stirring and mixing as they descend. The ground malt is placed in a binn above it, and a sluice regulates the quantity which is run down; by this method, the malt is completely mixed with the water either by the machine or oars; there is also less danger of setting the goods, and the process is more effectually forwarded. This mode of mashing is well worthy consideration of the English brewers who have not already adopted it.

Stirring by the machine has been given up by the

Edinburgh brewers, on the supposition that the oxide of iron tainted the worts during the process. In England the machine is in use everywhere. It is the most effective method ; and no injury can possibly arise from its use, if the size and weight of iron are anything commensurate with the quantity of malt it is employed to work. When first brought into use by the Edinburgh brewers, it was made too strong and complicated for the work to be performed ; a machine, strong enough to mash 50 quarters of malt, was put in motion to stir 15 or 20. A stranger, in looking into the tun, and seeing it full of heavy machinery, could not be surprised at the worts being tainted, but must have been very much puzzled to conceive how it could hold worts to taint.

In all cases where a machine is to be constructed for mashing, it ought to be made on the simplest principle ; and with no more weight than necessary to do its work effectually. The motion of the blades or stirrers should be vertical ; when horizontal, their action pushes the malt before them round the tun and injures the mash.

The method of mashing by a machine is of very great importance to small brewers, who have not a sufficient number of hands employed to make it convenient to work the mash with oars. The hand machine is capable of mashing 10 or 12 quarters of malt ; and as the dimensions of a tun to mash such a quantity is that used by a numerous class of English brewers, it deserves their attention.

A perpendicular shaft rises in the centre of the tun ; on this shaft a tube is placed ; a double wheel is fixed on the top, receiving motion from a bevelled pinion, on the end of the horizontal axis of a fly-wheel at the side of the mash-tub, which is driven by hand, and which gives motion to the whole machine. From the tube four arms project, on which are fixed the vertical stirrers ; these are put in motion by two wheels on each side of the shaft acting on each other, the axles of which are the projecting arms from the moveable tube, and which are sent round the mash-tun by the outer wheel on its top. The upper cogs of this are acted upon by the horizontal axis of the fly-wheel, which thus keeps the machine steady, and distributes the power which keeps it in motion.

The attention of the reader may be directed to several important points in the process of mashing.

1. Sparging, or sprinkling the mash, in such a manner as would give a stronger wort, without drawing so great a length as to render it necessary to boil down to strength for such a protracted time, which injures the extract, and drives off the essential aromatic bitter principle of the hops.

The mode of accomplishing this requires very little explanation to make it easily understood.

The brewer having laid on the first mash, and drawn it about a fourth less than his usual quantity, lays on his second with the same proportion of water. When he sets the tap of this second mash, and the

worts begin to flow, he fixes the sparger at the same time, and sprinkles slowly as much water at  $180^{\circ}$  as of worts which flow from the tap. By trying their strength, he can work out the saccharum as much as he may deem safe to preserve the quality of the ale.

It is submitted, that this method would answer better in the English method of brewing than sprinkling the first mash, especially when the quick system of fermentation is followed. The worts obtained by stirring the mashes, and drawing them separately, are purer than when drawn by sparging the first mash; although, it must be granted, that the slow fermentation causes the wort to cast a surer crop of yeast than by the quick method, and much of the purity and flavour of the ale depends on the worts being judiciously cleansed. But it is for the brewer to be cautious in changing his own system, until he is perfectly assured that another is better.

*2d.* The division of the worts into separate quantities of different strengths, so as to produce different priced ales from the same brewing, is of very great importance when the establishment is on a scale of magnitude; and where a quick supply of ales of different values is in demand.

The brewer, in this case, must calculate a certain weight of saccharine extract, per barrel, to represent a certain price, and divide the worts obtained from each mash accordingly. By calculating how much wort strengthens in boiling per hour, and also, in

cooling down for fermentation, and how much of it is driven off by evaporation during these processes, he is able to proportion the whole suitable to produce given quantities of ale at the required strength and price.

Suppose the worts of a brewing are divided, so as to consist of three quantities of 32 barrels of worts each, containing saccharine extract as follows:—

No. 1.	32 barrels saccharine extract, per barrel,	50 lbs.
2.	32 .....	70 lbs.
3.	32 .....	90 lbs.

calculating that these worts were to be boiled two hours, and cooled down for fermentation; that each would strengthen one to ten per hour in boiling, and would condense on the coolers in the proportion of 12½ per cent., deducting the saccharum lost by evaporation, the production would be—

No. 1.	21 barrels ale, saccharine extract, per barrel,	66 lbs.
2.	21 .....	92 lbs.
3.	21 .....	118 lbs.

which, in practice, is nearly correct. The division of the worts from the mash,—a knowledge of the strength to which a given quantity can be brought down to the point of fermentation,—and the processes to produce ales of the different classes previously distinguished, all ought to be studied by the brewer. From the same mash, it would not be a very difficult matter to separate the worts, and produce ales of the various qualities known as home-

brewed, Scotch ale, and common brewers' ale, equal in every respect to what could be made, separately, by these different methods, in their own localities.

Of the best heats to be used in mashing,—of the quantity of water to be used for each mash,—and of the water taken up by the malt,—these subjects have been noticed in the former chapters; but it may be useful to recapitulate them, in their proper place, while on the subject. The heats generally acknowledged to be the best in the English system of ale-brewing, for mashing, are  $170^{\circ}$  for the first, and  $185^{\circ}$  to  $190^{\circ}$  for the second mash; for the third, any heat from  $170^{\circ}$  to  $180^{\circ}$  will answer. It has been found that too high heats have a tendency to bring the ale sooner to acidity than when ranged low, although a stronger extract is obtained. The quantity of water to be used for the first mash, of course, is regulated by the required strength of the ale.

Malt takes up about 28 gallons of water for every quarter in operation. With this knowledge, the brewer may lay on his first and second mash, so as to obtain the quantity of wort required, according to the time he intends to boil. The Scottish brewers for the first mash never exceed 2 barrels of water to each quarter of malt, and sprinkle until they obtain their desired quantity for the brewing. The English brewers go the length of  $2\frac{1}{2}$  barrels to 3 barrels to each quarter, but which, as has been repeatedly mentioned, compels them to boil longer down to strength.

*Boiling the Worts.*—The process of boiling regulates the strength of the worts; and as it is during this process that the extract of the hops is obtained, to impart their aromatic flavour and bitter principle to the ale, it is always desirable in brewing, to conduct it so as to produce the objects required,—to arrive at the calculated strength as nearly as possible, and to preserve the aroma of the hops in the greatest perfection.

In the brewing on hand, there are 33 barrels of worts in the copper; containing 66 lbs. saccharine extract per barrel, made from 80 bushels of malt; and there are 80 lbs. of hops to be managed during the boiling process, to extract the aroma and first bitter in the best manner, towards the preservation and flavour of the finished ale.

By boiling these worts for two hours, the calculation is, that they will strengthen in the copper and on the coolers 20 to 21 lbs. per barrel, and give 21½ or 22 barrels of ale, of the weight, before fermentation, of 87 lbs. per barrel saccharine extract.

It has been shewn, in the first chapter, that, in boiling malt worts, four actions take place, which materially affect them: 1. The process of boiling, which cuts the wort, as it is technically described, and coagulates the fecula of the malt. 2. Evaporation. 3. Concentration of the saccharum in proportion to the evaporation of the wort; and, 4. Destruction of part of the saccharum during the whole time of the boiling process. The reader's attention

is again particularly requested to this, because it is upon such knowledge that the brewer is enabled to take advantage of the strength of his worts, and to vary his process so as to obtain the greatest possible quantity of finished ale, and to work to a required strength.

The proposition is: *Worts boil down to strength in proportion to the quantity driven off by evaporation, and to the weight of saccharum they contain; and strengthen on the coolers in the same proportion, deducting the saccharum destroyed during the whole of these processes.*

I have formerly stated that, during the process of boiling, worts strengthen one to ten per hour; that, when of the strength of 50 lbs. saccharine extract per barrel, they increase to 5 lbs. in one hour; and when at 100 lbs., they increase 10 lbs. In two hours' boiling, therefore, the first would increase  $10\frac{1}{2}$  lbs. per barrel, and the second 21 lbs. per barrel. The increase of strength on the coolers is in proportion to one-eighth part of the whole wort lost by evaporation, deducting the weight of saccharum which escapes during the process.

I have already acknowledged, that this is the result of observation during practical experience. The proposition, however, is simply stated. The *exact* quantity of wort driven off during one hour's boiling, and the weight of saccharum concentrated, both in the boiler and on the coolers, can only be determined by experiment. The subject is worthy the

consideration of intelligent brewers, leading, as it does, to very important consequences.

In the present brewing, the 33 barrels of wort are boiled one hour, and then one half of the hops are added, and the boiling continued one half hour longer. The remainder of the hops are now delivered into the copper, and the whole boiled another half hour, making two hours' boiling in all.

Had a lesser quantity of hops been in operation, I would have boiled one half for the whole two hours, and the other half for one hour; but, in this brewing, the present arrangement of their boiling is sufficient to extract the aromatic bitter principle in the finest state. Brewers who draw a large extract are obliged to boil down to strength; but they are not under any obligation to destroy the hop aroma, by boiling the hops all the time they boil the worts. Let any brewer try a simple experiment: Let him infuse  $1\frac{1}{2}$  ounce of Kent hops in 1 gallon of strong ale wort (which is about the proportion used in brewing), brought up nearly to the boiling temperature, and keep it at that heat for an hour, he will find that the hops have imparted to the worts their fine aromatic bitter principle, without any boiling whatever.

The truth is, that hops give up their essential aroma and first bitter very readily. One hour's boiling is quite sufficient. When boiled for two hours together, most part of the essential oil or aroma and finest bitter are driven off, and the second or empy-

reumatic bitter succeeds, which is nauseous to the taste, and injures the ale.

After the worts have been finished in the boiler, I have always found it advantageous to let them remain there for half an hour or so,—more especially, when the time of boiling the hops had been shortened. Two benefits are obtained by giving the worts time. They secure the virtues of the hops to some extent; and they lose a considerable portion of heat before being spread on the coolers;—thus saving a part which otherwise would be lost, by the rapid evaporation which takes place, when run down from the copper at the boiling temperature.

The form of construction of the boiler is of some importance. The open boiler is still in use by provincial brewers. An upperback is of great utility, and, when properly constructed, becomes an object of value, as a larger quantity of wort, by one-third, can be boiled with safety when it is used. The best construction of boilers are those used in London. They have a condensing-pan on the top, into which pipes are introduced, conducting the steam from the boilers beneath, which heat the water for the purposes of the brewery. The Edinburgh brewers use neither condensing-pan nor upperback, the form of the boiler precluding their adoption.

There cannot be any reason to doubt that iron boilers would be very useful to brewers who require several in operation. It may be important to determine the best form of construction of the iron

boiler, which may soon come into general use. An iron boiler brings the worts sooner to the boiling temperature than a copper one, by one-fourth of time. It is easier kept clean; the oxide of iron is never present, the white fur with which it soon becomes encrusted preserves it from the action of oxygen; while, in the copper boiler its oxide is poisonous. It can be built at a comparative trifling expense, and is kept easily in repair. These advantages are worthy of consideration, and I shall endeavour to describe the form of one which answers every purpose for brewing.

The form of the boiler is hemispherical, and its size is in proportion to the number of barrels of 36 gallons it is required to contain. It is made of  $\frac{3}{4}$ -inch boiler-plate, and the leggins which unite the crown are  $\frac{3}{4}$  inch. The boiler is enlarged with a leaden crib, which is fixed to its inner top by copper rivets, about an inch apart, all round; these, though small in the nail, have large flat heads to hold the lead close and prevent leakage. This leaden crib is of a convex form, being in diameter about a third more at its head than where fixed to the boiler. An upperback, of a square form, is placed on the top, and which is capable of containing about one-eighth of the contents of the whole boiler. In fixing the upperback, a wooden seat is first placed round the head of the leaden crib. This is laid with white lead and paper, on which the upperback is placed; a strip of sheet-lead is run round the inside of the

boiler-crib where the upperback and the wooden seat on which it is placed unite, and nailed close with small nails, which keeps the whole water-tight.

An iron boiler of this description, capable of brewing 25 barrels of ale, would cost about £30, including leaden crib, and putting it up complete.

The form of construction of the hop-back, and the methods of running the worts, and filtering them through the hops, on to the coolers, in as pure a state as possible, have been formerly noticed, but is of so much consequence as to require repetition. The best construction is that made with a false bottom like the mash-tub, with a stopcock to regulate the flow of the worts. It is all the better to have a hair-cloth spread inside; but some brewers have objected to this addition, as it permits the worts to escape too rapidly, and diminishes the filtering action. The bottom of the hop-back ought to be narrowed to about one-fourth of the width of the top. In this case the haircloth is useful. Through such a hop-drainer the worts come very pure.

Hops take up four times their weight of wort. When boiled for two hours, or two hours and a half, they shrink, and the capacity of taking up the worts is diminished. The best method to recover the stronger, is to infuse the hops with weaker worts; but this is not always practicable in a small brewery. Except they are boiled separately, the brewer must run his small-beer wort through the hop-back, which transfuses the strong worts contained in the hops.

Where the mashes for strong ale are divided to make kinds of different strengths,—the management of the hops requires judgment and calculation, but neither rule nor direction can be offered with propriety,—this management of the hops resting on the views of the brewer as to the future disposal of the production.

Before the worts are run from the boiler, the strength must be ascertained by the saccharometer. Should any other method of cooling be adopted than that on the open coolers by evaporation, an allowance must be made to regulate the required strength, at the fermentation point, for the saving effected. In proportion to the saving which arises from the worts not being exposed to evaporation, they must be made stronger in saccharum, and less in quantity.

*Cooling.*—The method of cooling the worts by evaporation is generally the same both in the English and Scottish systems of brewing. In describing the latter, I have entered at some length into the subject, suggesting such improvements as might be useful in practice; and explaining the actions which go on during the refrigeration of the worts. They condense,—concentrate saccharum by evaporation,—lose bulk in proportion to such evaporation; and lose also a part of the saccharine extract, which escapes, more or less, during the whole time of the process.

From the time that the worts are brought through to boil in the copper, until they are cooled down to the temperature required for fermentation, they are subjected to a loss of bulk by evaporation, and gain increase of weight in proportion, deducting such part of the saccharine extract as has been destroyed during the processes.

The weight of saccharum per barrel, contained in the wort, after the process of boiling has been finished, and before it has been run from the boiler, will be increased, when cooled down for fermentation, in proportion to what it acquires by evaporation on the coolers.

A rule, therefore, can be established for brewers to calculate the strength of their worts prospectively, from the time of obtaining them from the mash. The reader cannot fail to perceive of how much advantage this knowledge must be to those who require to make ales of different strengths, from the same malt in operation ;—or to vary the process of making a single description of ale, when the malt turns out a stronger wort than usual ; and thus secure an additional quantity of ale to the brewing.

Whether or not I have assumed a correct principle in dividing the processes of boiling and cooling the worts, each into separate actions ; and attempting to prove the loss of wort sustained, and the weight of saccharum acquired in each process, during the time of boiling and cooling down for fermentation, I must leave for competent judges to determine ;

but the subject is so valuable to brewers, that the investigation, perhaps, may arrest their attention, and lead others to decide the question by more accurate experiment.

In describing the Scottish method of ale-brewing, several improvements in cooling the worts have been noticed; the most important of which may again be brought before the reader.

1. The refrigeratory cooler.—A given quantity of worts are run into a large tube immersed in water, which cools them down to a required temperature, before being spread on the adjoining open coolers, to permit them to deposit their sediment. These cooled worts are forced out of the tube by another charge from the boiler, which is cooled in succession; and thus the whole of its contents pass through the refrigeratory.

2. Flat surface refrigerator.—A flat, close receiver is fixed round the inside of the coolers, and cold water is kept constantly running into it. The bottom of this flat receiver dips an inch into the surface of the worts, and cools them rapidly down to the temperature required for fermentation.

3. The iron coolers, and the refrigeratory worm described in last chapter, will be found of much utility during the summer months; and are worthy the consideration of brewers who have not yet adopted these methods of cooling.

In the process of brewing, as generally conducted, when the whole quantity of worts obtained from the

different mashes, and the weight of saccharine extract they contain are ascertained, and afterwards compared with the quantity and weight brought down to fermentation; the loss of both worts and extract are correctly proved. To economise the processes of boiling and cooling, without deteriorating the quality of the production, is an object, therefore, of the greatest importance,—the whole being resolved into this: *From a given quantity of malt and hops, to bring the greatest weight of saccharine extract in solution to the temperature required for fermentation with the least possible loss.*

The reader will instantly perceive that this is the only rational view that can possibly be taken of the subject.

The art of manufacturing malted barley into various descriptions of liquor, ought to be taken in the light of a complicated chemical process,—for such it undoubtedly is in reality; and the theory of each part of the process being once understood, the object should be to reduce to practice whatever is established by science as correct in principle.

It is admitted, that in the prosecution of the business of brewing malted liquor,—to change the mode of conducting any part of the process which custom has established, is attended with difficulty; and many brewers have sustained loss, by incautiously giving in to schemes of projectors, and pretenders to secrets. But all this is no reason why advantage should not be taken of the principles

which science has demonstrated to be applicable towards effecting a saving of materials which are lost during the process of brewing; and for submitting to which no necessity exists,—except that arising from the construction of utensils and deficient knowledge.

In London all this is well understood; and improved utensils and scientific investigation have done much for the advancement of the art; but it must be acknowledged, that provincial brewers are placed at a disadvantage in these respects. An improvement in any part of the process of brewing, which would effect a saving, on the aggregate, of sixpence per barrel, in London, would be an object of some importance;—to a provincial brewer, who produces 2000 barrels of ale annually, it might appear of no importance whatever, because the saving would not be sufficient to induce him to change his usual method of working; and this keeps back the progress of the art so much, that it may account, in some measure, for the faulty construction which many provincial breweries exhibit in their utensils and economical arrangement.

Economy in the process of cooling the worts, however, must be desirable by every brewer; and the methods of effecting it, which I have submitted, are worthy of their notice.

Having brought the brewing I set out with to the point of fermentation, I find, on taking the gauge of the worts on the coolers, that there is sufficient to cleanse 22 barrels of ale, and that the weight of sac-

charum they contain is 87 lbs. per barrel, the temperature of the wort being  $62^{\circ}$ , at which it is proposed to set them to fermentation.

*Fermentation.*—In the English and Scottish methods of brewing, there is no part of the process which differs so much as in that of fermenting the worts. In the two preceding chapters, the difference has been shewn to arise from pitching them to ferment at different temperatures, and with different quantities of yeast. By the English method, a temperature of  $60^{\circ}$  to  $65^{\circ}$  is chosen. The English brewers are extremely cautious with their heats of fermentation; and the intelligent have generally adopted the mean of these heats,  $62\frac{1}{2}^{\circ}$ , or for practice  $62^{\circ}$ , as the best that can be adopted during all seasons of the year. By the Scottish method, as formerly mentioned, the heats are from  $50^{\circ}$  to  $55^{\circ}$ ; and  $52\frac{1}{2}^{\circ}$  is the mean, or  $52^{\circ}$  in practice,  $10^{\circ}$  being the difference of quick and slow fermentation.

