THE BREWING INDUSTRY

JULIAN L. BAKER

THE BREWING INDUSTRY

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BY

JULIAN L. BAKER, F.I.C., F.C.S.

WITH 28 ILLUSTRATIONS

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PREFACE

CONSIDERING the great importance of the malting and brewing industry in this country, the number of people employed therein, and the capital invested by the public, it is surprising how little is generally known of the operations involved in the manufacture of malt and beer. The few excellent text-books on these subjects are obviously too technical to be appreciated by the ordinary reader.

The author has written this short work with the object of giving an account of the different operations which take place in malting and brewing, and of indicating the relative position which the brewing industry occupies in the manufactures of the United Kingdom. Some of the more modern improvements which are met with in the malting-house and brewery are described, and brief reference is made to the licensing laws and the tied-house system.

The author is indebted to Messrs. Richard Moreland and Sons, Messrs. Strauss and Co., and others, who have kindly supplied many of the illustrations which appear in this work.

THE LABORATORY, STAG BREWERY,
PIMLICO, S.W.

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THE BREWING INDUSTRY

CHAPTER I

HISTORICAL

IT is necessary to go back several thousand years to find the first mention of ale or beer. In the well-known Egyptian work entitled *The Book of the Dead*, reference is made to the preparation of an intoxicating beverage from grain. The celebrated Egyptologist, Dr. Birch, says that the ancient beer called  (*heqa*) is referred to as early as the fourth dynasty, and was made from red barley or malt. The foreign beer came from Kati, a country to the east of Egypt, celebrated for its production, and there were two kinds, alcoholic and mild, employed in medicine. The Egyptians indulged in beer, and the description of a person overcome by intoxication is given in papyri of the time of Seti I. (1300 B.C.).

Diodorus Siculus states that "wherever the vine was not found in Egypt, Osiris taught the method of preparing a corn wine from grain." This lends support to the view that ale or beer was from the earliest times the natural substitute for wine in the countries where the grape did not flourish.

Æschylus held the Egyptian barley wine in contumely, and stated that it was a drink fit only for women.

According to some authorities, the Hebrew word *sicera*, which is translated in our Bible as "strong drink," was the barley wine referred to by Herodotus, and it is remarkable that this word is differentiated from wine, for, in certain parts of the text, the expression "wine and strong drink" occurs.

To show how well known and widely practised was the art of making beer, the following quotation from Pliny is interesting: "The several nations who inhabit the west of Europe have a liquor, with which they intoxicate themselves, which is made of corn and water. The manner of making this liquid is somewhat different in Gaul, Spain, and other countries, and it is called by various names, but its nature and properties are everywhere the same. The people of Spain, in particular, brew this liquid so well that it will keep for a long time. So exquisite is the cunning of mankind in gratifying their vicious appetites, that they have thus invented a method to make water itself intoxicating." The various beverages so made were known by the names Zythum, Cœlia, Ceria, Cereris vinum, Curim, and Cerevisa.

Diodorus Siculus mentions in his writings that upon festive occasions the Britons drank a fermented liquor, made of barley, honey, or apples.

Geoponius writes that in Britain the Celts steeped and germinated grain, by which its spirits were excited and set free; it was then dried, ground, and infused in water, when, after fermentation, it produced a pleasant, warming, strengthening, and intoxicating liquor.

When the Romans conquered Britain, they found that the inhabitants in the south drank mead, cider, and ale, but in the north and midlands the latter drink was unknown. Since the preparation of ale demands a knowledge and practice of agriculture, it is probable that the art was acquired from traders who visited these shores, and that it was not indigenous to the Celtic community in this country. The ancient British methods of making ale were greatly improved by the Romans.

It appears that the manufacture of ale was practised in very early times in Ireland, and this is not surprising when the advanced civilisation of the Irish—as compared with the British—Celts is remembered.

Ale was the common drink of the Saxons before they invaded Britain, and no doubt they adopted the improved processes of manufacture which the Romans had taught to the Britons. By this time ale and beer was the general drink of the country, so much so that in the ninth century rents were sometimes paid in malt and ale.

For a short time after the Norman Conquest, the popularity of the national beverage waned somewhat, owing to the introduction of French wines, but by the twelfth century ale had again established its supremacy. At this time English ales were famous on the Continent.

The English monasteries were noted for the excellence and strength of their ales, and frequent references to this beverage are to be found in the regulations of the old monastic establishments. Long before Burton-on-Trent was a brewing town, the religious houses in that neighbourhood brewed large quantities of ale. At the time of the Reformation many of the monks from the dispossessed monasteries became brewers.

The use of hops for flavouring beer was well known on the Continent, and the Germans, in Pliny's time, brewed ale with hops. Hops are commonly supposed to have been introduced into England about the middle of the fifteenth century, but this is probably incorrect, as there is a certain amount of evidence that Saxons used them in brewing. Thus, in an old poem in praise of the various celebrated ales of Ireland, supposed to date about A.D. 687, and compiled in A.D. 1390, there is reference made to the Saxon "ale of bitterness." This is interesting, as it suggests that England had begun to make bitter beer at a much earlier period than is commonly supposed.

Before the introduction of hops, attempts were made to flavour the beer with aromatic and bitter astringent plants, oak bark being employed for this purpose. The Cimbri used the *Tamarix Germanica*, the Scandinavians the fruit of the sweet gale (*Myrica gale*), the Cauchi the fruit and twigs of the chaste tree (*Vitex agrius castus*). In Iceland the yarrow (*Achillæa millefolium*) was made use of.

At first the practice of brewing ale with the addition of hops was strongly opposed, and there were frequent prosecutions for so doing. The following quotation from Boorde's *Dyetary*, published in 1542, illustrates the difference in meaning in the terms ale and beer, and the esteem in which each was held: "Ale is the natural drink of Englishmen, and made of malt and water, while beer, which is composed of malt, hops, and water, is the natural drink of the Dutchman, and of late is much used in England, to the great detriment of many Englishmen." This distinction between ale and beer lasted for a considerable time. Hops gradually came into general use, but the word ale was retained, whether the liquor designated by it was hopped or not. The word "beer" now includes all malt liquors, whilst ale includes all but black or brown beers.

It is an interesting fact that in early times a great deal of the brewing was carried on by women. Up to the eighteenth century, the making of ale in country houses was a recognised duty of the housewife. Frequent references are made by writers of Elizabethan times to ale-wives.

In the reign of Henry IV. the brewers of London formed themselves into a mutual society, and in 1445 the first charter was given to the Brewers' Company. At this time the brewers were subjected to very harsh and irksome conditions, and their trade was one which was held in some contempt. Moreover, they had continual quarrels with the authorities over the strength and measure of their ale. The formation of the Brewers' Company was, no doubt, a measure of protection. The brewers of ale continued at variance with the brewers of beer, and it was not until the reign of Queen Mary that the ale and beer brewers were united under a single corporate body. From about that time better feeling began to exist between the brewers and authorities, and the former were no longer subjected to unjust and capricious treatment.

Up to the time of the introduction of tea, coffee, and cocoa, beer was the popular beverage with the general public; it was taken at all meals, and in large quantities. The varieties of beers and ales were numerous. Even so far back as Saxon times five or six different kinds of ale and beer were drunk. In the fifth year of Edward VI. the London brewers obtained a decision from the Common Council that only two kinds of ales should be brewed, double and single; and it was enacted that four barrels and one firkin of double ale should be obtained from a quarter of grain, and twice this quantity of single ale. The price of double ale was 4*s.* 8*d.* the barrel, and of single ale, 2*s.* 4*d.* the barrel. In Queen Elizabeth's reign a double double beer was brewed at 7*s.* 6*d.* the barrel. A little later the brewing of this beer was forbidden. Although London was famous from a very early date for its beers, other parts of the country produced some which were held in much esteem. Country beer was notoriously strong.