The chemical principle is the same in both methods; the difference of heats used causing a different action of the worts in their time of resolving into alcohol, and throwing off the yeast and impurities they contain. These facts have been stated in last chapter, and are worthy of attention.

The reader will observe one important fact. The fermentations, at the mean of these heats,  $52\frac{1}{2}^{\circ}$  and  $62\frac{1}{2}^{\circ}$ , are *equivalent*, producing, by different modes of action, the same results. When worts are fermented at  $52\frac{1}{2}^{\circ}$ , in eight to ten days a liquor is produced, com-

bining alcohol and starch-sugar in such proportions as constitute strong-ale, of a certain flavour and quality: and worts fermented at  $62\frac{1}{2}^{\circ}$  produce a liquor of somewhat different flavour, but combining alcohol and starch-sugar in like proportions; all things being equal in the quality of the malt and the strength of the worts;—in both instances, the heats of the fermented worts rising nearly to similar temperatures,— $10^{\circ}$  or  $12^{\circ}$  above those at which they were set to ferment.

Now, were the worts pitched to ferment at  $72\frac{1}{2}^{\circ}$ , in place of  $62\frac{1}{2}^{\circ}$ , they would spring rapidly to a high temperature, before a sufficient quantity of alcohol was evolved. They would bear yeast, no doubt, but it would be deficient in those requisites which distinguish strong, healthy yeast; and when tunned and cleansed, the ale would have a thin, vapid taste. *The fermentation heat was not equivalent* to the production of malt liquor made at a temperature of  $52\frac{1}{2}^{\circ}$ , and the chemical action is different accordingly.

The subject is too important to be passed over hastily. It is either true in principle, or it is not. It is quite evident, that, in the quick and slow methods of fermentation, there must be equivalent heats. All that can be done, however, while the question remains unsettled, is to endeavour to fix on the best heats to produce the best results.

The worts in the coolers being all in readiness, nine gallons of strong, rich yeast having been thrown into the gyle, about a barrel of wort is pitched and

thoroughly mixed with the yeast. The worts are now run into the gyle in full flow, until the whole have been obtained.

In twelve hours a head has gathered on the worts, the healthy state of which cannot be mistaken. In a few hours a faint, white line breaks round the head of the gyle; afterwards the surface begins to shew white spots, which soon increase and rise on the surface. In twenty or twenty-four hours the head is formed; it consists of white froth, at first shooting up in little pyramids, and then uniting and swelling up with a very slight and scarcely audible singing noise, which is a favourable sign that all is well.

In a few hours this white froth is changing into gas bubbles, caused by the carbonic acid escaping from the wort, these soon appear numerous, and enlarge into each other. The head assumes a cream-coloured tinge, and the formation of viscid yeast has evidently commenced. The fermentation proceeds; the head of the wort still bearing up the yeast, which swells up towards the centre. The heat of the wort is 70°. The flavour from the gyle is cool and sweet, and this is more perceptible when fine new malt is in operation. The appearance of the head of the gyle now assumes the look of the worts coming to maturity. In thirty-six hours it is decisive. The yeast is of a rich, close texture, but without rolling over in a broad, unbroken mass, as in the Scottish gyle during slow fermentation. The head of the gyle now begins to sink, and the yeast to slacken

round the edge ; but the brewer need not hurry the process ; two or three hours at this time are of essential service to strengthen the yeast in cleaning, but it must not be permitted to sink much. Four lbs. of flour, and 2 lbs. of salt for every 25 barrels, is a good proportion of these substances, to be mixed with the worts, before tunning, to season the ale and increase the fermentation in the barrels. The heat of the worts is now  $72^{\circ}$ , and the gyle is judged to be ready. The flour and salt are thrown in by handfuls over the yeast on the gyle, and the contents are plunged and mixed together. When this is accomplished, which occupies a minute or two, the whole is run into barrels placed in the tunning-room, to undergo the process of cleansing.

It may be remarked, that during the quick process of fermentation, the head of yeast in the gyle is never touched until beat in at last, when the flour and salt are mixed with the worts. Were it beat in as in the Scottish process, the worts would spring into so rapid a fermentation, from the quantity of yeast with which they were pitched, and from their high degree of temperature, as to endanger the brewing.

*Cleansing.*—The continuation of the process of fermentation, by mixing the yeast and worts together, and overturning the whole contents of the gyle into casks, from which the worts partially escape in froth with the carbonic acid, and are again filled at intervals of two hours, for twelve hours, and then

every four hours, until, by repeated working out and refilling, the yeast comes to maturity, and separates from the worts. This is called cleansing.

In the Scottish method, the reader has already been informed this term signifies, merely, the running the finished ale into casks, where no more fermentation takes place; but the present method is a continuation of the process, which requires much care and judgment in the brewer to bring to a successful termination.

The casks should be examined singly before being placed on the stillions or troughs, to ascertain that the bung-stave is good,—the spile holes filled,—the tap ends all right; and that the casks are sweet, and in good condition to serve their purposes. The general reader must not deem these matters trivial. The process of brewing is a chemical experiment on a large scale, during which the materials in operation must be watched with vigilance and managed with caution. Every thing must be cared for connected with the whole operation. However talented or respectable the brewer may be, if he is worthy to stand at the head of the copper, and work out the experiment, until the final production of the liquor is accomplished, he is no more degraded by superintending minute details, than the chemist who arranges the apparatus of an experiment in his own laboratory.

Everything being right in the tunning-room or cellar, the first operation proceeds, of removing the worts from the gyle into the casks, for doing which

there are several methods ; *1st*, By carrying the worts from the gyle in a pail, and filling the barrels progressively, sufficient wort being left to finish the cleansing. *2d*, By means of a hose made of leather, long enough to reach to any part of the cellar where the barrels are placed. The one end of the hose is open, to admit the tap of the gyle. On the other a stopcock is fixed, with a small conduit to enter the bung-hole, and to prevent the spilling of the wort. *3d*, By the filler-trough. This is a small trough laid across the tops of the barrels, the whole length of the stillion ; into each bung-hole a filler descends from the trough, and a stopper is fixed by a small chain to each division of it, where the fillers are placed, to be instantly ready when wanted to stop the flow of wort when the barrels are full. The worts are conveyed to the trough by the hose already described, and which is still kept in use. *4th*, By the cleansing-vat with float-valve. This method of cleansing is confined to the London porter breweries. The fermented worts are distributed into the barrels, by means of the cleansing-batch being placed on a proper level with the casks, which are kept constantly full, on the same principle that regulates the common water-cistern fitted with a ball-cock or floating-valve.

The casks having been all carefully examined and placed on the stillions, the filler-trough is laid over the first division of barrels, and everything being right, the tunning proceeds. The filler-trough is, to a certainty, the best method of cleansing in practice ;

and provincial brewers who are judicious enough to appreciate the value of quick, clean, and economical work, would do well to adopt it.

The number of barrels to be tunned is judged of by taking a gauge of the gyle. The brewer then places such a number of casks on the stillions as the quantity of ale in the gyle requires. In the present instance, I shall tun twenty-two barrels, which are two more than were stipulated for; and the reader's attention is called particularly to this, because he will have perceived that, provided the mash has yielded a rich return of wort, it is quite an easy matter to vary the process of the brewing, so as to secure the advantage.

When the casks are all filled, which, when the filler-trough is used, is very expeditiously done, the overplus of the wort in the gyle is run into the *plus-tub*, as near as can be guessed, to the quantity of a hogshead of 54 gallons for every twenty barrels of ale in operation. This, with the liquor on the stillions, is sufficient to keep the barrels in fermentation until cleansed. The wort flows out of each barrel in a stream of froth, composed of worts under the action of carbonic acid. This stream accumulates in the stillions beneath, and, the carbonic acid escaping, the froth is again resolved into wort, which is taken off the stillions by a spigot or stopcock, and filled into the barrels every two hours with wort from the plus-tub, until the yeast separates from the worts, and the fermentation has ceased altogether.

The brewer, in finishing the ale on the stillions, must not trouble himself with filling up with mild ale of another brewing. It does no good whatever. If justice has been done to the operation on hand, it is independent, and requires no assistance. But it is very useful to reserve a firkin or half a barrel of wort of the same brewing in hand; and in place of filling up with refuse of the plus-tub and stillions, and doing damage, the brewer has thus fine worts to finish with and preserve the purity and flavour of the ale.

#### CHAPTER IV.

##### OF PROVINCIAL PORTER-BREWING, AND MAKING HOME-BREWED ALE.

FROM the accumulation of advantages possessed by the London porter-brewers,—of immense capital, scientific arrangements, improved utensils, select materials, brewing on the largest possible scale, with constant and regular demand by customers, to suit their equally constant and regular consumpt,—the superiority of their porter may, in some measure, be accounted for. But the true cause lies, in all probability, in the long-established, uniform methods of working up their materials, prepared by judicious previous steps to produce a certain result; which, in the production of this species of malt liquor, bestows on it a particular flavour and quality; ultimately

confirming its distinctive character,—which no other district can either rival, or even attempt to imitate, with any chance of success.

But, notwithstanding, very good porter has been made in many provincial towns; and in Scotland and Ireland efforts have been made to establish porter breweries, which have more or less succeeded, according to the skill and capital employed. Dublin porter, although inferior to that made in London, has obtained a considerable celebrity; and the porter of Aberdeen is not considered behind it in quality. But all this is only comparative. Two or three of the principal London houses brew as much or more malt liquor than all the brewers of Scotland and Ireland put together.

In Scotland, the business of brewing porter has rather declined, in consequence of the increased demand for draught ale. In Glasgow, better porter is produced than at Edinburgh; but their ale is generally considered inferior to that made at the latter city. There cannot be any doubt whatever, that in such a flourishing commercial district as Glasgow, the brewing of ale and porter might be carried to great perfection, were judicious steps previously taken, in selecting proper localities, for malting the finest samples of barley.

The brewers of London obtain their supplies of malt from Norfolk,—and other districts where fine barley is produced; for in England, wherever it is abundant, a malt-house is established.

The climate of the west coast is too humid for making fine barley into fine malt, and for keeping it any length of time ; but the drier climate of the Lothians is at hand, and were the brewers of Glasgow to establish maltings on the eastern coasts, they could supply themselves constantly with fresh made malt, the production from which might stand competition with the ales of Edinburgh or the porter of London. It has been urged, however, that their water is defective for the purposes of brewing. It may be so ; but where a great commercial advantage is to be obtained, skill and capital overcome many difficulties.

The question has often been asked, Can porter be made on a small scale, to approach near in quality to that made in London ? The question cannot be easily decided. In many provincial towns, it is very useful to make two or three brewings of porter to take up hard ale, which answers excellently, when it has been properly treated with hops ; and although the quality of such a production is not equal to porter made in London, it may be equal to the purpose for which it is intended. In many districts, during the summer months, this description of malt liquor, when mixed half-and-half with mild ale, forms a very refreshing beverage, and is in much demand where it can be produced.

I propose, therefore, to give a short statement of the method of brewing porter, which may be practically useful ; premising that no deleterious ingredients

are used; for every intelligent brewer will acknowledge, that, whether in the manufacture of porter or ale, the best malt and hops are the cheapest materials that can be employed. There are various substances, however, which are used, such as roasted malt, burned sugar, malt wort boiled down (*Essentia bine*), liquorice, orange powder, heading, and finings; but all these additions are simply to improve the flavour, or to preserve the keeping quality of the liquor, and not as substitutes for malt.

As porter is made by provincial brewers in the same utensils as those in which they make their ales, it is unnecessary either to repeat a description of them or to notice their dimensions; but it may not be unacceptable to the reader to notice the method of making porter-malt; as every brewer should have some knowledge of the mode of preparing it,—although it has been nearly displaced, in large establishments, by the more profitable use of pale malt in porter-brewing.

The form of the genuine porter malt-kiln differs from the common description for drying pale malt. The floor of the former is laid with tiles in the usual manner where such are used. The fire-chamber beneath is built with brick, within the square apartment, in the shape of an inverted pyramid, in the apex of which the furnace is placed. The furnace is arched with fire-brick, and extends  $2\frac{1}{2}$  feet within the chamber, to disperse the heat equally to the floor above.

The malt to be prepared for porter-brewing is half made in the usual manner for drying pale malt. It is then divided into two or three parts, which are dried and finished on the kiln at such a high temperature as speedily turns it of a brown-colour, but without scorching or charring it ; and converts it into porter malt.

It is first dried with coke in the usual manner. Birch-cuttings, or beech, when the former cannot be procured, are prepared to blow it, as it is termed, on the kiln, and give it the brown colour and that bitter principle which is so desirable to the taste in the consumption of porter.

When the malt is spread on the kiln-floor, the furnace is gradually charged with the wood-cuttings until a temperature upwards of 200° is obtained. It is carefully watched by the maltster, until it begins to burst by the escape of the air confined between the kernel and husk of the grain. It is now turned by the maltster and his assistants with shovel and broom, working it quickly, and sweeping each division, as it is proceeded with ; and this process is repeated until it is judged sufficiently brown for its purpose.

By this incipient charring its germinating principle is destroyed, and it loses the capacity of yielding sugar, by mashing, in the proportion of twenty per cent. to pale malt made from the same description of barley.

*Malt and Hops.*—The malt required to make 20 barrels of stout porter is 40 bushels of pale, and 20

bushels of genuine porter-malt. Both kinds are rather small ground, and mashed in the same tun. In large brewings they are mashed separately ; but, on a small scale it is not requisite. Seventy pounds of hops are employed ; they are good Sussex hops, the strength and flavour of which are better adapted for porter brewing than those from Kent. The other ingredients used, will be described during the process.

*Mashing.*—Forty bushels of pale, and 20 bushels of genuine brown malt are prepared as previously stated. The quantity of water for the first mash is 20 barrels, heated to the temperature of  $180^{\circ}$ , which is stirred for twenty minutes, and stands three hours to extract ; the head of the tun being covered.

After three hours the tap is set and the worts flow into the underback. The heats of the mash are about the same as in ale-brewing,  $140^{\circ}$  at the surface, and  $148^{\circ}$  to  $150^{\circ}$  at the tap. Fourteen barrels of wort are drawn, weighing 66 lbs. extract per barrel. Fourteen barrels of water at  $190^{\circ}$  are laid on for the second mash, which is stirred for ten minutes, and allowed to extract for two hours. From this mash 12 barrels of wort are drawn at 34 lbs. per barrel. The first mash having previously been pumped into the boiler, 8 barrels are laid on for the third mash at  $180^{\circ}$ , which, after standing to extract one hour, are recovered at 20 lbs. per barrel.

*Boiling.*—The whole quantity of worts now in the

boiler are 34 barrels, weighing 44 lbs. saccharum per barrel, and which are brought through to boil as speedily as possible. Sprinkling the mash does not succeed in porter brewing; and, in mashing, the temperature of the atmosphere is a matter of indifference, care being taken that too high degrees of heat are not used, although brown malt bears a higher temperature than pale. With brown malt, the heat of the water should never exceed 190°.

The worts having come to the boiling temperature, 80 lbs. of Sussex hops are delivered into the boiler. Farnham or other hops may be used as convenient; but it is not so much the aroma of the fine kind for brewing ale that is now wanted, but a strong, rich bitter, which the Sussex or Essex hops yield, and which is preferable in the manufacture of porter.

The time of boiling the worts is regulated by the quantity drawn from the mash. In the present instance, two hours and a-half will be required. The ingredients to be mixed during the process are,—Spanish juice, burned sugar, clarified sugar, and liquorice root. *1st*, Burned sugar. Thirty pounds of good raw sugar are put into an iron boiler which has a circular bottom, and dissolved in one gallon of boiling water, over a moderate fire. It must be kept stirred, and attended to with care. After boiling a few minutes, and being stirred with an iron scraper, it thickens, and acquires a bitter taste. Care must be taken that it does not get scorched. It must be constantly stirred, and a small quantity of hot water

added, to keep it from setting on the bottom of the boiler. As soon as it approaches to inflame, it is ready to be removed, which is done by thinning it with boiling water, and delivering it into the boiling worts. *2d*, Spanish or Leghorn juice. Six pounds weight are broken into small pieces, put into a net, and sunk into the worts in the boiler, to be dissolved during the process of boiling. The net is hung from the top, and must be put in when the worts come through to boil; or the liquorice may be dissolved previously, and thrown into the copper as soon as the worts come to the boiling temperature. *3d*, Twenty pounds weight of clarified sugar, broken into small pieces, are mixed with the worts. And, *lastly*, three pounds ground liquorice-root are added.

These materials being now in the copper, the worts are boiled rapidly for two hours and a-half, when the quantity and weight must be ascertained, and a judgment formed of the time for their being run through the hop-back into the coolers.

It is of importance to mention, that the third wort is often boiled separately without hops, and run into the hop-back after the worts from the main copper have been strained; by which means the strong kind taken up by the hops is transfused by those from the third mash. But it is evident that this method deprives the worts from the third mash of their share of ingredients in the boiler, although, from the quantity of hops used, it becomes an object to transfuse them. The question for the brewer to decide, is,

whether the transfusion of the hops will compensate for the deterioration of the worts, from the third mash not having been boiled together with the two first worts, to obtain their share of the foreign ingredients necessary to flavour and enrich the porter.

In practice, I boiled the three worts together, and run small-beer worts through the hop-back ; but this is a matter of choice on the part of the brewer. The brewing of porter on a large scale is altogether different from the practice of a provincial brewer. The latter makes a few brewings for summer consumpt. It is hardly an object for him to divide his worts. A regular porter-brewer mashes his pale and brown malts separately, divides his worts, and transfuses the hops with the weakest. The whole operation of manufacturing porter becomes a well-regulated process ; and, as mentioned in the preceding chapter, is a distinct business from that of ale-brewing.

*Cooling.*—The process of boiling the worts, and the laws which regulate that process, having been explained in the description of ale-brewing, it is unnecessary again to enter on the subject. The porter worts being spread on the coolers, are cooled down by evaporation to 62°, being the same temperature for the fermentation of ale wort by the quick method, by which porter is always made.

The laws which govern the brewing of ale worts also regulate those of porter. They strengthen in the boiler and on the coolers in proportion to the water

driven off by evaporation, and the prospective increase of weight, and loss in quantity may be calculated when the worts are drawn from the mash, on the same principle as that which guides the brewer in the production of ale.

*Fermentation.*—When cooled down to 62°, twenty-two barrels of worts, containing 65 lbs. saccharum per barrel, are pitched to ferment with nine gallons of yeast. The best yeast for onset is fresh strong ale yeast. To cause it to strike well just before being thrown into the gyle, an ounce of the best ground ginger is mixed with it; but when the brewer is sure of the goodness of his onset, this is unnecessary. The fermentation of porter wort runs the same course, and is similar in chemical action to that of ale; but when the head of yeast is formed, and comes to maturity on the worts, it does not support itself there so long as ale yeast; it has not the same capacity of holding sugar in partial decomposition as the latter, and were it not beat in after full formation, it would sink down through the wort and leave the surface clear; but in this latter case, which would ruin a brewing of ale by yeast biting, and subsequent vinegar formation, the porter, although deprived of the cleansing process of fermentation, is not lost. The strong combination of hop bitter and burned sugar it contains, preserves its vinous state. It is stored in a vat with finished porter, and without deteriorating the quality of the latter, recovers its own value.