In the early part of the eighteenth century London became noted for its porter. About that time the malt liquors in general use were ale, beer, and two-penny, and it was customary for the drinkers to call for a pint or tankard of half-and-half, that is, a mixture of two half-pints of any two of the above-mentioned beers. The practice then became common to ask for a pint of "three threads," meaning a third of ale, beer, and twopenny; and thus the publican had the trouble to go to three casks. To avoid this inconvenience, a person named Harwood prepared a liquor which had the flavour of a mixture of equal parts of ale, beer, and twopenny. It rapidly became popular, and from the fact of its being largely consumed by porters, it was distinguished by the name of *porter*. Enormous quantities of this beer were brewed in London in the early part of the nineteenth century, comprising, in fact, more than half the quantity consumed at that time. Mild ale has now, however, largely taken the place of porter.

The eighteenth century witnessed a change, which gave a great stimulus to the brewing trade. Hitherto the wealthy classes had brewed their own beer, but they began to find that it was cheaper and less troublesome to engage a brewer to do it for them at a brewery. The brewers charged 30*s*. per barrel for pale ale, and 8*s*. and 10*s*. per barrel for small beer. This gradual transference of the brewing of beer from the private individual to the brewer was of undoubted benefit to the latter, for, owing to the centralisation of his trade, his increased turnover, and facilities for the advantageous buying of materials, he was in a position to make a good profit.

A brief reference must be made to the "ale-houses" or taverns. These were the clubs of former times, and, in the days of Dr. Johnson, they attained great social importance. The tavern or public-house of to-day reminds us of the times when the duties of hospitality were discharged by the Church. Attached to a monastic establishment was the almonry, where unimportant strangers and travellers found food and shelter. Persons of higher rank were received in the monastery. The nobles and landowners also dispensed open hospitality to the traveller; but, in the course of time, the accommodation which had been provided by the great houses was transferred to an inn set up in the vicinity, the innkeeper being usually a retainer of the landowner. In the large towns and cities, inns and ale-houses existed as far back as Saxon times, and records of regulations are extant regarding the relations existing between landlord and guest. When the social part which the ale-houses played in a community is borne in mind, it is not surprising that, in many towns and villages, their numbers exceeded the requirements of the population. The question of excessive drinking often exercised our forefathers, and it was by no means uncommon for the numbers of ale-houses to be arbitrarily reduced.

There is not much information left which helps us to form an idea of the plant that the early brewers used. Some of the old illustrated treatises on brewing of the sixteenth and seventeenth centuries, show very primitive apparatus; and, in the light of our present knowledge, it can only have been the strength and alcohol content of the old ales, and the large quantities of hops used, that kept them sound. Much of the light beer brewed must have been of a very indifferent character. It was comparatively late when the custom of curing malts in a kiln was adopted; before that time the barley was steeped, germinated, and air-dried. The thermometer is quite a recent innovation. Brewers have always shown themselves to be very conservative in adopting improved methods and processes, and it is only recently that keen competition has aroused their interest. Even now we are far behind the Continent and America; but there appear to be indications that English brewers are recognising that their industry, to be profitable, must be worked on scientific and economical principles, and that rule-of-thumb methods are out of date in these times.

For many years past a steady change has been arising in the taste of the beer-drinking public. The old-fashioned heavily hopped ales have been practically displaced by lightly hopped, fresh, and bright ales. The brewers have responded to this demand, and, though doubtless some people regret the extinction of the ales of former years, yet there can be but little doubt, that the beers made now are lighter and more wholesome. The lighter beers are more difficult to manufacture than heavy beers, for these will withstand an amount of bacterial and other contamination, which would be fatal to the former. Brewers accordingly have improved their processes, so that light beers can be satisfactorily brewed. This is probably the principal reason why such great advances have been made in the brewing and malting industries during the last twenty or thirty years.

The first beer duty was imposed by Charles II., in 1660, and amounted to 2*s.* 6*d.* per barrel on strong, and 6*d.* on table, beer. In 1688, the revenue derived from the duty amounted to £666,383. In 1694, the duty was raised to 4*s.* 9*d.* on strong, and 1*s.* 3*d.* on table, beer. The amount was increased slightly between this date and 1800, when it amounted to 8*s.* to 10*s.* on strong, and 1*s.* 4*d.* to 3*s.* on small, beer. In 1829, the duty and malt-tax amounted to about 13*s.* 8*d.* per barrel. In 1830, the duty was repealed.

In 1711, a duty of 1*d.* per pound was charged upon hops grown in England, and 3*d.* upon imported hops. In 1801, the tax was increased to 2½*d.*, but was lowered again to 2*d.*, in 1806. In 1860, it was 1½*d.* This tax brought in very variable sums, owing to the uncertainty and fluctuations of the crops; in 1862 it was taken off.

The Excise duty on malt was originally established in England during the reign of Charles I., but it was soon repealed, and was not re-established until 1697. The duty varied from 6*d.* to 4*s.* 5¾*d.* per bushel. The revenue derived from malt, in 1880, the year that the malt-tax was removed, amounted to £6,827,139.

The duty on sugar has also fluctuated. It was first imposed, in 1850, at the rate of 1*s.* 4*d.* per cwt.; in 1854 it was 6*s.* 6*d.*, and between 1874 and 1880, was 11*s.* 6*d.*

In addition to these duties, licenses were imposed upon breweries, varying in amount from 20*s.* to £50, according to the strength and number of barrels of beer which they brewed, and upon maltsters, in proportion to the number of quarters malted.

In 1880, the malt and sugar duties, and the brewers' and maltsters' licenses were repealed. Instead of these, a license duty of £1 was charged annually to every brewer for sale, and a duty of 6*s.* 3*d.* on every barrel of beer at a gravity of 1057°, with an allowance of 6 per cent. for waste. In 1889, Mr. Goschen altered the specific gravity of beer upon which duty is levied, from 1057° to 1055°. In 1890, the beer duty was raised 3*d.* a barrel. In 1894, this was again raised to 6*s.* 9*d.* per barrel, and in 1900, owing to the South African War, to 7*s.* 9*d.* In 1901, a tax of 4*s.* 2*d.* per cwt. on sugar, and 2*s.* 4*d.* on molasses, and glucose, was imposed. No rebate was allowed to brewers, notwithstanding that an ingredient of beer was taxed twice over. In 1902, a registration duty of 1*s.* per quarter, was placed on foreign malting barley, but, in 1903, this was taken off. The total taxation on beer, taking into account the duties upon materials, now amounts to about 8*s.* per barrel, of a specific gravity of 1055°.

The varieties of beers brewed at the present day are exceedingly numerous. Roughly speaking, they may be divided into strong, medium, and light. In the strong, we may include stock or old ales, and the heavier stouts. The medium, comprises the lighter stouts, superior bitter beers, mild or four-ale, which latter is still the beverage of the working classes, and porter.

The light beers, of which increasing quantities are being brewed every year, are more or less the outcome of the demand of the middle classes for a palatable and easily consumable beverage. A good example of this type of beer is the so-called "family ale," and the cheap kinds of bottled bitter beers and porters.

CHAPTER II

BARLEY, MALT, AND MALT SUBSTITUTES

BARLEY AND MALTING

OF all brewing materials barley must be regarded as the most important, for it is the cereal from which is prepared malt, the essential constituent of beers. Barley, like wheat, oats, and rye, is a member of the family Gramineæ, or grasses. Barley has been known and cultivated by man since the earliest times. It has been found in the Swiss lake-dwellings, and in ancient Egyptian tombs. Pliny writes about barley, and mentions how the races of Central and Northern Europe prepared a fermented beverage from germinated barley. The Romans recognised it as a staple form of food, and portrayed ears of barley on some of their coins.