When porter is made with fresh malt and good quality of hops, and when the ingredients have been judiciously prepared, the worts, under process of fermentation possess a full taste, rather bitter, but grateful to the palate, and the gyles send forth the flavour by which porter, as a malt liquor, is distinguished.

When the worts have come to maturity, which is known by the head of yeast beginning to slacken round the sides of the gyle, and to drop a little in the centre, 4 lbs. of flour and 2 lbs. of salt are thrown by the hand over the yeast, which cause it immediately to shrink together. The worts and yeast are then plunged and mixed thoroughly, and the process of tunning commences.

*Cleansing.*—Porter ought always to be cleansed in pipes or butts in preference to barrels. The fermentation goes on better in large casks. It is not so strong as that which takes place in cleansing ale, and requires to be more frequently filled up. In cleansing porter, the casks must be filled up every half hour for twelve hours; then every hour for the same length of time; then every two hours; and until the fermentation ceases altogether, every four hours. The stillions must not be drawn too close, as the yeast would clog up the run of the liquor and loss ensue, care being taken that there is sufficient wort in the *plus-tub* to finish the brewing.

*Storing.*—The cleansing being finished, the future

disposal of the porter determines the brewer what course to pursue,—either to remove the brewing into cellar-stock, in the same casks into which it was tunned, to be afterwards racked into barrels, to be sent out to customers ; or to store it in a vat for the same purpose.

In the first instance, supposing the porter to have been made in the spring, to be ready for delivery during the summer, such old ale in the brewery as may be fit for the purpose is put down with hops, 2 lbs. to each barrel, and kept until required. In racking the porter from the pipes into barrels, 9 gallons of the old ale are first delivered into each barrel of 36 gallons, and smaller casks in proportion, and the barrels filled up with porter. A table-spoonful of heading is added ; this consists of equal parts of alum and carbonate of potash ; also the same quantity of orange powder ; last, about the third of a pint of finings made up with vinegar and isinglass. Some brewers keep a supply of London porter by them, and add a gallon or two to each barrel racked ; and it may be easily imagined, that the provincial production will be all the better for such an addition. In porter-brewing one thing is essentially requisite, the brewer should contrive to make a strong-bodied, fine-flavoured, malt liquor, which, if it does not pass for London porter, will pass on its own merits, which is all that is required.

When porter is required to be stored, a quantity equal to three-fourths of the measure of the vat must

be overturned into it fresh from the stillions, immediately after having undergone the process of cleansing. One-fourth of prepared old ale is added to fill up. The manhole is battened down air-tight, sufficient space being left for the rise and fall of the liquor within,—a slack-spile or vent-plug being inserted at the same time on the head of the vat.

A trial stopcock is placed about a third part up, by which the brewer has access to judge of the progress the contents are making towards ripeness. In two or three months it is ready, when the same additions are made in racking as previously described in racking from the pipes.

It is at this stage that brewers differ as to the additions to be used to obtain the flavour of London porter. Decoction of bark, and porter extract, are sometimes used ; but, as has been already mentioned, if the malt liquor is really good, there is not much occasion for using such ingredients.

The reader must take the preceding description of brewing malt liquor, not as the general method adopted by provincial brewers of making porter, but rather as affording general information of the mode of conducting the process, and preparing the foreign ingredients, by a judicious management of which, an imitation of London porter can be produced.

I have already mentioned that very good porter is brewed in Dublin, The business there being done on a scale of magnitude exceeding any provincial district,

it may justly be reckoned next to London in importance. In Scotland, it has been remarked, the brewers of Glasgow and Aberdeen make porter little inferior to that of Dublin ; but in England it is produced by numbers of brewers in the larger towns and populous districts, sometimes in such perfection as not unfrequently to be mistaken for genuine London porter.

Every brewer who makes porter is in possession of some secret or other, by which he contrives to regulate his process. With a good sample of malt and hops, and skilful preparation of the other ingredients necessary for flavour and keeping quality, a species of malt liquor may be produced anywhere, forming, by a mixture with old ale, a very agreeable beverage during the heats of summer ; and it is chiefly for this purpose that porter is made in the English provinces.

When *essentia bina* is preferred to burned sugar for colouring, it is made by boiling down 15 gallons of strong ale wort of the strength of 72 lbs. saccharine extract per barrel, to the consistence of molasses, and then carefully treating it over a slow fire, until it thickens and acquires that bitter taste required for the purpose intended. Fifteen gallons of worts boiled down, is sufficient to make 20 to 25 barrels of porter.

When sugar is subjected to a slow heat and dissolved, it crystallizes on cooling, and loses the capacity of granulation ; but on being dissolved in water, it is still subject to fermentation, although not with such rapidity, or to such a degree, as common sugar

or glucosin (malt-sugar), hence the motive for using it in porter brewing. But when sugar is boiled down to make colouring, and subjected to the continued action of caloric, it loses both the capacity of crystallization and fermentation, and becomes a vegetable bitter. When it is reduced to this state, it is dissolved in the porter-worts, giving them a dark-brown colour; and, not being subject to the fermenting principle, remains dissolved in the finished liquor, preserving its transparency and bitter quality. *Essentia bine* or malt-wort, boiled down and burned, possesses the same qualities, and gives to porter a similar property as sugar colouring. Spanish liquorice should be dissolved in water, previously to being mixed with the malt-wort in the boiler. When dissolved in the worts during the processes of boiling, it causes the liquor, afterwards, to become ropy, more especially when put down with old ale. The peculiar flavour of liquorice or liquorice-root is slightly perceptible in every species of porter, properly made.

The following description of making up a vat of 60 barrels of porter may be serviceable to the reader.

Two brewings of porter, consisting each of 20 barrels being required,—60 bushels of pale and brown malt in equal proportions, with 30 lbs. weight of hops, thirty pounds of *Essentia bine*, and the same quantity of clarified sugar, with 6 lbs. of Spanish juice, and 4 lbs. of ground liquorice root, were used for each brewing. They were conducted by stirring each mash; and quick fermentation; and cleansed in wine pipes.

Two days after being cleansed, the whole was overturned into a vat, and 15 barrels of fine old ale, previously prepared with 2 lbs. of hops to each barrel, were added. The vat was headed with 5 barrels double-stout London porter, room being left for expansion; the manhole was battened down, and a vent-tube properly inserted on the head of the vat. It thus contained 60 barrels of porter, averaging, with the double stout, 66 lbs. saccharum per barrel. The porter remained to ripen for three months, from April to July, when it was racked off, to order; and turned out in remarkably good condition. Nothing was added but the usual heading of carbonate and orange powder, and about one-third pint finings per barrel when sent out to customers.

Before closing the description of provincial porter-brewing on a small scale, it may not be out of place, to call the reader's attention to the best method of managing returned ale, either for the purpose of porter-brewing; or to preserve it, to be resold as old ale, which, in many districts, becomes acceptable during the summer months. There are few brewers but who have ale, on the second fermentation, occasionally returned by their customers; which is often a cause of reflection, as useless as the loss is serious, if not immediately remedied. Publicans are not always to blame for mismanagement. In populous districts, where competition exists, ale is often forced on the customer, notwithstanding it is quite palpable that his stock is already too large for the run

of his business. In such a case, part of it inevitably gives way; and no alternative remains but to return it. The best thing a brewer can do, is to remove and replace it with stock in better condition.

Of the ale returned, if there be a considerable quantity on hand, part is selected to be used in porter-brewing; or the whole is made up for keeping, or old ale. The first is mixed with 2 lbs. of hops to each barrel, and placed aside until required. The kind for keeping is overturned into wine-pipes, which, when obtained fresh from the wine-merchant, do not require to be washed, but the ale may be overturned into them on the wine lees. The pipes require a quarter-hoop, and chime on each end, to render them secure and serviceable for brewing purposes.

In overturning the ale into the pipes, a barrel of the strongest kind, new from the tunning-room, is added to each pipe, with 4 lbs. of best Kent hops. A slack bung is put in each, and they must be kept full and carefully attended to.

This ale soon acquires the flavour of home-brewed, and is sold during the summer months, in fine condition. Some brewers use carbonate of potash to take up the acidity of old ales; others put a barrel or two of old ale into the gyle before tunning. In both cases, injury is done by mixing them, which is more hurtful to the brewer, in the end, than any immediate advantage he may derive. In porter-brewing, none should be used except what has been carefully prepared, and is quite fit for the purpose.

## HOME-BREWED ALE.

The method of brewing ale, by private families, is nearly similar in the different counties of England. The diversity of flavour it exhibits arises chiefly from the materials and quality of water used. The possession of those which are good, with established modes of brewing, give the production a distinctive character, which must be preserved so long as these advantages exist. Thus, the kind made in one county, from the same quantity of material as that which is made in another, differs in strength and in purity; and so much in flavour, as to be locally distinguished. No other cause can be traced to create this distinction, but variety of malt, hops, and water, with that difference in the manner of conducting the process of brewing which ever attends the manufacture of malt liquor,—for no two brewers ever work out the process alike. The same causes operate in the manufacture of ales by common brewers. Particular tastes and customs demand a certain quality at fixed rates, which must be supplied; and thus the kind is established, and becomes characteristic of the locality.

In proposing to notice the method of making home-brewed ale, it is unnecessary again to enter either into the theory of brewing,—the various improvements which have been introduced, or of which

the art is still susceptible,—or of the methods of working towards establishing economy in conducting the process. Nor would it be acceptable to the reader, to lengthen out the description of the various modes of brewing in the different counties. I shall, therefore, class home-brewed under three denominations, making a few remarks on each, which may afford a general view of the whole.

There are three classes, in England, who make ale for their own use:—*1st*, Families of distinction; *2d*, Of the middle classes; *3d*, Cottagers; and, although the last are not numerous, they ought to be encouraged by every facility which the reduction of the malt-tax, the prospective reasonable price of malt, and the patronage of the rich might afford.

It will be obvious, that it must rather be the description of making ale from a given quantity of materials, than that of the construction and adaptation of utensils, that will form the subject of the following remarks.

*1st, Home-Brewed Ale by Families of Distinction.*—In brewing ale of the best description, in any considerable quantity, it may be at once supposed that a commodious brewhouse exists, fitted up with every requisite for its purpose; and that a brewing is to be made of 9 hogsheads of ale, from 9 bushels of malt to each hogshead, with 1 lb. of hops to each bushel of malt.

In laying on the first mash, it may be assumed that the 81-bushels of malt take up 5 hogsheads of

water to saturate the malt. The calculation to be made is, how much water must be laid on, in addition, to extract the saccharine matter or wort necessary to make up the quantity required, to produce 9 hogsheads of finished ale; making an allowance for the waste that takes place, from the water being taken up by the malt, and by evaporation, in boiling and cooling down for fermentation?

The quantity of water required for the brewing will be 18 hogsheads; but it is certain that, were the whole laid on at once, a large proportion would be left in the mash, and the malt prevented from yielding a further extract. Separate mashing is therefore necessary, to obtain sufficient quantity of worts, of strength, commensurate with the weight of malt in operation.

The first mash will require 12 hogsheads of water at a temperature of  $170^{\circ}$ , which, after being stirred a quarter of an hour; or until the malt and water are thoroughly mixed, is allowed three hours to extract. Seven hogsheads of wort will be obtained, weighing 130 lbs. saccharum per barrel of 36 gallons. Seven hogsheads water, at  $180^{\circ}$ , are laid on for the second mash; which, after being stirred, and allowed two hours to extract, yield six hogsheads of wort, weighing 70 lbs. per barrel. Five hogsheads of water, at  $170^{\circ}$ , are now laid on for table-beer, which, after infusing one hour, are drawn at the weight of 30 lbs. per barrel.

*Boiling.*—Thirteen hogsheads of worts are now in the copper, weighing 103 lbs. saccharum per barrel, and brought to the boiling temperature as rapidly as possible. To obtain the finest hop extract must be carefully minded. After the worts have been boiled for an hour, 40 lbs. of the hops are delivered into them, and boiled another half hour. The remainder is then added, and boiled rapidly half an hour more; making two hours' boiling for the worts, one hour's boiling for half of the hops, and one half-hour for the remainder. This is quite sufficient to extract the aroma and first bitter principle, and impart to the ale that fine aromatic flavour which it should possess, when finished in the highest possible state of perfection.

It is almost unnecessary to state, that, in brewing ale of the very first quality, it is essential to use malt and hops the best that can be procured. The malt must be known to have been manufactured from barley of the first kind; to be fresh made, of a pale colour, mellow, and sweet-flavoured; and the hops, the finest produce of Kent. Ale, of the first-rate quality and flavour, can only be made from materials of such description.

When the worts have been boiled from one-and-a-half to two hours, according to the quantity to be boiled down to strength, the fire is drawn, and they are allowed to remain in the boiler for half an hour. This arrangement, as mentioned in last chapter,

allows the hops to infuse the better, and reduces, at the same time, the capacity of the worts to escape by evaporation, which is greatest at the boiling point.

The worts are now drained through the hopback, and cooled down in the usual manner, by evaporation to 60°, before being pitched to ferment. This heat is 2° below the standard; but with these strong worts it is prudent to be under the common brewers' heats, whose ales are weaker in saccharine extract. The quantity of ale required is 9 hogsheads, or 13½ barrels, and the weight in saccharine extract is 134 lbs. per barrel.

The quantity of yeast for ferment is six gallons. Half a barrel of wort is run into the gyle-tun, with which the yeast is mixed; and the remainder of the wort immediately pitched in full flow from the coolers at 60°, as previously mentioned. The appearance of the gyle becomes similar to that of common ale, except that during the carbonic acid formation the froth rises on the surface bolder, sometimes swelling up to the head of the tun. This is always the sure sign of a healthy, vigorous fermentation. From having been pitched at 60°, the worts take more time to come to maturity for cleansing; but they are generally ready within forty-eight hours: 1 lb. of salt and 3 lbs. of flour are thrown into the gyle before cleansing, and, as usual in quick fermentation, the yeast and worts are plunged and mixed together.

The worts are cleansed in pipes set on their bilge on stillions. The common method of filling up when working out until they come to yeast, is generally followed, in making home-brewed ale. The pipes must be filled up every hour for the first six hours; then every two hours, until the worts come to form yeast,—then every four hours until cleansed.

In six weeks after cleansing, the ale arrives at the stage of what is called the first fining; and may be bunged down, and brought into use. But it is a general practice, in family establishments of magnitude, to hop down the new ale for keeping; the ale used, from the cellars, being in succession of stock, generally from six to twelve months old. Six pounds weight of hops are put into each pipe of new ale, which is reckoned sufficient to keep it over the summer season. The bungs are always out for the first two or three months. The cask being kept full, and the hops remaining at the surface, render driving the bung unnecessary, and prevent the ale running into the acetous state.

In all cellars where a large stock of ale is kept, the bungs of the pipes must be raised before the heats of summer, and  $1\frac{1}{2}$  lbs. of the best hops put into each, as required; they are kept slack bunged, with a vent-plug in each cask. Ale, in bottle, should never be kept longer than the season in which it was intended to be used. But when in wood it may be preserved in fine condition for many years. The judicious addition of hops seasonably made, is the

means for its preservation. When ale has been more than one year in the cask, it may be renewed as follows: The contents of two pipes are overturned into three empty ones, which latter will require about 36 gallons of new ale, each, to fill them up; care being taken that the old ale is racked off, pure, and free from the hops which had been put into it in former years for its preservation. The new ale must be as strong, or stronger if possible, than that to which it is added; and it must be added in a day or two after being cleansed, and before it is removed from the stillions; 3 lbs. of the finest hops are to be put into each pipe, which are bunged down, and placed, on end, in the cellars. This ale, supposing that both the old and new, made from 9 or 10 bushels of malt to each hogshead, when ripe, approaches to wine in quality, and affords, in all probability, the best sample of home-brewed that it is possible to produce.

*2d, Home-brewed ale made by the middle classes of society*, comprehending the numerous families whose establishments do not require such a large stock of ale to be made and kept for use as those of the nobility,—wealthy yeomen, and farmers,—and numerous families, in town and country. By all these classes ale is made of the richest description, and which, from being proportioned with hops, either to keep during the year, or to be used after its first fining, is reckoned by judges even superior to the ale made by the nobility, which is often so

strongly hopped for preservation. In the former kind, the fine, peculiar, fresh-malt flavour is obtained, with the aroma of the hop in greater perfection than in old ale, and the due proportion of alcohol and starch-sugar better preserved. But this is a matter of taste; both kinds are excellent, and exhibit the art of brewing in a state of great perfection.

In selecting for the reader information of the best methods of brewing this second description of ale, to do justice to the subject, it would be necessary to describe the modes adopted in different counties, where ales of a very fine quality are made; and to fix on such towns or districts which have become celebrated for their production. It may be sufficient to notice the method of brewing in Nottingham, which will afford an idea of making home-brewed of a superior description.

In a brewing of 2 barrels, or 72 gallons of ale, 9 strikes (bushels) of malt, with 12 lbs. of hops are used; but the quantity of the latter may be 2 lbs. less or more, according to taste. The malt is ground small, and mashed with 72 gallons of water at the temperature of  $160^{\circ}$ . The malt and water are stirred completely, and allowed three hours to extract, the mash-tun being closely covered up with sacking. Forty gallons of wort are drawn, into which the 12 lbs. of hops are mixed and left to infuse; meantime 60 gallons of water at  $170^{\circ}$  are run into the tun for a second mash, which are drawn off after standing two hours. The worts are boiled together for two hours,

and, after being cooled down to  $65^{\circ}$ , strained through a flannel bag into the fermenting-tub. One-and-a-quarter gallon of yeast is then mixed with the worts, and left to work from 24 to 30 hours. When run into the barrels to cleanse, 6 or 7 gallons are reserved for filling. About 18 gallons of beer are made after the second mash is drawn, and the same hops used as were boiled with the ale-wort, or fresh hops, if such are preferred.

The reader will perceive, that by the Nottingham mode of brewing, the heat of the first mash is only  $160^{\circ}$ , which is in consequence of the malt being small ground. The hops are infused in the first mash, an excellent method for extracting their fine aromatic bitter principle; and the fermentation heat is  $65^{\circ}$ , which accounts for the worts coming to maturity in 30 hours.

When it is considered that the Nottingham district yields barley of the first quality, and is equally celebrated for judicious malting as for the goodness of its ale, it may be calculated that the strength in saccharine extract of the kind brewed, as described, is 110 lbs. per barrel.

It may be once more remarked, that the quantity of malt and hops used in brewing strong ales must be in proportion to the quality and strength of the kind required. In England, the general calculation, when speaking of the strength of ale, is to name it at a given number of bushels of malt per hogshead, which contains 54 gallons, or  $1\frac{1}{2}$  barrel.