It appears to be doubtful whether the many varieties of barley which are now cultivated have a common origin, although some botanists hold this opinion. It has been suggested that the original wild species of more than one form were first used as food, and then cultivated.

Cultivated barleys are known to English botanists by the specific name of *Hordeum sativum.*

The sub-species, according to the Linnæan classification, are :—

Hordeum hexastichum		Six-rowed barleys.
,,	*vulgare*	
,,	*distichum*	Two-rowed barleys.
,,	*zeocriton*	
,,	*cœleste*	Naked barleys.
,,	*nudum*	

If an ear of barley be examined, the axis, or spike which bears the corns, will be found to be divided into a number of internodes. Each internode bears three spikelets, the groups of three being arranged alternately on either side of the axis. These three spikelets may be fertile, in which case the barley is known as six-rowed, or only one spikelet is fertile, and a two-rowed barley is the result.

According to E. S. Beaven, the following types of barley are met with in the United Kingdom and in imported grain :—

Hordeum hexastichum, or six-rowed barley, is grown in England as a winter barley. It is used mostly as a forage plant. In France it is known as "l'Escourgeon."

Hordeum vulgare is known as "four-rowed," or "bere." It occurs as winter and spring barley in the United Kingdom, and is found in Smyrna, and other foreign barleys. This variety is commonly described as *Hordeum tetrastichum.* The name would suggest a distinct sub-species. Such, however, is not the case; as the two rows of spikelets issuing from one side of the main stem intersect and overlap the alternate set of

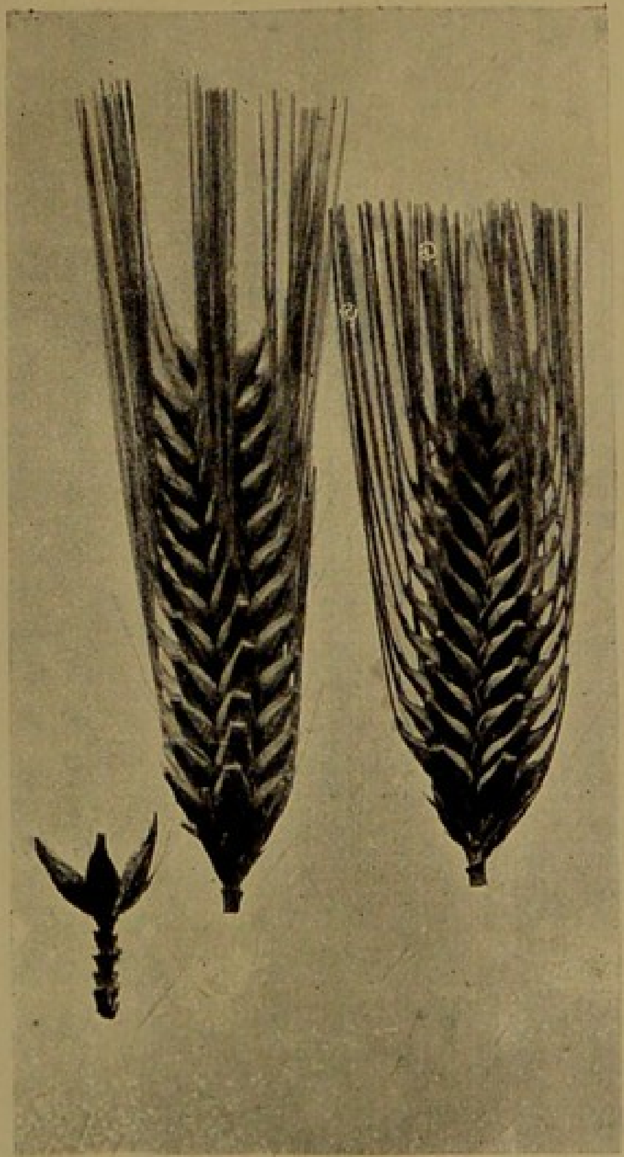

FIG. 1

H. HEXASTICHUM

(*a*) Three spikelets *in situ* on the rachis showing short internodes.
(*b*) Spike. Median spikelets uppermost, and with lower awns removed.
(*c*) Spike. Lateral spikelets uppermost, and with lower awns removed.

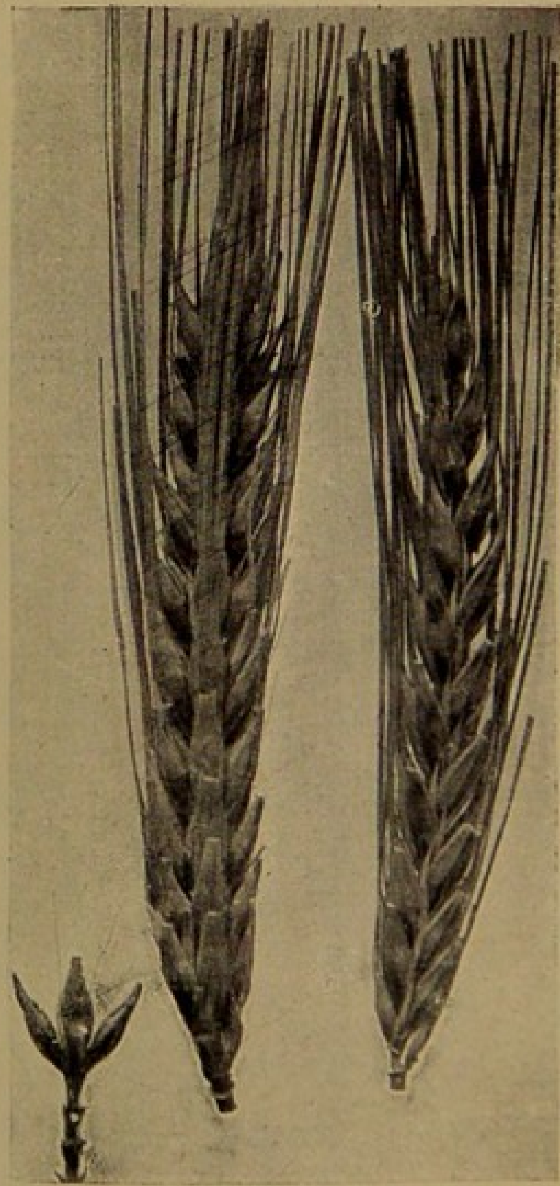

FIG. 2

H. VULGARE

(*a*) Three spikelets *in situ* on the rachis, showing long internodes.
(*b*) Spike. Median spikelets uppermost.
(*c*) Spike. Lateral spikelets uppermost.

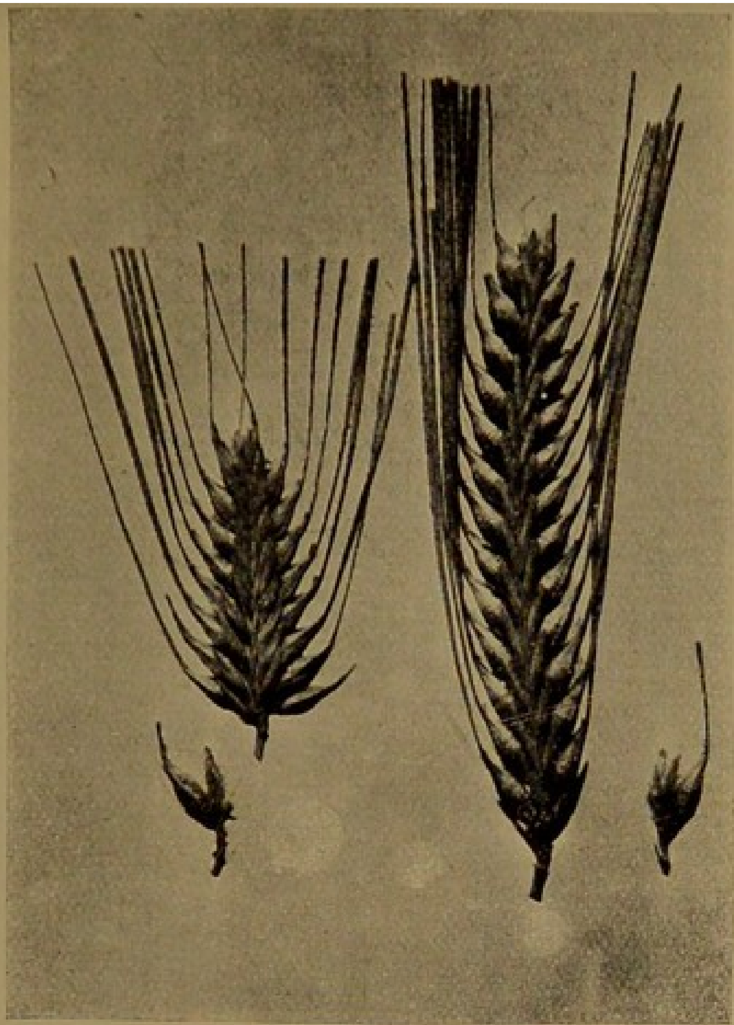

FIG. 3

H. ZEOCRITON

(*a*, *d*) Spikelets, Rachis edgewise, shewing short internodes.
(*b*) Variety *zeocrithum* (Fan barley), spike converging.
(*c*) Variety *erectum* (Goldthorpe), spike parallel.

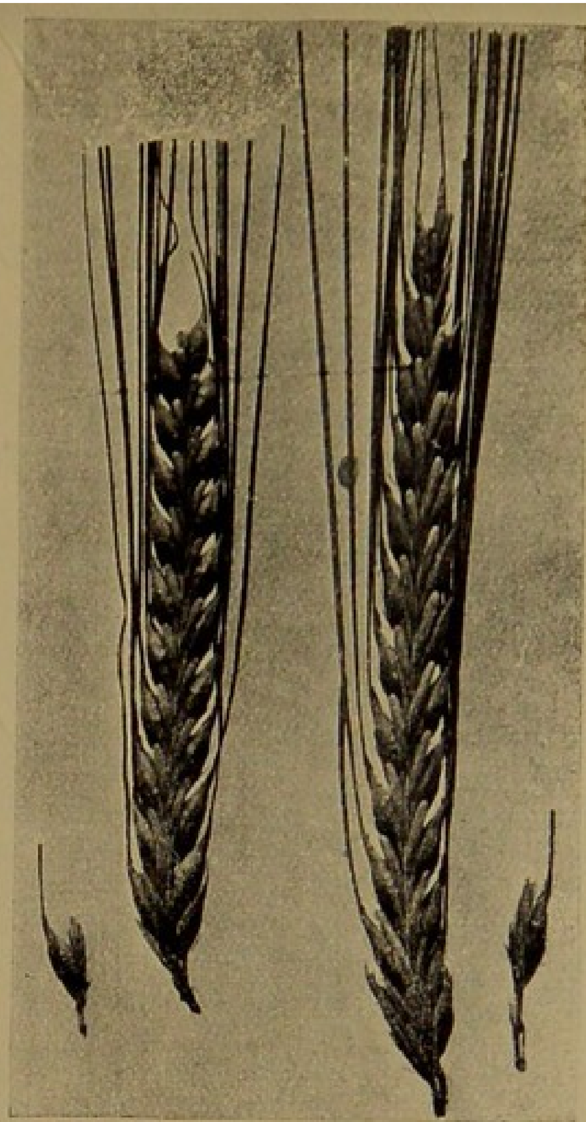

FIG. 4

H. DISTICHUM

(*a*, *d*) Spikelets, Rachis edgewise, shewing long internodes.
(*b*) Variety *nutans* (Chevalier).
(*c*) Ouchak barley.

spikelets, which issue from the opposite side of the stem. When the ear is mature, it has the appearance of a four-rowed barley.

Hordeum zeocritum is known as Goldthorpe or Sprat barley.

Hordeum distichum. Of this type the well-known "Chevalier" is an example.

The difference between the types of barley is admirably shown by E. S. Beaven in the accompanying figures, for the use of which I am indebted to the Council of the Federated Institutes of Brewing.

The following list, compiled by E. S. Beaven, shows the different varieties which are met with in imported barleys. It also illustrates the different sources from which the maltster derives his raw material. The wide selection is the natural outcome of Mr. Gladstone's "free mash tun" Act of 1880.

Californian Chevalier	*H. distichum*, mixed with *H. vulgare.*
Californian Brewing .	*H. vulgare.*
Chilian Chevalier .	*H. distichum*, mixed with *H. vulgare.*
Chilian Brewing .	*H. hexastichum* and *H. vulgare.*
Mexican . . .	*H. vulgare.*
Argentine . .	*H. vulgare.*
Moroccan, Algerian, and Tunisian .	*H. vulgare.*
Tripoli (Ouchak type)	*H. distichum.*
Gaza . . .	*H. vulgare.*
Persian . . .	*H. hexastichum*, *H. vulgare*, *H. distichum.*
Beyrout . . .	*H. hexastichum*, *H. vulgare*, *H. distichum.*

Smyrna (Yerli) . .	Mostly *H. vulgare*, often mixed with *H. distichum*.
Ouchak . . .	Mostly *H. distichum*, mixed with *H vulgare*.
Marmora . . .	*H. vulgare*.
Black Sea . .	*H. vulgare*, generally mixed with *H. distichum*.
Danubian . .	Both *H. vulgare* and *H. distichum*, often mixed.
Cyprian . . .	*H. vulgare*.
Spanish . . .	*H. vulgare*.

From this list it will be seen that mixtures of two-rowed and six-rowed barleys are common to most foreign barleys.

The malting-barley generally grown throughout the United Kingdom is the two-rowed *Hordeum distichum*, commonly called "Chevalier." Curiously enough, this barley owed its origin to selection. The Rev. John Chevalier describes its origin in the following words: "A labourer living in a cottage of mine at Debenham, in this county (Suffolk), as he passed through a field of barley, plucked a few ears, and on his arrival home threw them for his fowls into his garden. In due time a few of the grains arrived at maturity, and, as the ears appeared remarkably fine, I determined to try the experiment of cultivating them."

The reader must not infer from this that all Chevalier barley is derived from the particular kind collected by the labourer referred to above, nor is it possible to say how much is so obtained.

The question of improving the quality of malting-barleys by cross-fertilisation has, during the last few years, been receiving much attention. Cross-fertilisation, theoretically, could produce innumerable intermediate varieties of barley ; and, in this connection, it is natural to ask, Why should not cross-fertilisation take place in the field? Most botanists are of opinion that natural cross-fertilisation of cultivated barley rarely occurs. To carry it out artificially is a difficult matter. According to Messrs. Munro and Beaven, the glumes which enclose the barley-flower open sufficiently to allow the stamens to protrude, although they are frequently caught, so to speak, in the act of escaping, by the reclosing glumes. Probably fertilisation has already taken place before the complete or partial escape of the stamens. Notwithstanding the difficulty of effecting cross-fertilisation, there are now two fairly well established varieties, known as Standwell and Invincible. Both of these are crosses, and so far appear to be permanent.