The range of measure of malt for home-brewed may be taken from 6 to 10 bushels per hogshead ; above the latter quantity, it is mere waste to attempt to mash, except it is intended to keep the ale a number of years ; but in farther explanation of this subject, the reader must be referred to *Fermentation*, in the Scottish system of ale-brewing.

*3d, Home-brewed ale, made by cottagers and private families* who brew on a small economical scale, and which, in the midland and southern counties of England, are pretty numerous. It cannot admit of a doubt, that ale of a fine quality can be made at such a moderate expense as to render it an object in domestic economy.

The utensils and other requisites to brew on a small scale, are provided at little cost. A wine-pipe or rum-puncheon sawn in two, makes an excellent mash-tub and gyle. A boiler made of iron plate, capable of holding 36 to 54 gallons, and a cooler in proportion, can be procured, at a very reasonable price, in every town or village which possesses a smith and carpenter ; these, with two or three casks, and other requisites procured, necessary for the purposes of brewing, the whole may be completed and fitted up in any small outhouse that can be conveniently adapted as the brewhouse.

Three bushels of malt, and  $2\frac{1}{2}$  or 3 lbs. of hops, are sufficient to make 36 gallons of ale of a good quality, equal in strength to what is sold by respectable publicans at threepence per pint. By dividing

these materials, 18 gallons may be produced of equal strength. In both cases, a few gallons of small beer are obtained, which, with the grains and yeast left after each brewing, every family, especially those in country residences, can find use for.

The reader will observe, that 3 bushels of malt produce 36 gallons of ale equal to 72 lbs. saccharine extract, which is a strength of good ale for family use. Another bushel added, would increase the saccharine extract to 94 lbs. per barrel of 36 gallons, another to 116 lbs.; and were 6 bushels used, it would be 130 to 138 lbs. saccharine extract per barrel, which is equivalent to the best description of ale brewed from 9 bushels to the hogshead by the first families in England. In all these cases, 1 lb. of hops to each bushel of malt in operation is sufficient.

In the description of brewing, on a small scale, for family use, it is unnecessary for the reader to be troubled about the density or specific gravities of the worts, or weighing them by the saccharometer, or with technical or chemical terms. A thermometer, however, to ascertain the heats, is a very safe guide, to make sure work with, and ought to be found in every brewhouse. All the information on the subject necessary may be contained in a few plain directions, by which the process may be carried through successfully, and ale of the best quality produced.

The first essential in brewing, is a minute and careful inspection of all the utensils, casks, and requisites; everything must be previously arranged,

and in proper place; and each and all of them scrubbed and scalded with boiling water repeatedly, until the whole apparatus is perfectly sweet and clean.

Supposing, therefore, that the whole utensils are perfect and in readiness, and that 36 gallons of ale, and 10 gallons of table-beer are required from three bushels of malt and three pounds of hops. One hundred gallons of pure soft spring-water must be provided; and the boiler filled, and brought to the boiling heat. By waiting until the water cools down to the heat required for mashing, is better than tempering it with cold water. When at the temperature of  $180^{\circ}$ , 32 gallons are run into the mash-tun. The water loses about  $5^{\circ}$  in going down; if the malt be small ground, it is better to let the water in the mash-tun be  $170^{\circ}$  to  $175^{\circ}$ . The three bushels of malt are now added, one bushel at a time, and immediately stirred and mixed thoroughly with the water; the whole operation taking a quarter of an hour, or twenty minutes. The mash-tun is then covered, and allowed three hours to extract. In the mean time, the remainder of the water is delivered into the boiler, and prepared for the second mash. After three hours, the worts are drawn from the first mash slowly at first, until they run transparent. About 22 gallons worts are obtained, the remainder being taken up by the malt, and left in the mash-tun. The second mash is now commenced by letting down 34 gallons

water at 180°, and immediately stirring it for ten minutes. The mash is then covered up as formerly, and allowed two hours to extract. The water in the boiler is now prepared for the small beer, and when it comes to the boiling heat, it is run into a clean receiver,—and the worts of the first mash delivered into the boiler. The second mash is then drawn, and also removed into the boiler, which now contains 54 gallons worts, and must be brought through to boil as quickly as possible.

The water for the small beer is now laid on to the extent of 14 gallons, at any heat from 160° to 170°, and allowed one hour to extract. The 54 gallons of wort in the boiler, are boiled for half an hour without the hops, these are then added, and boiled another hour, which is quite sufficient to extract their aroma and first bitter principle. The fire is then drawn, and the worts allowed to remain in the boiler twenty minutes, or half an hour, to infuse the hops a little more, and prevent too rapid evaporation on the coolers, were the worts spread on them at a boiling heat.

The worts are then strained through the hop-drainer on to the coolers, and cooled down to 65°. Were a larger brewing in hand, 62° is a better fermenting heat, but on a small scale, 65° is judged necessary, in consequence of the heat lost by using small utensils. The Nottingham and Midland County family brewers generally prefer 65°; and as they

are reckoned amongst the best in England, the heat used by them may be assumed as the best for fermentation on a small scale.

For 36 gallons of worts, half a gallon of yeast is requisite. It must be thick, strong, and fresh, and obtained from a brewing of equally strong worts, or stronger than those to which it is to be applied. The worts are first run into the fermenting-vessel, and the yeast then put in and mixed together.

In thirty hours, or thirty-six at farthest, the fermentation will have come progressively forward, as described formerly; and when the head of yeast begins to sink, the worts are tunned into casks, as suitable for family convenience. Three or four gallons of the fermented worts are reserved to fill up with. The casks work out into a receiver or trough, and are kept filled up every hour and two hours, until the yeast separates, and the fermentation ceases. The reader will observe that the 54 gallons of worts taken from the two mashes are reduced to 36 gallons of finished ale, by waste, arising from evaporation in boiling and cooling down for fermentation; and in cleansing.

Some family brewers add refined sugar, sometimes, to help the worts; but when there is plenty of malt, there is no occasion for it, except, indeed, where too much wort is drawn from the mash, and threatens weakness; 6 lbs. of refined sugar will greatly improve it, and may be put into the boiler with the hops.

The beer-wort is boiled for an hour, after the strong worts, and the hops used in the brewing are boiled half an hour, or a quarter of an hour will do. When ale is made from 4, 5, or 6 bushels of malt, to a barrel of 36 gallons, a strong table-beer or weak ale may be made, in which case it is requisite to use 1 lb. of fresh hops, and boil them one hour with the wort. When ale is required to be kept over the summer, 1½ lb. of fine Kent hops are put into each barrel of 36 gallons,—the bungs of the casks slackened, and the casks kept full.

In cases where a smaller quantity of ale is required to be made than 36 gallons, the materials are divided in proportion. It may be once more repeated, that on whatever scale the brewing is conducted, the best malt and hops are requisite to produce malt liquors of the best quality; and that it is almost an infallible proof of skill, when to the eye of a judge, every thing about the brewhouse appears to be arranged and conducted with cleanliness and economy.

## CHAPTER V.

### SUMMARY OF MALTING AND BREWING.

THE design of adding Observations on the practical methods of brewing to Dr Thomson's Treatise, was suggested, when it was first proposed to reprint

it, from the *Encyclopædia Britannica*, in a separate volume; for it was evident that the author, from the limited space afforded in that great work, had necessarily passed over a variety of details, to give more room for a general description of brewing, and to establish the main structure of the art on the solid foundation of science.

There were two modes by which these additions could be united to an original work of such acknowledged superiority. 1. By writing a series of annotations on the text, supplying such practical details as might be useful to the reader, explanatory of the operative processes of brewing the different species of malt liquors, distinguished as national productions; and, 2. By dividing the art of brewing into parts,—arranging them into classes; and, by investigating each separate process in connection with the whole, to endeavour to trace the principles which distinguish malt liquors, so much, as to give them a permanent local character.

The general reader will at once perceive that the first plan, at best, could have been attended with very little utility. Brewers are, generally, too well informed to give much attention to aught but what evidently tends to substantial improvement; besides, Dr Thomson is distinguished amongst British chemists, as having bestowed much of his time investigating the whole range of malting, brewing, and distillation; and his writings on these subjects bear such an impress of practical usefulness, that it would have

been justly deemed presumptuous to make any remark on them whatever, either by note or by way of explanation.

The only course, therefore, that could be pursued with propriety, was to adopt the second plan ;—and relying on the resources of practical experience, and, the light thrown on the more intricate processes of brewing by Dr Thomson's works, to frame the subject so as to be of some utility to those engaged in the business of malting and brewing.

This design afforded another advantage. The Author of these Additional Observations on the practical methods of brewing, was left at perfect liberty to refer to the works of Dr Thomson, the same as to those of other writers, and could thus offer to the reader authority from the best sources for the reasons on which his assertions on the more intricate processes of brewing were founded.

The plan of these additional observations may be described in a few words : 1. Introductory remarks on the progress of malting, brewing, and distillation, since the establishment of the Excise laws ; 2. Practical methods of brewing ; 3. Scottish system of ale-brewing ; 4. English system ; 5. Provincial porter-brewing, and the production of home-brewed ale.

Under these heads, every part of practical brewing has been investigated. The different species of malt liquors have been classed and described separately ; no secrets are either preserved or pretended ; and all the methods of economical working within the

writer's knowledge have been brought forward that were deemed worthy of the brewer's notice, or could in any manner tend towards improvement.

But it may be useful to take a retrospective glance at the state of knowledge, in England, in relation to the arts of malting, brewing, and distillation, almost up to the end of the last century.

Till that period, from the first establishment of the Excise, at the restoration of Charles II., no author had appeared, whose writings on these arts afford anything like an investigation, on rational principles, of the processes by which liquors of required strengths and qualities were manufactured. When it is considered that the thermometer, so necessary, now, at every turn of the operations of brewing, had not been long in general use, and that the saccharometer was unknown, it may be readily imagined little progress had been made, by practical men, in the scientific knowledge of their profession.

Nor was it possible. Though the most celebrated chemists, who arose during the course of the eighteenth century, had turned their attention to the processes of brewing; and although many important points were investigated, and the substances employed in the manufacture of malt liquor and alcohol rigidly analysed, the more intricate problem remained unresolved; for, until the laws were discovered which regulated the arrangement of the particles of carbon, hydrogen, and oxygen, in the formation of alcohol and carbonic acid by the decomposition of sugar, it

was evident that the true theory of fermentation could not be established. Nothing else can account for the crude notions and ephemeral theories that were published during the above period; nor for the vain endeavours to explain the chemical phenomena that appear during the processes of malting, brewing, and distillation.

It is unnecessary—nor would it be of any advantage to practical brewers of the present time—to review works which are gradually becoming obsolete as knowledge advances. For it is in the arts of malting, brewing, and distillation as in others; nothing is permanent but what is established on the accurate principles of science.

Mr Richardson, of Hull, may be considered as the last of this class of authors, whose writings attracted considerable notice, and whose researches were of some importance, as leading towards improvement in the art of brewing. Dr Thomson, in his historical notice, gives him the credit of discovering the first method of constructing an instrument for weighing the saccharine solution of malt, which, although made on erroneous principles, was an approximation towards the invention of the saccharometer now in general use.

Mr Richardson, however, is mentioned in the treatise in terms of marked severity, as the author of a work on Brewing, in which he avows concealment of part of the process. There cannot be any doubt whatever, that these advertisements of the possession

of secrets in brewing were made from interested motives; and it may be safely assumed, that he possessed no secret of any importance to conceal. He published two works, *Theoretic Hints on Brewing*, and *Statical Estimates of the Materials* employed; in neither of which, in a scientific view towards practical improvement, can anything be made out that establishes any part of the process by rational theory; all is mystery and conjecture; and when he meets with a difficulty he cannot surmount, it is set down as "beyond the reach of philosophical investigation." The range of his experiments shew, that he was rather below the state of knowledge of the time. He has the merit of discovering the saccharometer; but it does not appear from his writings that he made any experiments whatever to improve it, by dissolving determinate weights of the saccharine extract, to ascertain the capacity of water at different temperatures to hold sugar in solution. Again, he fermented two quantities of ale worts of different specific gravities, and found to his astonishment, that the weaker solution yielded the greater quantity of alcohol, in proportion to the quantity of saccharine matter in solution; but arguing that the strongest ale, notwithstanding, possessed the inebriating principle in proportion to its original weight of saccharum, which was exemplified by those who drink equal portions of the stronger and weaker kinds, although the latter contained as much spirit as the former, which was proved by his own experiment. He

advances a hypothesis, that strong ale contained an inebriating principle independent of alcohol, and, after some unintelligible remarks, he explains the matter thus:—"The most natural supposition which occurs to me, on the present occasion, is, that the principle here alluded to is the gas or *fixed air*, produced by and inherent in all fermented liquors, so long as they contain the least essential particle of their original composition, or of those constituent parts."

But of course he was ignorant of the principle of attenuation, or rather of fermentation, as applicable to the conversion of the starch-sugar of malt into alcohol and carbonic acid; and appears to have been altogether unaware of the fact, that the former possesses the power to diminish, and ultimately to destroy, fermentation in proportion to the original quantity of sugar in solution. Every distiller knows, that 70 lbs. of sugar, dissolved in 36 gallons of water, subjected to fermentation, and attenuated as much as possible, yields, by distillation, more alcohol, by 40 per cent., than the same weight of sugar dissolved in 18 gallons of water, and subjected to the same processes.

In the latter case, the rapid evolution of the alcohol from the strong worts, checks, and ultimately destroys, the fermentation, and thus prevents the farther decomposition of the sugar in solution.

These facts are mentioned at some length, to prove that brewers have lost nothing by Mr Richardson's concealment of the process. The only temporary

advantage which he appears to have possessed, was the division of the worts obtained from the mash, to brew ales of different strength, which he was enabled to do by the first possession of the saccharometer. He advertised this, and instructed others for a remuneration,—which he was entitled to do; but when he published a book on the subject, he was bound, by every principle of common sense and honesty, to let the community have the benefit of his researches.

But notwithstanding that science had as yet done little for the advancement of the arts of malting and brewing in England, maltsters, brewers, and distillers made prodigious efforts during the long reign of George III., to improve their various manufactures, by every means which skill and capital could devise or command.

During the last ten years of the century, or rather from the beginning of the first French Revolution in 1788, up to 1798, the consumption of malt, in England, had rapidly increased. In 1799, the quantity of malt made and paid duty for, amounted to 30,000,000 of bushels. The London porter-breweries had kept pace with the wealth and population of the great metropolis, for within thirty years the production of beer and ale had more than doubled; and the accumulation of immense capital, and enlargement of business, afforded undeniable evidence, that the stationary limit of the malt-trade had been passed; and that the future growth and consumption of barley

would keep improving with the wealth and prosperity of the country.

Such, certainly, were the prospects of the malting, brewing, and distilling interests, at the commencement of the present century; nor were these prospects obscured by existing circumstances, arising out of the war of the French Revolution. For the Government, from some inexplicable cause, had as yet left untouched the productions of barley in the shape of malt, beer, and spirits, as a source of additional taxation; the duty on the former being still 1s. 4½d. per bushel, and on beer 8s. per barrel.

The whole was delusion. The failure of the crops of every species of grain, for two years successively, in 1800 and 1801, might have been got over; for a series of abundant harvests followed, but the peace of 1802, 1803, was merely an experiment,—during the process of which, the Ministry, as a prelude to a predetermined event, hurried a bill through Parliament, raising the duty on malt to 2s. 5d. per bushel, and on beer to 9s. 3d. per barrel. War was proclaimed, and, as a matter of course, the war-taxes, as they were now termed, were passed; the tax on malt being fixed at 4s. 5½d. per bushel, and on beer at 10s. per barrel.

The immediate consequence of such exorbitant and unwise taxation ensued. The consumpt of malt was reduced 25 per cent., and this took place chiefly amongst those who brewed their own ales; the com-

mon brewers also suffering a diminution of business ; while, on the other hand, smuggling in foreign spirits, and in whisky, was carried on to an enormous extent.

Such a state of things could not but arrest the attention of Government. Commissioners, scientific men, were appointed to inquire into the state of the relative growth and value of English and Scotch barley, and its manufacture into malt. Intelligent and respectable excise officers were sent out in various directions to examine and report on the state of the various maltings, breweries, and distilleries of the United Kingdom,—of their methods of working,—and especially of such plans, forms, and restrictions, as might be deemed advisable to prevent fraud on the revenue.

By the act 42d George III., it was enacted, that no maltster should sprinkle his grain, making it into malt, until the expiration of twelve days after its removal from the cistern, under a penalty of £200.

This destructive act of Parliament had caused much loss, by damaging the quality of malt ; and forced the maltsters of England to send a deputation to London and remonstrate. The deputation were introduced by Mr Manners Sutton, solicitor-general, to N. Vansittart, Esq., secretary of the treasury. They made proposals to regulate their process of malting, on the principles of security to the revenue and sound practical experience.

They proposed,—

1. To steep the barley for sixty hours.
2. To lock down the cistern during the time of steeping.
3. To sprinkle the growing malt after the eighth day, instead of the twelfth.

As neither Mr Vansittart nor Mr Manners Sutton knew any thing about the matter, and, perhaps, were unacquainted with the practical bearing of the maltsters' demands, they very properly referred the matter to the Board of Excise, who rejected the proposals.

In consequence of the losses, however, which took place, and, perhaps, of the numerous prosecutions for sprinkling the floors of grain, petitions were poured into the House of Commons praying for relief; and another deputation waited on Lord Grenville and Lord Henry Petty, on a similar errand as the first.

Their lordships took up the matter in earnest. They were men of business; and, from the explanation of the gentlemen, who were chiefly maltsters, who waited on them, understood wherein their grievance consisted, and promised redress.

In a very short period a Treasury Minute was issued to the Board of Excise, ordering them to direct their officers to permit the sprinkling of malt on the floors after the expiration of the ninth day, until a bill could be passed to confirm it by law.

The maltsters of Hertfordshire, Cambridgeshire, Norfolk, Suffolk, Essex, and other southern districts, immediately opposed the relaxation of the Excise-

law in favour of sprinkling the malt on the floors after the ninth day's growth, and petitioned the House of Commons against any such indulgence.

The general reader may require an explanation of the distinction between the Hertfordshire method, and what may with propriety be called the English system of malting.

The Hertfordshire method consists of steeping the barley in the cistern for 50 hours, and working it on the floors, to the process of kiln-drying, without sprinkling water on it during germination. The English system is that which is followed in Yorkshire, Lincoln, Nottingham, and all the northern counties and other districts of England possessed of strong alluvial soils,—steeping from 60 to 70 hours, but generally about the former time, and sprinkling water on the grain on the floors after the sixth or seventh day from its being cast from the cistern. The latter method requires the floor of malt to be spread thin, and the heat kept nearly up to 50°; while the Hertfordshire method requires the malt to be rather kept thick on the floors to preserve the original moisture, and the heat to range from 55° to 60°.

The House of Commons determined that a Committee should be appointed to investigate the subject, the result of which was, that the most intelligent maltsters and brewers of England were examined, whose evidence forms a valuable collection of reference as to the methods of malting above described.