Since no well-defined property of barley can be utilised for effecting a convenient valuation, it is always bought in the open market; and the purchaser has to rely on certain characteristics, which can only be recognised by long experience in the handling of samples. Many attempts have been made by chemists connected with the malting and brewing industries to overcome this rule-of-thumb valuation, but, as yet, without success, although the large amount of work being done in this direction will undoubtedly in the near future have a successful issue. A sample of barley should be mature, and free from damaged, heated, and discoloured corns. Mealiness is desirable, for mealy corns will malt more easily than those which are hard or steely. The sample should possess vitality, since a barley will not germinate, unless it has life. Defective vitality arises from numerous causes, such as, for example, excessively or insufficiently ripe ears, germination in these occurring during a wet harvest, and destruction of the germ or embryo owing to heating in the stack. The vitality of barley is greatly modified during storage, especially if it is damp. Dryness is another important factor, it being well known that barley will not germinate in a regular manner, until it has attained a certain degree of dryness. Barley improves for malting purposes after being stored for a certain time under favourable conditions; but, after eighteen months or two years, its germinative power retrogresses to such an extent that it becomes useless to the maltster.

A good barley should have a sweet smell; in this connection it is interesting to note, that barleys of different origin possess characteristic odours, the difference between a good English, Californian, or Smyrna being very marked. Uniformity of size is important, for this means regularity and evenness in the resulting malt.

Prior to the Malt Act, the weight per bushel of barley was a matter of importance, but other considerations have now to be taken into account. It is found that light barleys will yield as good malts as heavy ones. They vary much in weight, heavy samples scaling 55 to 56 lbs. and light ones 49 to 50 lbs. per bushel.

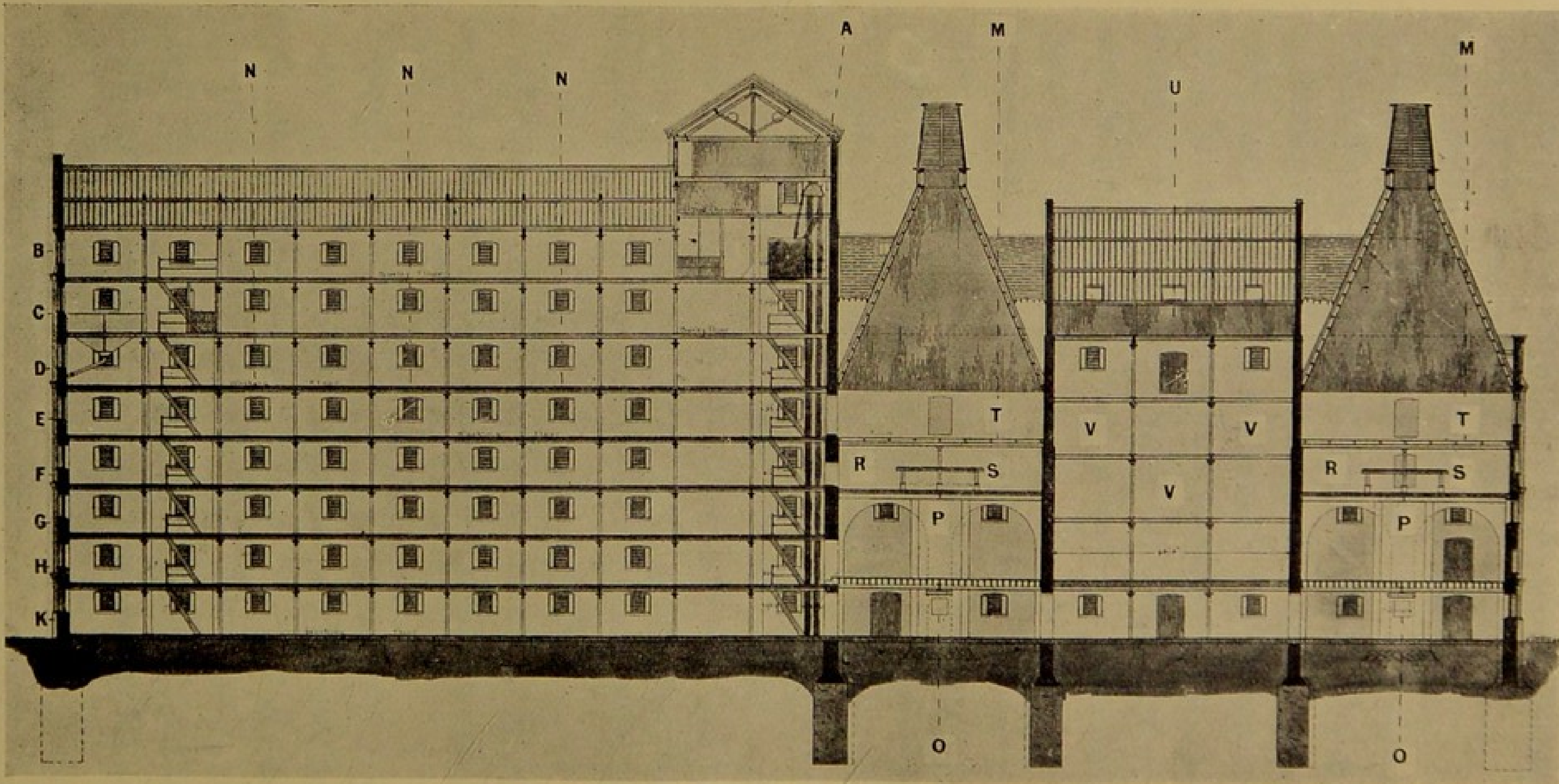

FIG. 5

LONGITUDINAL SECTION OF A MODERN MALTING

The illustration (Fig. 5), for the use of which I am indebted to Messrs. Watney, Combe, Reid, and Co., shows a longitudinal section of a modern malting. The barley is carried to the top of the building by the elevator A, where the screening and cleaning machinery is situated. As the barley leaves these machines it is conveyed by rotatory bands to the barley floor B. Beneath this is the floor C, containing the steeping cisterns. One cistern is shown in position. In this case there are six cisterns, one to each of the working floors D, E, F, G, H, K. The floors are ventilated by the louvres N, N, N, shown in the section. The cisterns are connected to the floors by means of shoots, plugs beings placed in the floors for this purpose. The "pieces" of green malt are gradually worked along to the kilns M, M, and are transferred to them by rotatory bands. The fireplaces O, O, of the kilns M, M, are arranged so that the draught may be easily controlled. The hot air and products of combustion pass up the shafts P, P, to the hot-air chambers R, R, where they strike the baffle plates S, S. These plates disperse the hot air and gases evenly beneath the bottom of the kiln floors T, T, which contain the green malt. When the drying and curing is finished the malt is carried by bands to U, where the culms are removed by suitable machinery. The finished malt is stored in the bins V, V, V. The water used for steeping is obtained from a high-pressure hydrant or from a tank situated on the roof of the building.

MALTING

When a large parcel of barley is bought by the maltster, it is by no means uniform in quality or ripeness. The grain is at first screened. Screening machines essentially consist of a number of sifters, which eliminate small, damaged, and half corns, stones, and foreign seeds, and grade the barley into different sizes. The screenings are sold by the maltster as cattle food. The custom has gradually arisen, and, indeed, now is almost general, so far as English barley is concerned, of "sweating" the grain before malting. This "sweating" really amounts to an artificial ripening process, for the grain is placed in kilns, and subjected to the action of warm air for two or three days. The temperature should never rise above 95°–100° F. During the heating the barley loses a considerable amount of moisture, from 5 per cent. to 8 per cent., according to the amount of water originally present. For example, a sample of English barley of the 1902 season contained 18 per cent. of moisture before being kilned; afterwards this quantity was reduced to 11·5 per cent. When the barley has been kilned, or "sweated," it is stored in bins, and it should not be used for malting for at least three weeks or a month. This rest is necessary to re-establish the intercellular equilibrium which has been upset by the kilning process. Most English barleys which have been judiciously kilned, germinate with more regularity than when unkilned. Kilning is of great advantage after a bad harvest, when the grain has remained in the ear under unfavourable climatic conditions. In such cases, it never properly ripens, and the kilning goes a long way to complete the sun's work. The barley crop from a very favourable or dry harvest need not of necessity be kilned. This, however, depends upon the maltster's discretion.

Foreign barleys, such as Smyrna, Californian, Indian, Southern European, etc., which are harvested under ideal climatic conditions, are not kilned.

After being kilned, and stored for three weeks or a month, the barley is ready to be malted. The barley is first of all steeped, or soaked, with water for a certain period, which depends upon the nature and quality of the grain, the thickness of its skin, the temperature and time of the year. To give an example, fine English barleys may be soaked for fifty, thick-skinned English barleys fifty to sixty, light European for sixty, Smyrna and other thick-skinned foreign barleys for seventy hours. The steep-liquor is generally changed twice on the first day, and once on each succeeding day; the temperature should be between the limits of 50°–60° F. The cistern, which is made of cement, wood, or cast iron, is provided with a false bottom, the perforations of which allow the water to run away. The cistern is generally cylindrical in shape, with a conical bottom, and is so constructed that the steep liquor is drawn off from below, whilst clean water is admitted from above, either by means of a pipe or of a spraying device. The cisterns usually have a capacity of twelve cubic feet for each quarter of barley to be malted. The object of steeping is to supply sufficient moisture to the grain to start and carry on germination, and, further, to extract from the barley certain substances (1·5 to 2 per cent.) which would be undesirable in the finished malt. During steeping barley takes up nearly 50 per cent. of water. 100 lbs. of dry barley will produce about 145 lbs. of steeped barley and swell to about one-fifth more than its original bulk. Barley should never become sodden by oversteeping, or its vitality may be seriously impaired, owing to the exclusion of air during the evaporation of the excess of moisture. In other words, the barley is drowned, and this is also hurtful on account of the excessive extraction from the grain of matters soluble in water. If the operation of steeping has been properly conducted, the individual corns, when cut through lengthwise, should appear uniformly wetted.

When the water has drained away from the grain in the steeping cistern, the barley, called the "piece," is massed in a heap from twelve to sixteen inches deep. This is termed a "couch," and it is kept piled up, until the grain "chits," or, in other words, until the rootlets pass through the husk. When this happens, the heap of sprouted grain is flattened, and spread out in a layer varying in thickness from three to ten inches, according to the judgment of the maltster. The "piece" is gradually worked along towards the kiln end of the malting-floor, and, as soon as it has advanced sufficiently, a second steeping is "couched," and in due course spread

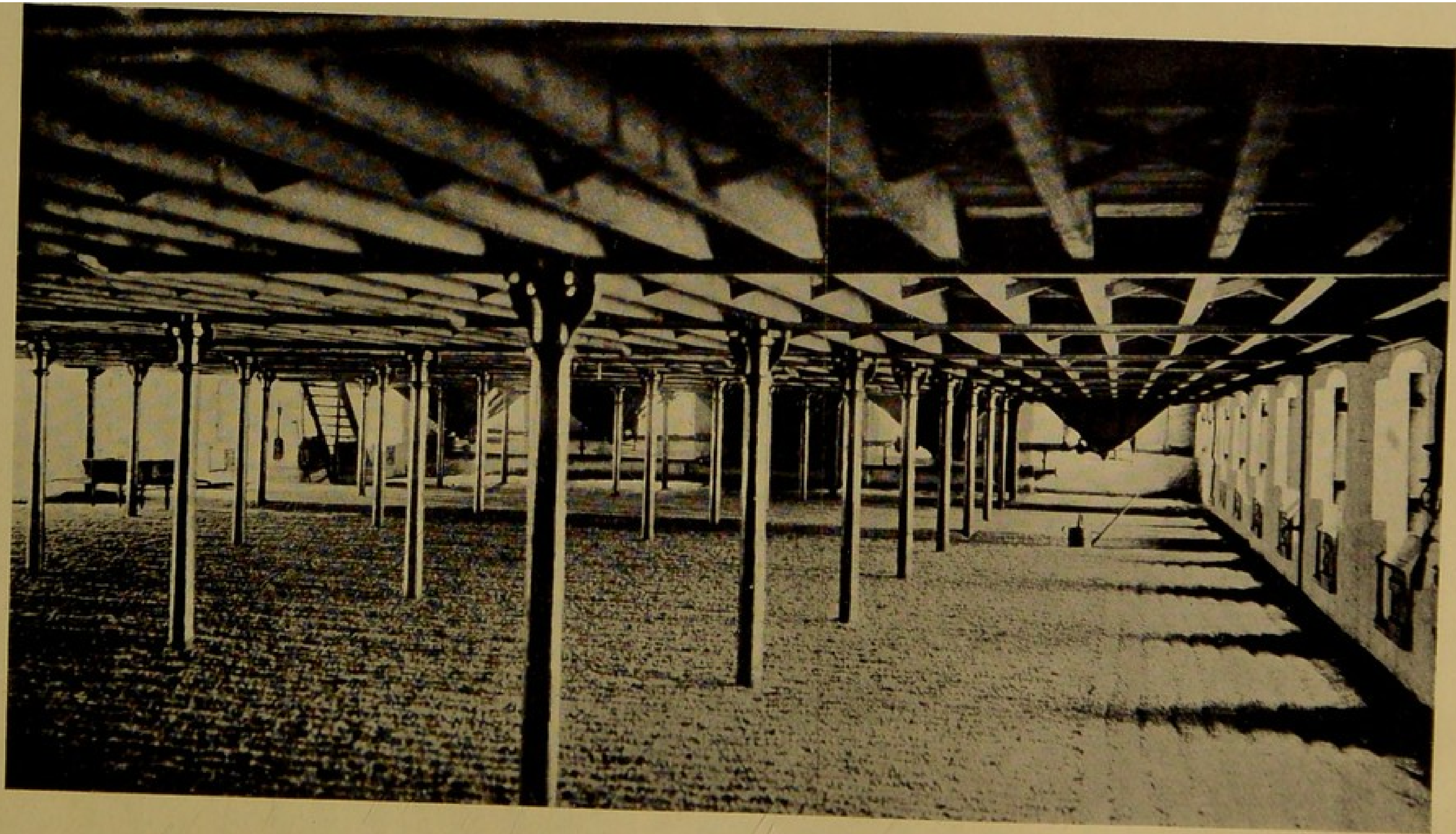

FIG. 6

INTERIOR OF A MALTING FLOOR

out. Thus there is a slow and continuous travel of grain from the cistern to the kiln, and there may be several "steepings" on the floor at the same time in different stages of advancement. It is obvious that the quantity of barley steeped, and the frequency of steepings, depend upon the kiln accommodation. The accompanying illustration (Fig. 6) shows the interior of a working floor. In the background the conical ends of five steeping cisterns will be seen, which are connected by shoots with the four working floors beneath the one shown. The sprinkling can divides two pieces of green malt, the piece behind the can having been steeped before and heaped to a greater depth than the piece in the foreground. The furrows on the surface of the green malt are left by the plough.

The process of germination may be conveniently divided into, firstly, the absorption of water and dissolution and transformation of the reserve substances; and, secondly, the development of the embryo. The grain of barley during these processes undergoes deep-seated changes, which extend, not only to the internal structure, but also to its chemical composition. During germination a sufficiency of moisture and a suitable temperature should be maintained, the grain must also be aerated and protected from any abnormal conditions. The contents of the endosperm have to become "modified," and the active principle diastase developed in sufficient amount. This "modification" constitutes the essential difference between barley and malt; and on the extent of the modification depends the amount of extract obtainable in the mash tun.