The Commissioners appointed in Scotland to examine into the relative values of English and Scottish barleys in the process of being manufactured into malt, were Dr Hope, Professor of Chemistry, Edinburgh; Dr Coventry, Professor of Agriculture; and Dr Thomson, Professor of Chemistry, Glasgow. The result of their investigations was drawn up by Dr Thomson, in a report, as remarkable for its explicit detail of the whole process of the artificial germination of barley, as for its practical usefulness to operative maltsters.

This report is incorporated with the Treatise on Brewing, Chap. II. and III., and is, beyond all dispute, the best summary of malting that ever was published.

The report to the Board of Excise, at the same period, on the comparative merits of the methods of malting as adopted in England, was drawn up by John Carr, Esq., Collector of Excise at Manchester, a gentleman of acknowledged ability, and whose report proved him peculiarly qualified to be dangerous to the party he opposed. He espoused the Hertfordshire method, and it was mainly through his instrumentality that the restriction of the sprinkling system was continued for a considerable time, after common sense and the public interest had united in declaring the gross injustice and impolicy of continuing the destructive regulation any longer.

By the law as now established, the maltster is permitted to sprinkle his malt on the floor, after the sixth day, provided it has been steeped for fifty hours

in the cistern, on giving twenty-four hours' notice. This law has conferred a great benefit on the whole malting interest; but the printed evidence before the Committee of the House of Commons,—the report of the Scottish Commissioners,—and Mr Carr's report, and other evidence to the Board of Excise,—would still be extremely valuable to maltsters, although dated so far back as 1806-7.

In the design of this summary, it was intended to give an outline of these valuable documents so far as might be useful in practice, for the information of the reader; but no space is left: and until another opportunity occurs, the subject must be deferred.

It was also within the scope of these observations on malting and brewing, to make a short recapitulation of the more important processes of these manufactures, which, either by improvement of utensils, or farther examination of the principles on which they are conducted, towards economy in the use of materials, might be of advantage to the practical brewer, in the prosecution of his business; but the length to which these subjects have extended, and the number of practical methods, and improvements in brewing which have been noticed, under the different heads, render further observations superfluous.

The reader's attention, however, may be directed to the value and importance of the maltings, breweries, and distilleries of Britain, in a national point of view, and, which have never been sufficiently appreciated. The capital embarked in these establish-

### 320 SUMMARY OF MALTING AND BREWING.

ments, and in victuallers' and publicans' business, cannot be estimated at less than thirty millions; and the annual retail value of the productions of malt, distilled spirits, and the various descriptions of malt liquors made for public and domestic consumption, will amount to fifty-two millions five hundred thousand pounds sterling.

The annual revenue which is derived from these manufactories, and the publicans' licences, exceed eleven millions; and the amount paid to the agricultural interest, for barley and hops, will not be less than ten millions five hundred thousand pounds, averaging barley at 32s. per quarter, and hops at 9d. per lb., while not fewer than 500,000 of the population are supported either by cultivating the soil for the growth of barley and hops, or in making and selling their various productions.

During the wars of the French Revolution, the tax on malt was 4s. 5½d. per bushel, and the tax on beer and ale 10s. per barrel; since then 2s. per bushel of the former, and the whole of the latter, have been repealed.

At the lowest estimate that can be formed, the revenue derived by excise from maltsters, brewers, distillers, and licensed victuallers and publicans, since the beginning of the first French Revolution in 1788-9, to the establishment of the last Republic in 1848-9, a period of sixty years, amounts to the enormous aggregate sum of six hundred and fifty millions of pounds; the sum paid for barley and hops to the

agriculturists during the same period, amounting to no less than four hundred and twenty millions.

These sums startle the imagination; and one would be very apt to think, on an examination of the official returns, that British capitalists who had contributed such vast sums in support of Government, and to the proprietors of the soil, would have been treated and cherished with much indulgence and protection; but the very contrary is the painful truth. The innumerable prosecutions that maltsters, brewers, and distillers have been persecuted with, not for fraud, but informality in not working out their processes by stringent acts of Parliament, in place of their own convictions of experience, incontestibly prove, that much valuable property must have been destroyed by legislation, which has always been felt by these parties to be oppressive and unjust.



A

**TREATISE ON DISTILLATION.**



## ON DISTILLATION.

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THE preparation of ardent spirits constitutes a manufactory which is carried on in this country to a considerable extent, and deserves a particular investigation, as connected with one of the most curious and intricate departments of Chemistry. We shall treat the subject as briefly as is compatible with perspicuity and utility.

It seems established by the experiments of chemists, that no other substance can be converted into ardent spirits, by fermentation, than sugar. Different species of sugar have been recognised by chemists. They are distinguished from each other by their sweetening power, and by the figure of their crystals. As far as the process of distillation is concerned, it seems only necessary to refer to three of these species; namely, *common sugar*, *sugar of grapes*, or *sugar of starch*, and *manna*.

Common sugar is usually extracted from the sugarcane, but it exists likewise in maple, in beet, and in various other vegetable substances. Its colour is

white, and it crystallises in rhomboidal prisms. When it is dissolved in a sufficient quantity of water, and mixed with yeast, it ferments, and the liquid thus fermented yields, when distilled, an ardent spirit. It is from the refuse of common sugar that the ardent spirit well known by the name of *rum* is obtained in the West Indies.

Sugar of grapes is the substance to which that fruit is indebted for its sweet taste. It may be extracted from the juice of grapes, by nearly the same process as is followed by the manufacturers of common sugar. It is white, not so sweet as common sugar, and not so soluble in water. It usually crystallises in spheres. These, when viewed with a glass, are found to consist of a congeries of small acicular crystals diverging from a centre. It is to the presence of this sugar that the juice of grapes owes its fermentability. The ardent spirits obtained by distilling *wine* are usually distinguished by the name of *brandy*. They are manufactured in great abundance in France and Spain, and other wine countries.

When starch is boiled with a large quantity of water and a little sulphuric acid for a considerable time, it is converted into a sugar, which possesses exactly the properties of sugar of grapes. From the experiments of M. Theodore de Saussure, it seems to follow that this sugar is nothing more than a combination of starch with water. During the process of malting, the starch which constitutes so great a

portion of barley is converted into this sugar. If barley-meal be mashed with water of the temperature of  $150^{\circ}$ , and the mixture be well agitated for an hour or two, the barley-starch gradually undergoes a process somewhat similar to mashing; for it becomes soluble in the water, and that liquid acquires a sweet taste. It is from this sugar that the ardent spirits known in this country by the names of *Geneva*, *Whisky*, *Gin*, are obtained. It has been ascertained that common sugar, before fermentation, is converted into starch-sugar or *glucosin*.

*Manna* is a saccharine substance, which exudes spontaneously from the *Fraxinus rotundifolia*, and several other species of ash. The fermented juice of the onion, melon, and carrot, likewise contains manna. Manna has a sweet taste like sugar. It is more soluble both in water and alcohol; it crystallises very readily on cooling, in needles. But its most remarkable property is, that when dissolved in water, and mixed with yeast, it cannot be made to ferment like common or grape sugar. Hence it is incapable of yielding an ardent spirit. To the distiller, therefore, it is totally useless.

Milk likewise contains a peculiar species of saccharine matter, distinguished by the name of *sugar of milk*. In consequence of the presence of this substance, milk is capable of being fermented into an intoxicating liquor, which, of course, if distilled, would yield an ardent spirit. This liquor is made by the Tartars, from the milk of mares, and is known

by the name of *koumiss*. It is made likewise in Shetland.

The liquid which exudes from the cocoa-nut tree also contains a saccharine matter, but of what species has not been ascertained. In consequence of the presence of this saccharine matter, it runs readily into fermentation, and when the fermented liquor is distilled, it yields an ardent spirit, well known in India by the name of *arrack*.

Thus the name of the ardent spirit differs according to the material employed in its manufacture. Every species of ardent spirit is distinguished by a peculiar flavour. The opinion entertained at present is, that the nature of the substance which produces intoxication is the same in all these ardent spirits, and is the substance to which chemists have given the name of *alcohol*; and that the flavour is owing to the presence of an essential oil, derived from the ingredient employed in the manufacture. Thus the sugar-cane yields the oil that gives the peculiar flavour to rum; grapes contain the oil that gives the peculiar flavour to brandy, and so on. We do not know that this opinion, though sufficiently probable in itself, has ever been established by decisive experiments; that the oils to which these spirits owe their flavour have ever been obtained in a separate state; or that all of these spirits have been made to yield alcohol destitute of flavour. But the opinion is so very likely to be true, that we will be forgiven for

adopting it, especially as we are not aware of any counter-evidence that can be brought forward.

The process of the distiller being essentially the same, whatever the substance be from which he procures his *ardent spirits*, we shall satisfy ourselves with a minute account of the processes followed by the distillers in Scotland in manufacturing whisky. We shall introduce, likewise, a few observations on the processes followed in manufacturing ardent spirits in other countries, such as Hollands and Rum; and we shall terminate the treatise by giving the present state of our knowledge of the theory of fermentation.

## CHAPTER I.

### OF THE MANUFACTURE OF WHISKY.

The kind of grain employed in this country for manufacturing whisky is *barley*. The processes are easier, and the spirits produced have a more agreeable flavour, when the barley is *malted*. But, in consequence of the duty upon malt, a portion of unmalted grain has been introduced into the distilleries. This portion has been gradually increased, and amounts very commonly to four-fifths, and in some cases, it is said, to nine-tenths, of the whole mixture of raw grain and malt. It may be laid down as a general rule, that the labour bestowed, and the time

requisite for brewing, increases in proportion to the quantity of raw grain employed.

The processes of the distiller may be reckoned four: namely, the mashing, the cooling, the fermenting, and the distilling. We shall take each of these processes in the order in which we have named them.

### 1. *The Mashing.*

The barley is previously ground to a fine meal, and the malt bruised by passing it between rollers. When the proportion of malt is very small, it is customary to add a quantity of the *seeds* of oats (the husk of oats separated during the grinding), to facilitate the separation of the water from the grains, after the process of mashing is over; for barley-meal parts with water with much greater difficulty than malt. When the proportion of raw grain to malt is as 2 to 1, or even as 3 to 1, this addition of oat seeds may be dispensed with. But it is probably essential when the proportions amount to 5 to 1, or, still more, when to 9 to 1.

The quantity of grain and malt employed at one time must be entirely regulated by the size of the distillery. But, that we may be able to give a precise notion of the proportion of the different substances employed, we shall suppose the quantity taken at once to be 60 bushels, and that it consists of a mixture of two parts raw grain and one part malt, or,

40 bushels barley,  
20 bushels malt.

The mash-tun is a large circular or square vessel, which now-a-days is usually constructed of cast-iron. It was formerly of wood ; but a wooden mash-tun was found to last for so short a time, that iron has been substituted in several distilleries with which we are acquainted, and probably the substitution will soon become general. Into the mash-tun a quantity of water is let down of the temperature of 150° Fahrenheit. The bulk of this water varies according to the fancy of the distiller ; but from 700 to 800 wine gallons may be reckoned a good proportion for sixty bushels of grain. The mixture of meal and bruised malt is then put into the mash-tun, and very carefully mixed with the water by a number of men, who wield each a wooden instrument adapted for the purpose. All the dry clots of meal are broken, and every portion of it wetted with the water. This agitation of the meal in the water is what is technically called *mashing*. It is continued for at least an hour and a half, sometimes much longer ; and the length of time must increase with the proportion of raw grain present, when compared with the malt ; so that sometimes we have seen it continued for three or even four hours. As the liquor in the mash-tun would lose a great deal of its heat during this length of time, about 500 wine gallons of water are added at intervals, at a temperature varying from 190° to 205°, according to the fancy of the brewer. After the mashing is

concluded, the whole mixture is allowed to remain at rest for about two hours, and this interval is technically called the *infusion*. During this interval the grains sink to the bottom, and the *wort*, still muddy, but quite liquid, remains at the surface.

If we have the curiosity to taste the wort every half hour from the commencement of the mashing to the end of the process, we shall find that at first it has little taste, but that it becomes sweeter and sweeter, till at last it acquires very nearly the luscious sweet taste of malt-wort. This indicates clearly, that the starch of the barley-meal is gradually converted, during the mashing, into starch-sugar. In what way this change is produced, we have at present no experiments to determine; but if Theodore de Saussure's theory of the formation of starch-sugar be accurate, we may conclude that the change is produced simply by the combination of a portion of water with the starch. The conversion, however, in the mash-tun, is never complete. A considerable portion of the starch still remains unaltered. The consequence is, that if we endeavour to make wort from raw grain, as strong as possible, to contain, for example, 200 lbs. of saccharine matter per barrel, we find ourselves unable to effect our object, because, long before it has reached 200 lbs. per barrel, the wort has lost its fluidity, and has assumed the form of a jelly. Our mode of trying this experiment was, to take the strongest raw-grain wort which we could procure, and to concentrate it by boiling, till it became as strong

as possible. We were never able, by this method, to obtain a wort much stronger than 150 lbs. per barrel. But malt-wort may be easily boiled down to the strength of 200 lbs. per barrel, without losing its fluidity.

Probably the change of the starch into sugar continues during the process of fermentation. Hence, we conceive, the reason why distillers find it advantageous to put into the fermenting-tuns all the solid starchy matter which had precipitated from the wort while in the coolers. Hence, also, the reason why the fermentation is conceived to go on best when it comes on gradually at first, and not with too much violence.

After the mashing and infusion is finished, the wort is drawn off from the grains. This is not done, as is the practice with the brewers, by opening a cock at the bottom of the mash-tun. It will not in this way pass through barley-meal. But it is drawn off from the top of the mash-tun, after the grains have subsided, by means of a tube pierced full of holes, which rises at one of the corners of the mash-tun as high as the surface of that vessel.

The quantity of wort that runs off in this way does not exceed one-third of the water which had been mashed with the meal. If 1200 gallons of hot water, for example, have been employed in all, the wort drawn off after the mashing will scarcely exceed 400 gallons. If the process were carried no farther, almost two-thirds of the wort would be lost. To pre-

vent this, about 500 gallons of water, of the temperature of  $190^{\circ}$ , are let upon the grains. The whole is well mixed together for about twenty minutes, and then allowed to *infuse*, or to remain at rest, for an hour and a half. It is then drawn off in the same way as the first wort. In general, the amount of the second wort is greater than that of the first, because the grains having been previously deprived of a great proportion of their starch, now part with their water more freely than before.

To carry off everything soluble from the grains as completely as possible, after the second worts have been drawn off, about 800 gallons of boiling hot water are let on the grains. The mashing or stirring is continued for twenty minutes, and the infusion for half an hour or forty minutes. This third wort is then drawn off. Being much weaker than the two preceding worts, some distillers are in the habit of reserving it, and employing it for mixing with the meal and malt in the succeeding brewing. Others boil it down to the requisite strength, and then mix it with the first and second worts in the fermenting-vessel. It is impossible to lay down any rule respecting this part of the process, because, unfortunately, the distiller is not left at liberty to follow his own judgment. The legislature has interfered, and obliged him to produce a determinate quantity of spirits of a given strength from 100 gallons of the fermented wort. Till within these few years it was necessary in Scotland to produce from 100 gal-

lons of fermented wort, 19 gallons of spirits of the strength one to ten over hydrometer proof, or of the specific gravity 0·90917. This law, we believe, still exists in England; but in Scotland the quantity of spirits from 100 gallons of fermented wort has been reduced to 14 gallons.\* The Scotch distiller at present is under the necessity of producing this quantity of spirits from 100 gallons of fermented wort, or, at any rate, of paying the duty for that quantity, whether he produce it or not. This law, of course, regulates the strength of the wort. For, in order to produce that quantity, it is necessary that the wort should contain a certain proportion of saccharine matter. Accordingly, the wort must be at least of the strength  $55\frac{1}{2}$  lbs. per barrel when it is let down into the fermenting-tun, and the law prohibits it from being stronger than 75 lbs. per barrel. If we suppose the whole saccharine matter contained in the wort to be decomposed during the fermentation, 100 wine gallons would produce 14 gallons of spirits of the specific gravity 0·90917, provided the original strength of the wort was  $55\frac{1}{2}$  lbs. per barrel. But this is a supposition which is never realised in practice. From a number of experiments,

\* Still more lately, an Act of Parliament has passed, reducing the product of spirits to thirteen gallons from the hundred gallons of wash, and the strength of the wort must not exceed 70 lbs. of saccharine matter per barrel. The excise regulations bind down the distiller to a particular mode of operating. All such restrictions are very injurious to the improvement of the process. How far they may have been provoked by the attempts of the manufacturer to evade the excise-duties, we pretend not to say.

conducted with considerable care, we consider ourselves warranted in concluding, that, even when the fermentation is conducted with the greatest success, the quantity of saccharine matter which will remain undecomposed in a barrel of wort of the original strength of  $55\frac{1}{2}$  lbs. per barrel, cannot be less than 15 lbs. Hence a distiller can scarcely be expected to produce 14 gallons of spirits of the specific gravity 0.90917 from 100 gallons of wort, unless the original strength of his wort was at least  $70\frac{1}{2}$  lbs. per barrel. In general, indeed, a still greater strength than this will be requisite. Now, to produce wort of the strength  $70\frac{1}{2}$  lbs. per barrel from raw grain, without boiling, is by no means an easy task. Formerly, when the product necessary was 19 gallons of spirits from the 100 of wort, the distillers were accustomed to give their wort the requisite strength by the process which they termed *lobbing*. This consisted in making up a very strong infusion of saccharine matter from malt, raw grain, &c., and adding it to the wort, till it acquired the requisite strength. This substance was likewise called *bub*; and every distiller had his own method of preparing it. Probably sugar, treacle, or other similar prohibited articles, often found their way into it. It was on this supposition that the addition of it to wort was entirely prohibited in the Act of Parliament regarding the Scotch distilleries. And it was to prevent the secreting of the surplus spirits which might be produced above the 14 per cent., that

the strength of the worts was limited to the maximum 75 lbs. per barrel.

When the quantities of grain, malt, and water, above indicated, are employed, the first worts drawn off will be about the strength of 73 lbs. per barrel, and the second worts of the strength 50 lbs. per barrel; and the two, when mixed together, would constitute a wort of the strength of about 62 lbs. per barrel. Of course, the worts actually made by the Scotch distillers must exceed the strength of those which we have employed by way of illustration, by about 8 lbs. per barrel. But we have reason to believe that 62 lbs. per barrel would be a better strength than that pitched upon by those who contrived the Act of Parliament by which the Scotch distilleries are regulated. Wort of such strength should yield about 12 per cent. of spirits of the strength one to ten over proof, or of the specific gravity 0.90917. The original strength of the wort from which Dutch Holland is made is considerably less than this; and we believe that nobody will deny that the Dutch spirit is, in general, much preferable to the whisky manufactured in the lowlands of Scotland.

The whisky made by smugglers in Scotland is universally preferred by the inhabitants, and is purchased at a higher price, under the name of Highland whisky. This is partly owing to its being made entirely from malt; but the chief reason is, that, from the unfavourable circumstances under which they operate, their wort is necessarily much weaker

than the wort of the legal distillers. Probably it is not much stronger, at an average, than the wort of the Dutch Hollands. It has been generally conceived, that the superiority of the illicitly-distilled or Highland whisky, as it is called, is owing to the mode of distillation. The smugglers distil it in a much slower way than the legal distillers. But nothing can be more absurd than this opinion. The flavour of the spirits depends entirely upon the previous steps of the process. The slowness or rapidity of the distillation can make no difference whatever in the flavour, provided it be properly performed. Accordingly, we have seen spirits distilled by the very rapid mode of distillation that formerly was practised in Scotland, possessed of all the flavour of the best Highland whisky.

Great pains have been taken to put an end to the practice of illicit distillation in Scotland; and, by greatly diminishing the duty, this object, of late years, has been nearly attained. The smugglers formerly set the whole force of Government at defiance, and carried on their processes in spite of all the attempts that were made to stop them. Many of them, indeed, were brought to absolute ruin; and few of them, we believe, were ever able to realise much money, or to rise to independence. But still a new race of smugglers rose up after another to carry on their illicit trade, to the great detriment of the revenue, and to an equal deterioration of the morals of the common people. Government do not

seem to have been aware of the principal reason of the continuance of this evil. They bound down the legal distillers in such a manner by injurious restrictions, that it was not in their power to produce a spirit equal in flavour to that manufactured by the smugglers, who lie under none of those restrictions which bind down the ingenuity of the legal trader. This superiority induces a corresponding desire in the inhabitants of Scotland to possess themselves of smuggled whisky, even at a higher price than that for which they can purchase the same article from the licensed distillers. The smugglers, in consequence, are winked at, or rather encouraged, by a very considerable proportion of the inhabitants of the country. While this feeling existed, it was impossible to put an end to smuggling in Scotland. But Government of late has removed the restrictions by which the Scotch distillers were bound, so far as to allow them to distil from malt at nearly the same rate as they formerly did from raw grain. The consequence has been, that the high reputation of smuggled whisky has gradually sunk, and smuggling has been nearly discontinued.

The only reason that was alleged for continuing the restrictions under which the distillers were placed, was the allegation that they were necessary in order to insure the payment of the duty upon the spirits actually distilled. But we conceive that this duty might be levied with as much accuracy, though all the restrictions on the strength of the wort were re-

moved. From a number of experiments conducted upon a large scale, we conclude that the fermentation, however successful, is capable of decomposing only four-fifths of the whole saccharine matter contained in the wort. Farther, we find, that for every pound of saccharine matter decomposed by the fermentation, there is formed half-a-pound of alcohol of the specific gravity 0.825. Now, every gallon of spirits of the specific gravity 0.90917, or one to ten over proof, contains 4.6 lbs. of alcohol of the specific gravity 0.825. To form a gallon of spirits, then, of the specific gravity 0.90917, there is required the decomposition of 9.2 lbs. of saccharine matter. But as only four-fifths of the saccharine matter present are decomposed, we must increase 9.2 by a fifth, which will raise it to  $11\frac{1}{5}$  lbs. The rule, therefore, for levying the duty on the distillers would be this: Ascertain, by the saccharometer, the strength of the wort, or the number of pounds avoirdupois of saccharine matter which it contains, and for every  $11\frac{1}{5}$  of these pounds charge the duty upon one gallon of spirits. This would be no hardship upon the distiller. If he is unable to produce a gallon of spirits from  $11\frac{1}{5}$  lbs. of saccharine matter, he is not sufficiently acquainted with his business, and the necessity of paying the duty would stimulate his ingenuity to acquire the requisite information. He would soon discover two facts which would probably regulate his conduct, namely, that the flavour, and consequently the value, of his spirits, increases as he diminishes

the strength of his wort, and that the produce of spirits from the same quantity of grain increases also as he diminishes the strength of his wort.

It would be difficult, according to the method at present followed by the distillers, for the excisemen to determine the strength of the worts with the requisite degree of accuracy; but it would be easy, we conceive, to order matters so, that this information might be gained, without in the least injuring the process of fermentation to which these worts are to be subjected.

Some distillers, not satisfied with three mashes, which they think insufficient to exhaust the grains of all the matter that may be useful in the formation of spirits, add a fourth quantity of boiling water, after the worts of the third mash are drawn off, and mash a fourth time. The worts of this fourth mash are always kept, to be employed instead of pure water during next day's brewing.

## 2. *The Cooling.*

Wort from raw grain has a much greater tendency to run into acidity than wort from malt. On that account, the distillers endeavour to bring it down to the temperature requisite to begin fermentation as speedily as possible. As soon as the first worts have begun to run into the underback, they are made to pass into the coolers. The nature and disposition of the coolers vary so much, according to the size of the

distillery, that a general description will by no means apply to them all. When the manufactory is of a moderate size, the coolers are a shallow wooden vessel, covering the floor of an apartment or suite of apartments, placed usually in the upper part of the distillery, and open as much as possible to the influence of the external air. Here the hot worts are pumped up, and left at a depth of one, two, or three inches, till they have acquired the requisite temperature.

When the distillery is on a large scale, it is usual to accelerate the cooling of the worts by agitation. Of late years, a new contrivance has been fallen on, which answers much better than the old method, by bringing the worts almost instantly to the particular temperature which the distiller wishes them to acquire. This method is to pass the hot worts through a certain length of tin pipe, which is immersed in a running stream of water. By properly regulating the length of the pipe, the worts may be cooled down either to the temperature of the surrounding water, or to any other intermediate temperature required. As the worts, in this case, are cooled in close vessels, no evaporation goes on during the process. Hence their strength will not increase during the process, and the quantity will be precisely the same as in the underback, making allowance for the change of temperature. This probably would be a disadvantage to the distillers, while the present law obliges them to brew worts of a given strength. But if this

restriction were removed, it would be rather an advantageous circumstance, because it would enable them to regulate the strength of their worts at pleasure, by the quantity of water employed during the mashing and infusion. To the excise-officer it would also be a convenient circumstance, because it would afford an additional security for determining the strength with accuracy. He would have it in his power to try the strength of the worts while hot in the underback, and when newly let down into the fermenting-tuns, before the yeast was added. This second trial ought to give nearly the same result as the first. We say nearly, because, when the worts are hot, it is not so easy to determine their strength with accuracy, as when they are cold.

During the cooling of the wort from raw grain, there is always a considerable deposit of flocky matter, which, we conceive, consists chiefly, if not entirely, of starch. This flocky matter is swept along with the wort into the fermenting-tun. It is the opinion of distillers, that it contributes materially to the formation of spirits during the fermentation. We have little doubt that the opinion is well founded. Probably, during the fermentation, it is converted first into saccharine matter, and then afterwards decomposed into alcohol and carbonic acid.

The temperature to which the wort is cooled before it is let down into the fermenting-tuns, differs a good deal in different distilleries, and even in the same distillery at different seasons of the year. Win-

ter is the usual season for the distilleries, and it is the season which is considered as most advantageous for conducting the fermentation with success; for it is easy to raise the temperature of the fermenting-room to the degree which is considered as best adapted for the process. But when the weather is hotter than that degree, it is a much more difficult matter to keep the fermenting-room sufficiently cool. In winter, the distillers usually let down the first worts at about  $70^{\circ}$ ; the second worts are cooled down to  $60^{\circ}$  or  $65^{\circ}$ . We do not perceive any good reason for this distinction, though we have frequently seen it practised.

### 3. *The Fermentation.*

This is by far the most important part of the whole process. It is by the skill and success with which it is conducted, that distillers excel each other. Upon it the profit and loss of the manufactory chiefly turn. Much pains have been bestowed in investigating it; but it is of so capricious a nature, as occasionally to thwart the most skilful and experienced brewers. We shall describe the method of proceeding in this process, usually followed by the Scotch distillers. In the TREATISE ON BREWING we stated the facts at present known respecting the saccharine matter of the wort, and yeast of beer, which is employed as a ferment. To that treatise, therefore, we refer those who wish for information on these subjects.

The yeast employed by the Scottish distillers is

chiefly brought from the London porter breweries. Small quantities may be occasionally obtained from breweries in their neighbourhood ; but never, we believe, a sufficient quantity to answer their purposes. The best yeast is that which is thrown off the top of the porter during its fermentation. But what is sold by the porter brewers consists chiefly of the slimy matter which remains at the bottom of the vessels when the clear porter is drawn off. Fresh yeast is better than stale ; but the distillers being unable to procure a sufficient quantity of fresh yeast for their purposes, are under the necessity of using both fresh and stale.

As the quantity of yeast employed depends upon its quality, it is impossible to lay down any very precise rules upon the subject. For the quantity of wort which we have supposed in the preceding part of this treatise, a Scotch distiller would probably employ about twenty-seven gallons of good yeast, and about thirty-six gallons if he considered the yeast of inferior quality. Only a portion of this yeast is mixed at first with the wort. The remainder is generally added on the second, third, and fourth day. Most commonly, indeed, the whole is added on the third day ; but it is customary to make a farther addition at a later period, if the brewer is of opinion that the fermentation is not proceeding so well as it ought to do. We have seen yeast added on the sixth day of the fermentation.

The first portion of yeast mixed with the wort is

always, if possible, fresh yeast; and it is a great object with the distiller to have it of as good a quality as possible. For our wort, the quantity of yeast first used may amount to nine gallons. On the second day, nine gallons more may be added; and on the third day, nine or eighteen gallons, according to its quality. Some distillers add nine gallons the first day, and twenty-seven the third. Some add nine gallons every day for four days. In short, there is considerable difference, and probably a good deal of caprice, in the practice followed in the various manufactories. At least we have never been able to obtain a satisfactory reason from any distiller why he followed one practice rather than another. In hot weather, we should prefer the addition of nine gallons of yeast every day for four days. But in cold weather, it would probably answer better to add the whole yeast at twice; and perhaps the third day is the most proper for making the great addition.

The fermentation lasts nine, ten, eleven, or twelve days, according to circumstances. Sometimes, though seldom, we have seen it last thirteen days. During the first five days the fermenting-tuns are left open on the top, or only slightly covered; but on the sixth day they are shut up as closely as possible, so as to render the escape of the carbonic acid rather difficult. Two reasons have been alleged for this proceeding. 1. The carbonic acid gas is conceived to carry with it a portion of the alcohol, and by binding down the top, it is supposed that the loss by this drain will be

diminished. We do not lay much stress on this reason. The fermentation is almost at an end before the tuns are shut down. Of course, almost the whole of the alcohol abstracted by the carbonic acid has been already removed. 2. The presence of carbonic acid is conceived to promote the fermentation. Hence it is supposed, that, by preventing that gas from escaping with facility, the attenuation will be greater than it otherwise would be. Perhaps there may be some foundation for this opinion. There is no doubt that carbonic acid gas may be substituted for yeast as a ferment; and that the fermentation of the wort, under such circumstances, will go on pretty well. We have seen the experiment tried, by mixing yeast with wort in a close barrel, from which there proceeded a tin pipe that passed through another barrel filled with wort, and opened at the bottom of it. The gas was absorbed by the wort in this second barrel, and the wort was fermented by it. But the fermentation, as might have been expected, was not so complete as if it had been produced by the usual addition of yeast. The distillers do not collect any yeast from their fermenting-vats, but beat it all into the liquid, being of opinion that any such collection would render the fermentation less complete, and, of course, diminish the proportion of spirits obtained.

The wort most commonly increases in temperature from  $20^{\circ}$  to  $25^{\circ}$  of the thermometer. Supposing it let down into the fermenting-tun at  $57^{\circ}$ , its temperature, when at the highest, may amount to from  $78^{\circ}$

to 82°. It usually acquires the highest temperature on the fourth day of the fermentation, frequently upon the fifth day; sometimes upon the sixth, the third, or the seventh day; and we have seen it as late as the eighth, or even the eleventh day, before its temperature became a maximum.

The following table exhibits the number of cases on which the highest temperature took place in these respective days in seventy-six brewings, conducted upon a pretty large scale :

4th day,	.	.	.	31 times.
5th day,	.	.	.	23 ...
6th day,	.	.	.	9 ...
3d day,	.	.	.	6 ...
7th day,	.	.	.	5 ...
8th day,	.	.	.	1 ...
11th day,	.	.	.	1 ...

This diversity, no doubt, depends upon the goodness of the yeast employed; and, as we have no good criterion by which to determine the exact value of yeast as a ferment, it is impossible to be able to foretell the exact result in any particular case. Indeed we consider the uncertainty of the value of yeast as the great difficulty which the distiller has to encounter. Any person who could discover a method of estimating the exact value of any particular yeast as a ferment would greatly improve this difficult manufactory. We do not believe that such a discovery is impossible. Perhaps the specific gravity of the yeast, or the quantity of solid matter which is left behind

when a given weight of the yeast is evaporated to dryness, might furnish very material information. We are rather surprised that no distiller has thought of subjecting yeast to a series of experiments, with a view to ascertain its real value as a ferment. The new information which he would acquire would more than compensate for the trouble, and would probably give him the means of improving his manufactory, or at least of forming some notion of the value of the yeast which he purchases.

As the fermentation proceeds, the specific gravity of the wort diminishes, owing to the decomposition of the saccharine matter, and its conversion into alcohol and carbonic acid. This diminution of specific gravity is called *attenuation* by distillers, and is employed by them as the measure of the success of the fermentation. They can easily foretell the quantity of spirits which their *wash* (the name by which their fermented wort is distinguished) will yield, if they know the attenuation which has taken place during the fermentation. This diminution of specific gravity is produced by two causes. 1. The destruction of the saccharine matter previously dissolved in the liquid, and which occasioned its specific gravity to be greater than that of water. If the whole of this saccharine matter were decomposed, it is obvious that the change of specific gravity from this cause would be exactly such as would sink the wash to the specific gravity of water. 2. The second cause of the diminished specific gravity of the fermented wort is the

formation of a quantity of alcohol, which, being lighter than water, occasions, by its evolution, a corresponding diminution of the specific gravity of the liquid. The specific gravity of the purest alcohol which it has hitherto been possible to obtain, is 0.793 at the temperature of 60°. When mixed with water it enters into a chemical combination with that liquid. Hence the specific gravity is greater than the mean of that of the water and alcohol, though considerably less than that of water. It is obvious, if we were to add alcohol to the unfermented wort, we would diminish its specific gravity. We might even, by this means, render it as light, or even lighter, than water, though none of the saccharine matter were destroyed. It is obviously impossible, therefore, to determine how much saccharine matter has been decomposed by the fermentation from the attenuation alone. Suppose the original specific gravity of the wort to have been 1.060; and suppose that, after the fermentation, its specific gravity is reduced to 1.002. The first of these specific gravities indicates 55.8 lbs. of saccharine matter per barrel; the second 1.6 lbs. per barrel. It does not follow, as the distillers suppose, that 54.2 lbs. of saccharine matter per barrel have been decomposed and converted into alcohol and carbonic acid. A considerable portion of the saccharine matter still remains undecomposed, but the alcohol which has been formed counteracts the specific gravity of this saccharine matter, and prevents its presence from being correctly indicated by the saccha-

rometer. But if we measure out a quantity of such wash, put it into a retort or still, and distil off about a third of it; if we then take the residual wash which remains in the retort or still, and add pure water to it till its original bulk be restored, the saccharometer being applied to it will indicate the quantity of saccharine matter which it still contains; and this quantity being subtracted from the original quantity of saccharine matter contained in the wort before the fermentation commenced, the remainder will be the saccharine matter decomposed by the process.

Alcohol is a substance which has a tendency to stop fermentation, and it stops that process completely when added to fermenting wort in sufficient quantity. It must be obvious from this, that very strong worts are injurious to the profits of the distiller; because the stronger the wort, the greater will be the proportion of alcohol evolved, and, of course, the fermentation will ultimately be impeded or stopped altogether, before the whole saccharine matter is decomposed. Accordingly, the *spent wash* will always be found to contain a considerable proportion of saccharine matter; and it might be fermented again, and made to yield no inconsiderable quantity of spirit. The writer of this treatise made nine trials with malt worts, which were designedly made weak. They were fermented as thoroughly as possible, and the following table indicates the specific gravities to

which they were reduced. The original specific gravity probably did not much exceed 1.045.

	Sp. Gravity.
1 . . . . .	1.0012
2 . . . . .	1.0045
3 . . . . .	1.0018
4 . . . . .	1.0000
5 . . . . .	1.0012
6 . . . . .	1.0045
7 . . . . .	1.0047
8 . . . . .	1.0007
9 . . . . .	1.0007

Upon examining the state of the wash after the fermentation was at an end, we found that 4.34 parts of the saccharine matter had been decomposed, and that one part remained unaltered. So that in these nine experiments, which were as favourable as possible to the fermentation, on account of the weakness of the worts, not much less than one-fifth of the whole saccharine matter remained unaltered. Surely, then, we may lay it down as a fact, that, in all cases of fermentation in a Scotch distillery, at least one-fifth of the whole saccharine matter is prevented from being decomposed by the antifermenting power of the alcohol evolved. The consideration of this circumstance renders it of more importance to allow the distiller to make his wort weak; for the weaker the original wort, the less will the quantity be of the saccharine matter which is prevented from being decomposed by the presence of the alcohol evolved.

When the heat has acquired its maximum, we may reckon, at an average, that nine-tenths of the whole attenuation has been completed. No judgment can be formed of the ultimate attenuation, by the rapidity or slowness with which the heat reaches its maximum. We have seen the attenuation equally good when the maximum temperature happened on the third, fourth, fifth, or sixth day.

It is impossible to lay down any specific rule with respect to the length that attenuation ought to be carried. The object of the distiller is to render his wash, if possible at least, as light as water. This object they frequently accomplish. But it sometimes happens that the fermentation stops when the specific gravity has sunk to 1.013 or 1.008, and no addition of yeast will make it sink lower. Bad yeast is the most probable reason of this ill success. If the wash be allowed to remain in the fermenting-tuns after the fermentation is at an end, its specific gravity will be found gradually to increase a little, and it will not yield so great a proportion of spirits. This is owing to the formation of vinegar in the wash, which takes place at the expense of the alcohol; and if the vinegar-forming process were allowed to go on long enough, the alcohol would disappear altogether.

Distillers always ferment their worts in tuns of a large size. This is attended with the advantage, that the artificial heat evolved by the fermentation is not so speedily dissipated as it would be if the

process were conducted in small vessels. Some distillers fill the tuns only partly, leaving a portion of the upper part empty, that it may contain the froth formed when the wort is in full fermentation. Others fill the tuns almost to the top, and cover down the mouth with a lid, from which a tube passes to an open vessel placed above the tun. When the liquid swells by the fermentation, it passes up the tube into the open vessel, and runs down again when the fermenting process subsides. No regular set of experiments, that we know of, has been made to determine which of these two methods is the best.

We have already observed that every 9·2 lbs. of saccharine matter really decomposed by the fermenting process yield a gallon of spirits one to ten over hydrometer proof, or of the specific gravity 0·90917 (at the temperature of 60°). But as the distillers are not in possession of a good method of determining how much saccharine matter has been decomposed, the easiest rule will be to allow 11½ lbs. of saccharine matter, estimated before the fermentation begins, to yield a gallon of spirits at 0·90917 specific gravity. If the original worts be very weak, perhaps we might take 11 lbs. of saccharine matter as producing that quantity of spirits; but while the present law respecting the strength of the worts continues, 11½ lbs. will be found, upon an average, to come very near the truth.