Diastase was the name given by two French chemists, Payen and Persoz, to this active principle, which converts starch into sugar and dextrin. Diastase is found in barley and most starch-containing seeds. When the latent life in a barleycorn becomes active, the soluble ferment or enzyme diastase dissolves a portion of the starch granules. The sugar which is thus formed is the principal food material for the growing germ. As the young plant develops more diastase is secreted; this, in turn, loosens the compact mass of starch granules, and transforms enough starch into soluble sugar to meet the requirements of the growing plant. The maltster stops the growth of the barleycorn, when the endosperm or starch-containing portion of the corn is sufficiently loosened by the secreted diastase. By experience he has found that this occurs, when the leaf-sheaf or acrospire has grown about three-quarters up the back of the corn.

If the starch-containing portion of the barleycorn were not loosened, or modified in this manner, the starch would not be dissolved in the mash tun.

In the longitudinal sections of the four barleycorns *a*, *b*, *c*, *d* (Fig. 7), the progressive modification is shown by shading. Thus: *a* represents a barleycorn as it comes from the steep; *b*, when it is "chitting"; *c* and *d*, when the acrospire is half and three quarters up the back of the corn. When the modification has reached the stage shown in *d*, the green malt is ready to be withered.

The growth on the floor should not be forced along too rapidly, otherwise the rootlets and young plant develop at an excessive rate, and the starch of the endosperm is considerably lessened in quantity. Frequently the moisture in the grain as it comes from the steep is insufficient for the later stages of development. When the sprouting barley shows signs of becoming dry, water is sprinkled over the "piece" at the rate of from one to five gallons per quarter, generally about

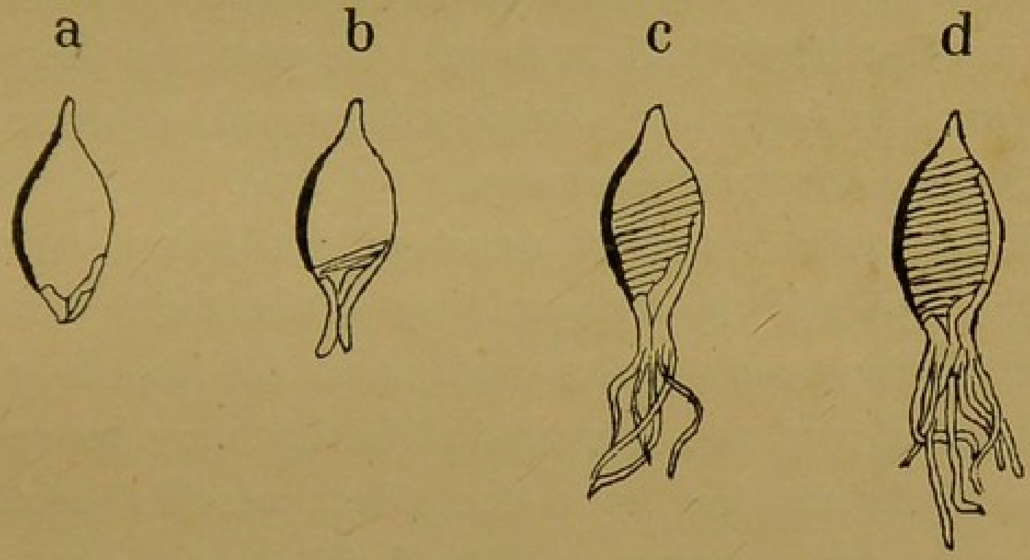

FIG. 7

the sixth day. Sprinkling is not an invariable rule. Some maltsters prefer to steep for a longer period, and to use no sprinkling liquor. This, however, applies only to English barleys, for most foreign barleys are sprinkled.

The temperature is maintained by opening and shutting the windows or louvres, by breaking up the "couch," and by turning the "piece." The piece is turned or "ploughed" regularly, so that the surface grain is worked into the centre of the new heap, and that which was in the centre comes to the outside.

Each new heap is spread lower than the old one, to keep the temperature within proper limits, for, as growth proceeds, more heat is generated. During the growth of the barley on the floors a delicate fruity odour is noticeable. If a malting has been properly carried out, the acrospire (future leaf) should be evenly developed, and the rootlets should look fresh and be well matted one into the other. When the barley is sufficiently grown, the acrospire will, as already stated, have developed three-quarters of the extent of the corn, the rootlets being half as long. On pressing the grain between the fingers, the endosperm should squeeze out and have a mealy consistency.

The proper stage of development being reached, further growth is stopped by withering. This is effected by heaping the malt, and so impeding the ventilation; or, the germinated barley may be spread very thinly on the floor, the effect of this being to lower the temperature and to facilitate the escape of moisture.

It is important for the maltster to "wither" properly, for if the malt goes on to the kiln insufficiently withered and the kiln temperature is not properly adjusted, the malt becomes permanently steely. The time taken for withering should not be more than twenty-four hours, and the temperature of the heap of green malt should not exceed 70° F. When the malt is ready to be loaded on the kiln, it usually contains from 35 to 40 per cent. of water.

Barleys generally remain on the floor from ten to fourteen days, according to the temperature, the mellowness of the barley, and other considerations; this time being measured from the end of the steep until the green malt is ready for the kiln.

KILNING

This most important operation is divided into two stages, drying and curing. During the curing the character of the product is finally determined. The drying is effected by passing large volumes of warm air through the layer of malt. A high temperature is avoided at first, otherwise the diastase would be crippled or destroyed, and the starch gelatinised. During the drying process the malt is frequently forked and turned over, so that a free passage of air may be ensured.

On the first day of kilning, the temperature does not exceed 95° to 100° F. During the second day this is slowly raised to 120° to 125°, the third day to 140° to 150°, the fourth day the malt is finished off at the desired temperature. This is allowed to fall gradually, and the malt is heaped up on the kiln. The time during which a malt is kept on the kiln varies according to the quantity; some maltsters dry and cure in forty-eight hours, but the majority take three or four days. The object in view is gradually to raise the temperature to a maximum, and maintain it for a length of time sufficient to enable the heat to penetrate to the centre of the individual corns. During the curing process the diastatic capacity is greatly restricted, the malt is rendered friable, and the flavour is developed.

Varieties of malt :—

Pale malt for pale ale brewing is finished off at a temperature of . . .	180°–200° F.
High dried malt for mild ale and stouts	200°–225° F.
Amber malt for mild ale and stouts .	225°–240° F.

Brown malt is dried off rapidly over a wood fire. It has a much higher colour than amber malt, and no diastatic capacity. Black or patent malt is malt which is roasted, so as to produce the maximum amount of colouring matter. Roasted barley is now largely used in place of black malt, as it is cheaper and in most cases gives equally satisfactory results.

In this country malt is cured by exposure to the products of combustion from the kiln furnace. Curing by indirect heat, viz. the products of combustion being excluded from actual contact with the malt, is not usual in the United Kingdom, but is practised more in Continental and American maltings. Probably the part played by the products of combustion in conferring flavour on the malt has been much exaggerated. Excellent beers have been obtained from malts cured by indirect heat.

The employment of kilns heated by indirect means will probably demand the attention of the maltster, for in addition to being cheaper, it is well known that anthracite, the fuel used in maltings, is sometimes contaminated with arsenic; and, as the products of combustion pass through the malt on the kiln, the malt will absorb any volatile arsenic contained in the fuel.

When the temperature in the kiln has dropped, the malt is passed through screens, where the dried rootlets (culms) are completely removed, and sometimes through brushing machines. It is then stored in large bins for at least a month, and afterwards sacked, weighed, and sent to the brewery.

PNEUMATIC MALTING

Under the English system of working, a maltster has to contend with many difficulties, the worst of which is, perhaps, the English weather. A rise of air-temperature means a corresponding rise on the malting-floor, and to keep the grains growing the maltster will have to sprinkle heavily, with the result that trouble will be experienced in removing this moisture before kilning. In this country the majority of maltings start working towards the end of September, or beginning of October, and continue until the end of April. Some maltsters continue throughout May and even until June, but this practice is hazardous, owing to the extreme difficulty of controlling the floor-temperatures. Consequently for about five months in the year many maltings are idle. The maltster has to sink a large amount of capital in the erection of maltings, and during the period of inaction no dividend is being earned. Years ago malting was a very different business from what it is at present; the maltster was then liberally remunerated, and he had not the severe competition to face that he has at present. The buyer of malt, that is the brewer, can no longer afford to pay the high prices that he formerly did, and, consequently, the margin of profit is becoming each year smaller for the maltster.