It does not seem to be possible to ferment wort from a mixture of raw grain and malt as completely

as is required for the purposes of the distiller, without its becoming sour. There seems no reason to doubt that the acid formed is the acetic. Some are of opinion that the presence of this acid contributes to improve the flavour of the spirits. But the quantity of acetic acid usually present in wash is so small, that we do not see any reason for supposing that it can produce any sensible effect. It is important, therefore, that the acidity should be as small as possible, because the acid is formed at the expense of the alcohol in the wash. Hence the wash ought to be distilled as soon as the fermentation has come to a conclusion.

#### 4. *The Distilling.*

The stills commonly used in other countries are of large dimensions, and very deep, so that a great deal of time is necessary to finish one process. Once in the week, for example, is no uncommon period. The same kind of still was used in Scotland till about the year 1787, when the duty began to be levied on the distillers by a license paid at the commencement of the season upon every still according to its capacity. This was done to prevent that propensity to smuggling by which the generality of Scotch distillers were supposed to be actuated. The quantity of spirits which a still of given dimensions could produce in a year was calculated, and the license was laid on according to it. This saved the excise-officers all farther

trouble, after gauging the stills and collecting the license-duty, excepting an occasional visit, to be certain that no new still of larger dimensions was substituted for the old one. But about the year 1788 Messrs John and William Sligo, at that time rectifiers in Leith, made an important alteration in the shape of the still, at the suggestion of an Englishman, which greatly increased the rapidity of distillation. They diminished their height, and increased the diameter of their bottom. The consequence of this alteration was, that they were able to distil off the contents of the still in a few hours, instead of once a-week, as had formerly been the practice. Thus they were enabled to produce a great quantity of spirits from a very small still, and, of course, paid in reality a much smaller duty than their brother manufacturers. This lucrative improvement they possessed exclusively for about a year; but a secret of such importance could not be long confined to a single house. It became gradually known to other distillers, and was soon imitated by all. The license-duty was increased year after year; but the ingenuity of the distillers enabled them to outstrip the acts of parliament; till, at last, a committee of the House of Commons was appointed to investigate the subject in 1799. A very bulky report was published by this committee, which contains a vast collection of curious facts respecting the mode of distillation at that time practised in Scotland. The license, in consequence of this report, was laid on the distiller,

on the supposition that he could discharge his still every eight minutes, during the whole season that the manufactory was in activity. Since that time the time of discharging the still was considerably shortened. But the saving in point of time was attended with such an enormous waste of fuel, that it is rather doubtful whether it was attended with much additional profit to the distiller. In the year 1815, which was the last year of the license-duty, a still capable of holding 80 gallons could be completely distilled off, emptied, and ready for a new operation in  $3\frac{1}{2}$  minutes, or even, it is said, in some cases in 3 minutes; and a still of 40 gallons in  $2\frac{1}{2}$  minutes. At that time a change took place in the excise-laws; the license-duty was abolished, and the whole duty was levied, as in England, on the wash and the spirits produced. There was, of course, no longer any necessity for continuing the rapid mode of distillation; and, as it was attended with a very considerable waste of fuel, and was in other respects much more expensive than the slow process, it has been, of course, discontinued. We conceive, however, that it will be worth while to give a short description of the still and furnace which the Scotch distillers employed during the existence of the license-duty. It would be a great pity indeed to allow the results of such a series of important experiments to be forgotten.

The stills were made of copper. Those capable of holding 44 gallons were about 44 inches in diameter at the bottom, and about 5 inches deep. Those

capable of holding 80 gallons were 54 inches in diameter, and about 8 inches deep. The bottom was perfectly flat, and about three-eighths of an inch thick. Within it there were a number of iron chains, which were turned round by machinery, and rubbing against the bottom prevented the thick matter, which the wash always contains, from adhering to the bottom of the still and catching fire. This would have almost immediately occasioned the destruction of the still; and the scorched starchy matter would have communicated a disagreeable flavour to the spirits, which could not have been got rid of afterwards. There was likewise a circular plate in the inside of the still, towards its top. The use of it was to break the bubbles that rise during rapid distillation; and, of course, lessen the risk of the still boiling over, or *running foul*, as the distillers term it; and, consequently, the distiller was enabled to put a greater charge of wash into the still than it would have been in his power to do if the plate had been omitted.

These stills were supported by resting an inch and a half on the brick-work all round the bulge. The furnace was quite level, and was placed at the distance of 15 inches below the bottom of the still. The inner end of the grating-bars was placed 15 inches within a line falling vertically from the part of support of the bulge of the still. The bars were in two lengths, the inner length was 21 inches, the outer 30 inches, supported by a cross bar between them,

four inches square. In front of the bars was a dumb plate 10 inches broad. The bottom of the ash-pit was three feet below the grating-bars, and on a level with the floor of the distillery. The bars were two inches thick, three inches deep, and three-fourths of an inch apart. The brick-work extended 21 inches beyond the dumb-plate, and was four feet wide and four inches higher outside than at the bulge of the still. The furnace-doors were 30 inches wide. The bottom of the furnace beyond the grating bars was lined with fire-brick nine inches deep, and passed level backward into the chimney.

The chimney was 60 feet high, four feet square within from top to bottom, and consisted of a double wall. The inner wall of fire-bricks was nine inches thick. The outer wall was placed at three inches distance on all sides from the inner wall, and the space was left open at the top. The outer wall was 18 inches thick at bottom, diminishing regularly on the outside till reduced to nine inches at top. The two walls were tied together, at certain distances, by long fire-bricks. This separation of the two walls was found to prevent the rapid destruction of the chimney from the intensity of the fire, which always happened when the two walls were in contact.

Such was the construction of the furnace and the shape of the stills during the time that rapid distillation was practised in Scotland, when both had been brought to the greatest degree of perfection which the distillers were capable of giving them. The

writer of this article has not had an opportunity of seeing the shape of the stills used by the Scotch distillers since the license-duty was abolished. But it is probable that the old shape will not have been entirely restored ; but that the present stills, though much larger in size, imitate the late stills, in the great diameter of their bottom, and their comparative shortness, when compared with the stills employed by the English distillers.

The top of the still ends in a kind of tube, which is bent downwards, and connected with a tin tube, which makes a number of revolutions in a large vessel filled with cold water, and therefore called the worm. This large vessel is called the *refrigeratory*, and care is taken to keep the water in it always cool by means of a stream of water which is constantly flowing into it. The wash being put into the still, and the top being fixed down, heat is applied to the vessel till it is made to boil. The spirits being more volatile than the water, pass over first in the state of steam, and are condensed into a liquid as they pass through the worm. The first portions that come over are very strong ; but the strength diminishes as the process proceeds. The distiller continues the distillation till the liquid which flows from the worm is as heavy as water, or at least so nearly so, that the quantity of spirits remaining is not considered as a compensation for continuing the progress any longer. The strength of the liquid proceeding from the worm is ascertained by a small hydrometer, with which it

is tried every now and then ; and whenever a certain mark on the instrument comes to coincide with the surface of the liquid, a cock at the bottom of the still is opened, and what remains in the still is let off. This liquor is called the *spent wash*. It is a muddy brown liquid, still containing a quantity of undecomposed saccharine matter. It is therefore used as food for cattle. These animals are fond of it, and soon fatten upon it.

To prevent the still from boiling over, which is apt to happen towards the commencement of the distillation, it is usual to throw a piece of soap into the vessel along with the wash. This substance is partly decomposed, and the oily matter which it contains spreading on the surface, forms a thin coat, which breaks the large bubbles when they reach it, and thus prevents the wash from swelling beyond the requisite bulk. Butter would answer equally well with soap, and would be less apt to give a disagreeable flavour to the spirits ; but its high price prevents the possibility of using it for that purpose. We have some suspicion that hogs' lard would answer. If it were found to do so, it would be cheaper than soap, and less apt to give a bad flavour to the spirits. The supposition, however, that soap communicates a disagreeable flavour to spirits, though very generally entertained, is, we believe, a mistake. We have certainly met with spirits distinctly tainted with soap, and having, in consequence, a highly nauseous taste. But this was at a time when the rapid mode of dis-

tillation was only on its progress to perfection, and was owing, we believe, to little bits of the soap having been accidentally forced into the worm, and afterwards dissolved by the spirits.

It is impossible to lay down any rule with respect to the strength of the weak spirit obtained by this first distillation, and which is called *low wines* in Scotland. That strength must depend partly upon the original strength of the wort, partly on the attenuation which has taken place during the fermentation, but chiefly upon the attention of the distiller to distil off the whole of the spirituous portion of the wash. In a great number of cases in which we have had the curiosity to determine the strength of the low wines in distilleries, we have found the specific gravity at 60°, differing but little from 0.978; frequently a little weaker, and very rarely a little stronger. Low wines of this strength contain the fifth part of their weight of alcohol of the specific gravity 0.825; the remaining four-fifths are water.

The low wines are put into the still and subjected to a second distillation, which in Scotland is called *doubling*. The first portion which comes over is a milky liquid, known by the name of *foreshot*. Its taste is disagreeable, and on that account it is received by itself, and returned back into the low wines to be subjected to another distillation. The properties of the foreshot are owing to a liquid with which it is loaded. When the spirits begin to run transparent from the end of the worm, they are allowed

to run into a receiver prepared for them. Whenever their specific gravity, determined by the hydrometer, has reached a certain point, they are no longer allowed to flow into the receiver containing the spirits, but into a place by themselves, and the distillation is continued till the liquid coming over has approached very nearly to the specific gravity of water. This third portion is called *feints*. It is mixed with the low wines and distilled again. Thus the distillation of the low wines is continued till the whole of their alcoholic part is brought to that degree of strength which fits them for the market. The strength at which the duty is levied on them is one to ten above hydrometer proof, which corresponds with the specific gravity 0.90917. They are prohibited from sending out of their manufactory spirits of greater strength than this, or of a strength under one in six below proof, or of the specific gravity 0.9385. Between these two intervals the specific gravity of their spirits may be considered as vibrating; for it is not to be expected that they should be able always to produce spirits of exactly the same specific gravity. We have found the spirits, as obtained by doubling, of a specific gravity as low as 0.908, and as high as 0.925. No doubt they might be obtained much stronger or much weaker than these two extremes, if there were any object in view to induce the distiller to alter his usual practice.

The *foreshot* owes its peculiar properties to the

presence of a liquid which has a strong smell and a hot and acrid taste. It is considered as a species of alcohol, different from the common sort; but analogous to it in the series of compounds which it forms. Its base has not yet been obtained, but it is considered as composed of

10 atoms carbon,  $C^{10}$ ,  
11 atoms hydrogen,  $H^{11}$ ,

and is distinguished by the name of *amyle*.

The hydrate of amyle is analogous to alcohol, and is composed of  $C^{10} H^{11} + HO$ .

Such is the mode followed in Scotland in order to obtain whisky. The distillers are at pains to purchase the best English barley which they can procure. They are certainly in the right to select English barley for malting; for English barley, when malted, yields more spirits than in the state of raw grain. But for that portion of grain which they use in the distilleries without malting, it would be their interest to employ the best big which they can procure; for good big, while in the state of raw grain, yields rather more spirits than an equal quantity of the best English barley; and as it can be purchased at a cheaper rate than barley, it could obviously be employed with economy as a substitute for that grain. Big is greatly deteriorated by malting it; of course it would be improper to employ it in distilleries in that way; but the distillers might employ it in the state of raw grain with great advantage.

The present duties on British spirits are—

In England . . . .	7s. 10d. per gallon.
In Scotland . . . .	3s. 8d. . . .
In Ireland . . . .	2s. 8d. . . .

On spirits made in Scotland from malt only, there is a drawback of 8d. per gallon.

When a distiller is first beginning to work, he gives a written notice, specifying the specific gravity of the wort which he intends to use; and he must not use worts of a higher gravity until he gives due notice thereof, nor until the end of one month from his former notice.

Immediately after every brewing of worts, and before any yeast or other fermentable matter is added, he must give a declaration in writing, specifying the quantity and gravity of such worts collected in each fermenting-vat. The accuracy of this declaration is tested by the officer; and, after the wort has been fermented, a presumptive charge of spirits is made, by taking one-fifth part of the number of degrees attenuated, or the number of proof gallons of spirits evolved in every 100 gallons of the wash.

When the wash has been distilled into low wines, the actual produce in low wines, deducting 5 per cent., is called the second mode of charge.

When the low wines have been again redistilled into spirits and feints, the actual produce so found is called by the officer the third mode of charge; and the best of these three modes, that is, the mode which produces the highest amount of duty (generally the

third mode), is set forward as the charge for duty against the distiller.

On the 10th of October each year, when the distiller's license expires, an annual balance is made, by adding into one sum all the wash made during the year, and if one gallon of spirits at proof has not been charged for every five degrees of the gravity at which the distiller had given notice of his intention to use in regard to every 100 gallons of such wash (without regard to the attenuation thereof), the distiller is called upon to pay for the deficiency. In point of fact, however, any such deficiency is seldom or almost never found.

## CHAPTER II.

### OF THE MODE OF MANUFACTURING OTHER KINDS OF SPIRITS.

In this chapter we shall merely make a few very short observations on the processes followed by the distillers in other countries.

#### 1. *Dutch Geneva.*

The Dutch have long been famous for the manufacture of an excellent kind of spirits, known in Scotland by the name of *Gin*, in England by the name of *Hollands*, and sometimes by the name of

*Geneva.* We have been told that the manufacture of it originated in the city of Geneva, and that this was the origin of the name Geneva, still applied to it in commerce ; but we have no means of determining how far this statement may be depended on. We have not seen in print any accurate account of the mode of making Geneva practised by the Dutch ; but the following account may, we believe, be relied on. We are indebted for it to a friend, who, about forty years ago, went over to Holland on purpose to make himself acquainted with the process. His object was to establish a similar manufactory in Scotland. But the severe laws by which the Scotch distillers were soon after bound, put it out of his power to execute his plan.

112 lbs. of barley-malt, and 228 lbs. of rye-meal, are mashed together with 460 gallons of water of the temperature 162°. After the infusion has stood a sufficient time, cold water is added till the strength of the wort is reduced to 45 lbs. per barrel. The whole is then put into a fermenting-back, at the temperature of 80°. The vessel is capable of holding about 500 gallons. Half a gallon of yeast is added. The temperature rises to 90°, and the fermentation is over in forty-eight hours. The attenuation is such, that the strength of the wash is not reduced lower than 12 or 15 lbs. per barrel. The wash is put into the still, with the grains and all. The low wines, as usual, are distilled again, and the spirits of the second distillation are rectified ; so that the Hollands

pass thrice through the still. A few juniper-berries and some hops are used to communicate a peculiar flavour to the spirits.

Now, 45 lbs. per barrel constitute a wort so weak that it will not yield above seven and a half per cent. of spirits of the usual strength ; so that the produce which the Dutch obtain from their wort, cannot amount to much more than half what the Scotch distillers are obliged to produce from theirs.

It is obvious from the preceding account, that the fermentation is very imperfectly accomplished in the Dutch process. The small quantity of yeast employed, and the short time that the wort is allowed to ferment, necessarily imply imperfection in the fermentation. And this is obviously the case, for the original strength of 45 lbs. per barrel is only reduced to 15 lbs. per barrel. We have often seen the attenuation of the porter in the London breweries not much less complete. What advantage is gained by putting the grains into the still along with the wash we have not the means of determining. Such a practice can only be followed in distilleries upon a very small scale. We do not see how it could be practised in the Scotch distilleries. Indeed, we have no doubt whatever, that when the mashing is repeated a sufficient number of times, and the grains sufficiently washed with hot water, every thing likely to contribute to the formation of spirits will be carried off.

Every person acquainted with the flavour of Hollands and Lowland whisky, must admit that the for-

mer is greatly superior to the latter. Indeed, the flavour of Hollands is equal to that of malt whisky. This is owing in part to the small proportion of raw grain used by the Dutch distillers. 112 lbs. of barley malt may be reckoned at three bushels. We do not know the average weight of a bushel of rye; but if we suppose it to be 50 lbs., 228 lbs. will amount to about  $4\frac{1}{2}$  bushels; -so that, in the Dutch distilleries, the malt bears to the raw grain the proportion of two to three. We suspect that another reason of the superiority of the Dutch spirit over the Scotch, is the small quantity of yeast employed by the manufacturers of Hollands. The vast quantity of porter yeast used by the Scotch distillers, often in a state almost approaching to putrefaction, cannot but have an injurious effect upon the flavour of their spirits, and has undoubtedly contributed to the superior reputation of Highland over Lowland whisky; for the Highland distillers (especially the smugglers) have not the means of procuring yeast from London. Of course their wash is less perfectly fermented, but the flavour of their spirits is much more agreeable. We think, indeed, that the flavour communicated by the yeast to Scotch Lowland whisky may be distinctly perceived, and on that account are disposed to suspect that the flavour of the spirits always differs in proportion as the fermentation is brought nearer a state of perfection. Any person who should find out a method of fermenting wort without the necessity

of employing such quantities of porter yeast as the distillers use, would undoubtedly prodigiously improve the flavour of the spirits manufactured by the Scotch distillers. If Government were to make such an alteration in the laws, as would enable the distiller to employ a greater proportion of malt without any material increase of expense, the object might be considered as accomplished. In the present state of the manufactures of Great Britain, it would be impossible to confer a greater favour on the country than a thorough revival of the excise-laws, under the auspices of a set of individuals at once intimately acquainted with the most improved state of chemical science, and with the most liberal principles of political economy. Every thing that improves the quality and diminishes the price of our manufactures is of more value to the country than our legislators seem to be aware of.

We do not think that Hollands could be manufactured in Great Britain with any probability of success. The experiment was tried at Maidstone, in Kent, by a Mr Bishop, who had interest enough with Mr Pitt to get a special clause introduced into an act of parliament permitting him to manufacture Hollands according to the Dutch method; but the manufactory was never successful. The Maidstone Hollands never acquired much reputation. The distillery languished for some years, and then terminated in a bankruptcy. Some attempts have been lately

made to revive the Maidstone establishment ; but we may venture to predict that they will not be successful.

## 2. *Rum.*'

This is the name given to a spirit manufactured in the West India Islands, from the molasses, &c., which remain after the sugar is separated in small crystals from the boiled juice of the sugar-cane. We do not know any thing about the origin of the word *rum*, or the time at which the manufacture of this spirit commenced ; not, probably, till after the West Indies were colonized by Europeans. At present it is chiefly in the islands belonging to Great Britain that this spirit is made. The process, as we obtained it from a Dominica planter, who had for many years been in the habit of making this spirit, is as follows :—

Twelve parts of sweets are dissolved in 100 parts of water, and fermented as completely as possible by means of yeast, which is chiefly obtained in the distillery itself by means of the fermentation of the rum wort, which gradually generates it. Fourteen gallons of spirits, one to ten over proof, are obtained from 100 gallons of wash. If this statement be correct, the produce of spirit from molasses exceeds considerably what can be obtained in this country from barley. A solution of 12 parts of sugar in 100 of water would make a wort containing about 44 lbs. of saccharine matter per barrel ; from 100 gallons of

which, in this country, we would not obtain more than 8 gallons of spirits of the above strength ; but we suspect some mistake on the part of our informer, as he communicated the process to us in this country several years after he had given over the actual superintendence of his rum distillery.

The peculiar flavour which distinguishes rum, and makes it so agreeable to the taste, is undoubtedly owing to a peculiar oil contained in the sugar-cane ; for when spirits are made in this country from sugar, they are entirely destitute of the peculiar flavour of rum, and resemble, in their properties, the common spirit made in this country from barley. The colour of rum is derived from the oak casks in which it comes to this country from the islands in which it is made.

CHAPTER III.

ON THE NATURE OF THE VINOUS FERMENTATION.

In the Treatise on Brewing we have given a short sketch of the facts hitherto ascertained respecting the nature of the change which saccharine matter undergoes when fermented; and we have very little to add to the facts stated in that Treatise. We shall merely enter a little more minutely into the detail of facts than we thought necessary in the Treatise on Brewing.

Common sugar has been analysed by Gay-Lussac and Thénard, by Berzelius, and by Dr Prout. The method followed by each differed a little from that of the others, and the results, though they do not quite tally, certainly approach considerably to each other. The following table exhibits the composition of 100 parts of sugar, according to each of these chemists:—

	Gay-Lussac and Thénard.	Berzelius.	Prout.
Oxygen, . . .	50·63 . . .	49·083 . . .	53·33
Carbon, . . .	42·47 . . .	44·115 . . .	39·99
Hydrogen, . . .	6·90 . . .	6·802 . . .	6·66
	<hr/> 100·00	<hr/> 100·00	<hr/> 99·99

To be able to determine from these analyses the number of atoms of oxygen, carbon, and hydrogen, which are requisite to form a constituent particle of

sugar, it would be requisite, in the first place, to be able to specify the weight of sugar capable of neutralising a given weight of any solifiable base. Berzelius found, that when a solution of a given weight of sugar in water was digested over oxide of lead, the oxide was first dissolved; but, after a certain interval of time, a light white powder makes its appearance. This powder is a compound of sugar and oxide of lead, and is composed, according to Berzelius's analysis, of

Sugar, . . . .	41·74	. . . .	10·03
Oxide of lead, . . . .	58·26	. . . .	14
	<hr style="width: 50%; margin: 0 auto;"/>		
	100·00		

Now the equivalent number for oxide of lead is 14. It follows from this, that if the white powder be a compound of an atom of sugar and an atom of oxide of lead, the weight of an atom of sugar is 10. But we have no evidence whatever for adopting one atom of sugar in this compound rather than two. And as one atom will not accord with the phenomena of fermentation, it is better to consider the white powder as a compound of one atom oxide of lead and two atoms of sugar. On that supposition an atom of sugar will weigh about five. Now if we suppose it to be composed of

3 atoms oxygen, . . . . .	= 3·
3 atoms carbon, . . . . .	= 2·25
3 atoms hydrogen, . . . . .	= 0·375
	<hr style="width: 50%; margin: 0 auto;"/>
	5·625

the weight of an atom of sugar will be 5·625, which does not differ very much from the weight, as resulting from Berzelius's analysis; not more, indeed, than might be expected from the extreme difficulty of analysing such a compound with precision. But if we suppose the weight of an atom of sugar to be as now stated, 100 parts of it will be composed of

Oxygen, . . . . .	= 53·31
Carbon, . . . . .	= 40·03
Hydrogen, . . . . .	= 6·66
	100·00

Now, as these numbers are almost exactly the same with those of Dr Prout, we are disposed to consider them as representing the true constituents of sugar.

From the phenomena of fermentation, as described in the present Treatise, and in the Treatise on Brewing, it appears that by the fermentation the sugar is decomposed and converted into alcohol and carbonic acid. Alcohol, according to the analysis of Theodore de Saussure, is composed of three atoms hydrogen, two atoms carbon, and one atom oxygen. Carbonic acid is composed of two atoms oxygen and one atom carbon. Hence the weight of an integral particle of alcohol is 2·875. For

1 atom oxygen, . . . . .	= 1
2 atoms carbon, . . . . .	= 1·5
3 atoms hydrogen, . . . . .	= 0·375
	2·875

And an integrant particle of carbonic acid weighs 2.75.

We see likewise that a particle of sugar is capable of being decomposed into an integrant particle of alcohol and an integrant particle of carbonic acid. For a particle of alcohol is composed of

	Oxygen.	Carbon.	Hydrogen.
	1 atom	+ 2 atoms	+ 3 atoms
Carbonic acid, of,	2	+ 1	+ 0
	<hr style="width: 100%;"/>	<hr style="width: 100%;"/>	<hr style="width: 100%;"/>
	3	+ 3	+ 3

both together, we see, corresponding to the number of atoms in a particle of sugar.

If fermentation then be merely the separation of sugar into an atom of alcohol and an atom of carbonic acid, there ought to be formed,

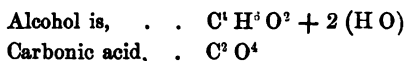
Of alcohol,	. . . . .	2.875
Of carbonic acid,	. . . . .	2.75

But alcohol of 0.825 contains about the fifth of its weight of water. Hence by fermentation sugar is converted into

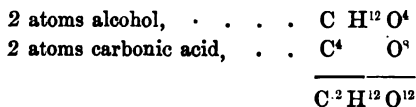
Alcohol of 0.825	. .	3.45 parts, or 55.6
Carbonic acid gas,	. .	44.4
		<hr style="width: 100%;"/>
		6.20                  100.0

Now these proportions approach very nearly the results obtained by Lavoisier and Thénard. We are disposed, therefore, to consider the explanation which we have given as likely to be the true one.

In the Treatise on Brewing, it was stated that the sugar existing in wort or wash is *starch-sugar* or *glucosin*. It will simplify the view taken if we consider it as composed of  $C^{12} H^{12} O^{12}$ .



Hence, by fermentation, an integrant particle of sugar is resolved into



In what way the yeast acts, if no portion of it enter into the composition of the alcohol or carbonic acid, as would appear from what we know of the subject, we have no means at present of forming a conception. It would be requisite, before we could reason on the subject, to be better acquainted with the composition of yeast than we are at present.

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Scotland, .....	5,922,948	6,441,011	6,975,091	1,086,875 12 8	1,180,352 0 4	1,278,766 13 8
Ireland, .....	6,451,137	7,605,196	7,952,076	860,151 12 0	1,014,026 2 8	1,060,276 16 0
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\* \* \* This Work embraces an Historical Sketch of the Progress of Geographical Discovery, the Principles of Mathematical and Physical Geography, and a complete Description, from the most recent sources, of all the Countries of the World, with numerous Tables of Population and Statistics. Appended to it is an Index of 13,500 Names, a number very much greater than is contained in any existing Gazetteer.

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"Executed with masterly ability."—*Atlas*.

### V.

#### OUTLINES OF GEOGRAPHY (CHIEFLY ANCIENT). By PROFESSOR PILLANS. Price 4s. 6d.

These Outlines have been prepared for the use of the more advanced Pupils of the High School of Edinburgh, and of the Students of the Universities. The volume contains Introductory Explanations of the System of the World, and of the most Approved Methods of Studying and Teaching Geography; and is illustrated with Nine Maps.

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ADAM & CHARLES BLACK, EDINBURGH;  
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Fig. 2.

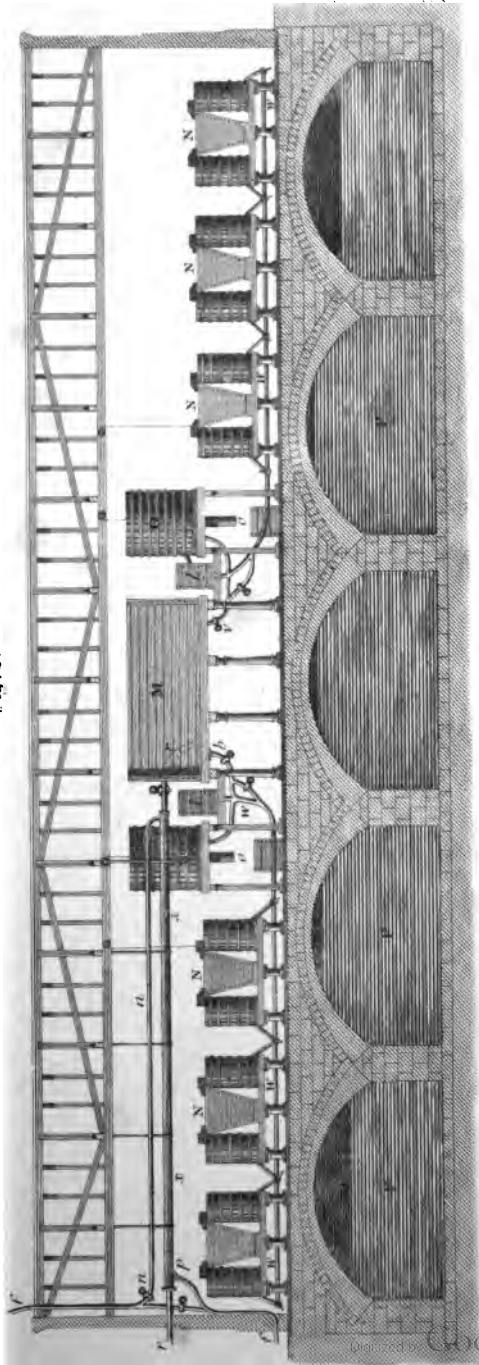




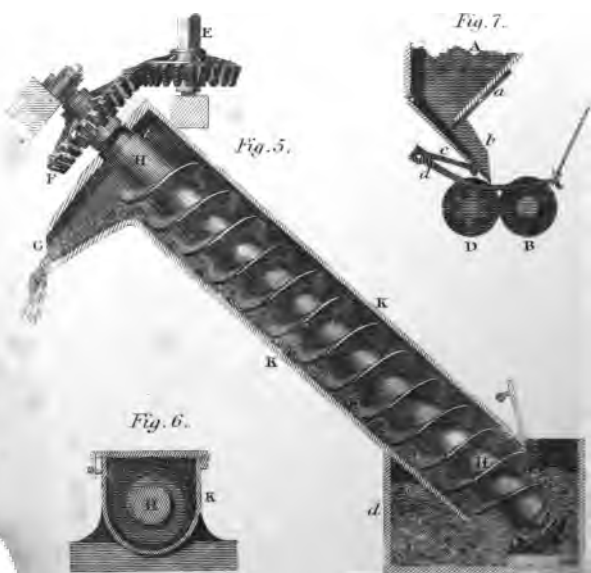
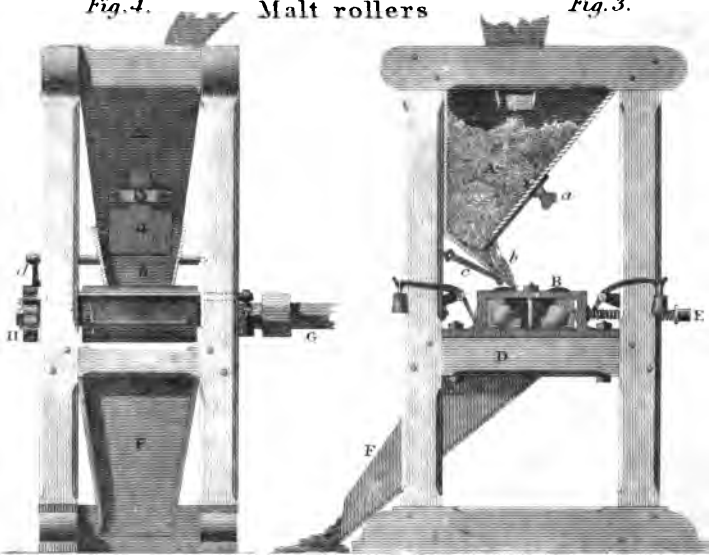


PLATE III.

Fig. 4.

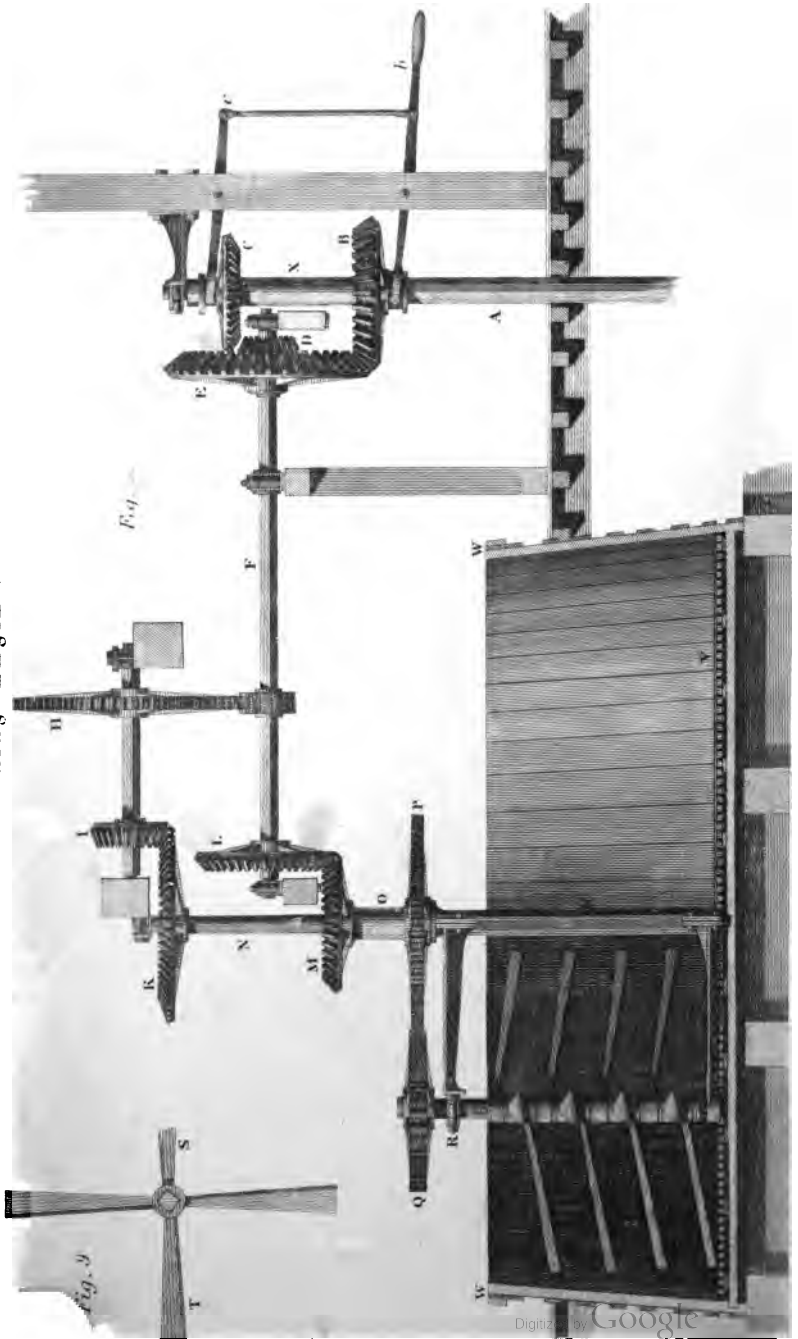
Malt rollers

Fig. 3.





Mashing Engine.



*PLATE. V.*

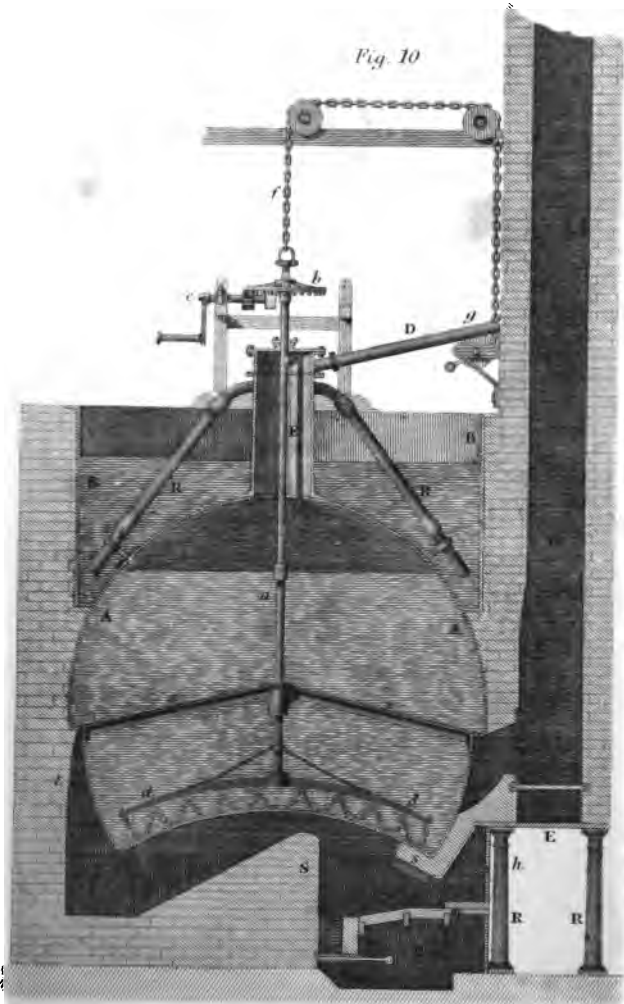




PLATE VI.

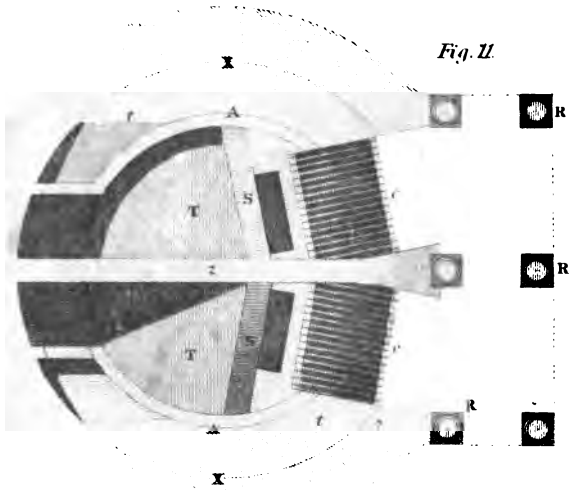


Fig. 12

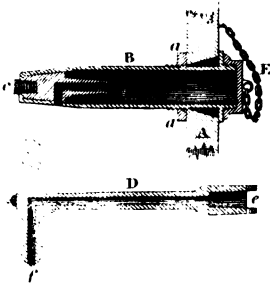


Fig. 13

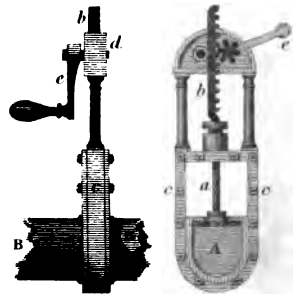


Fig. 14