This competition was felt sooner on the Continent and in America, than in the United Kingdom; and, as a result, mechanical systems of malting were devised which overcame many of the difficulties met with in floor-malting. These systems possess the following advantages:—(1) Smaller buildings and less space to produce a given quantity. (2) Continuous working throughout the year and absolute control over the growing operations. (3) No exposure of the growing barley to external contamination. (4) Reduced capital invested and diminished cost of labour as compared with the ordinary floor process. (5) The plant can be installed in breweries situated in large towns, and the brewer thus has the great advantage of using malt prepared according to his own directions and under his supervision. The cost of carriage of a bulky material is thus saved, and the brewer is enabled to use new malt at seasons of the year usually more or less critical from a brewing standpoint.

Notwithstanding these very solid advantages possessed by mechanical or pneumatic malting, the introduction of the system, although it is general in America and on the Continent, cannot be said to be altogether successful in the United Kingdom. There are several reasons for this. Probably the salient one is, that so much capital is invested in the existing buildings and machinery, that the maltsters are not in a sufficiently strong financial position to consider a system, which practically renders valueless their present buildings. Again, some of our more enterprising maltsters have gone to the expense of erecting pneumatic maltings, but the results have, in their estimation, not warranted the outlay; as no better, and in many cases not as good, malt was produced. With regard to the latter objection to pneumatic malting, the reason is probably due to the fact, that the system was introduced from Germany, where it is most successfully worked. Now the essentials of a German malt are very dissimilar from those of an English one, owing to the different processes of brewing in the two countries. German malt is everything that is bad from the point of view of an English brewer. The English maltsters were shown how to work the plant according to German methods, and the results were so unsatisfactory that the pneumatic system soon got a bad name, which has not yet been wholly removed. Looking at the matter broadly, it is evident that, with a few exceptions, only very limited and half-hearted trials of the system have been made in England, and that the pneumatic system needs to be adapted to the requirements of the English brewer. There is evidence that this is now being done, and in some cases very satisfactory material is being turned out. When the method of working is brought to perfection in this country, it is highly probable that the present system of floor-malting will gradually fall into desuetude.

The credit for first introducing radical alteration in the system of malting is probably due to Galland, who, in 1874, designed a process to minimise the amount of labour which is usually expended, whilst the germinating barley is on the floor of the malt-house. The barley after steeping was placed in a thick layer on a floor, that consisted of perforated iron plates, through which moist cool air was forced to circulate. It was, however, found, that the rootlets of the germinating grain partially clogged up the perforation of the plates, and bound the barley into a mass so compact, that the air was with great difficulty forced through. This objection was overcome by Saladin, who devised an arrangement for turning the barley every few hours. Galland then improved this process, and substituted slowly revolving drums in place of the perforated floors for germinating the barley. By the continuous turning of the drums, the germinating barley is maintained in a loose bulky condition, and the rootlets consequently have no opportunity of matting together.

The following diagrams, for the use of which I am indebted to Messrs. R. J. Hanbury and Co., show the principle upon which the pneumatic system is worked. The air, which has to be saturated with moisture before it reaches the drum, is forced through a tower partially filled with coke kept moist by a spray of water, which may be cold or warm, according to the season. It then passes into a number of passages on the inner surface of the drum. The second illustration (Fig. 9) shows a section of a drum, the arrows indicate the course followed by the incoming air. The fan is used for drawing in the air through the moistening tower and drums. The

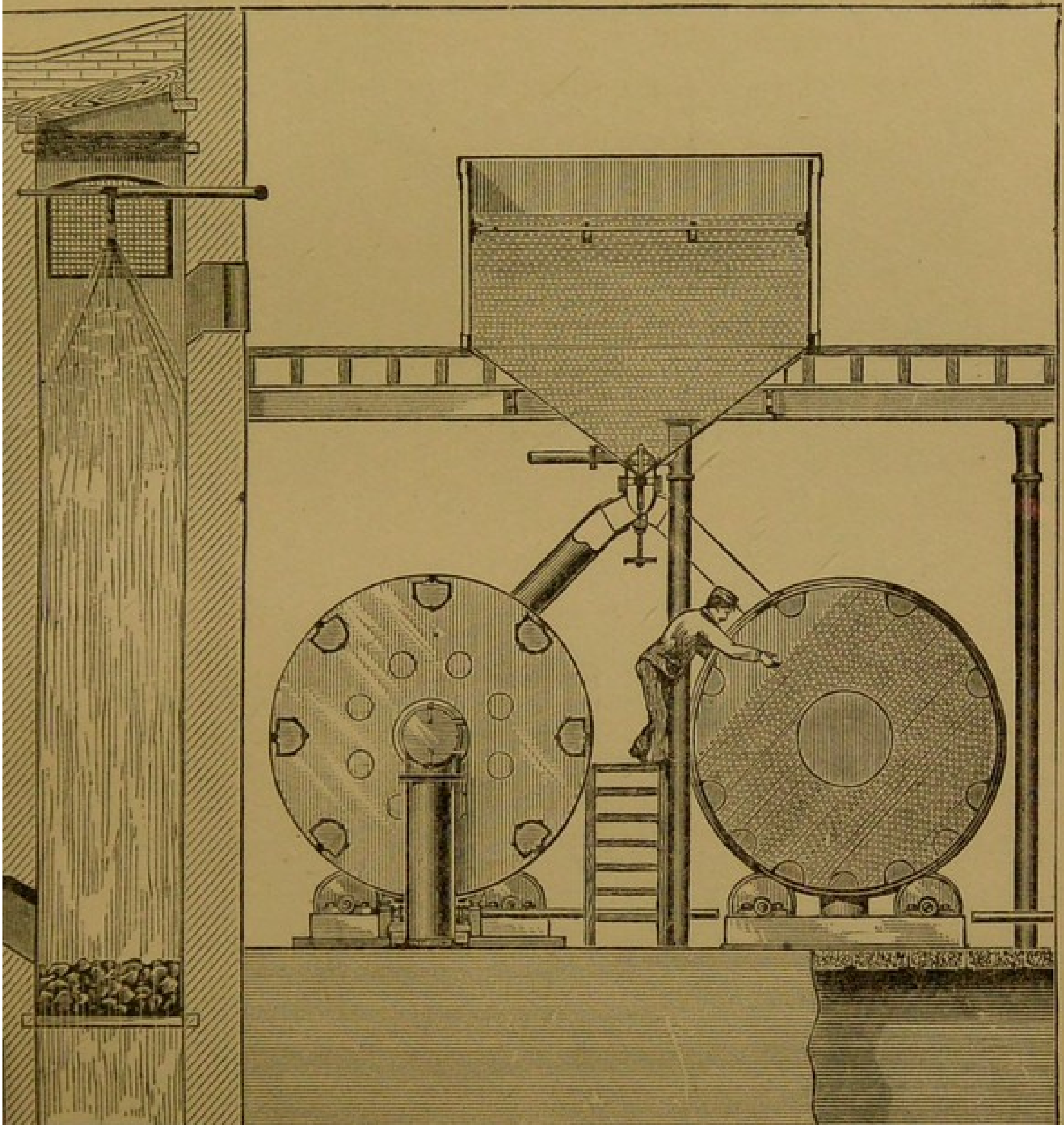

FIG. 8

SECTION OF A PNEUMATIC MALTING

D

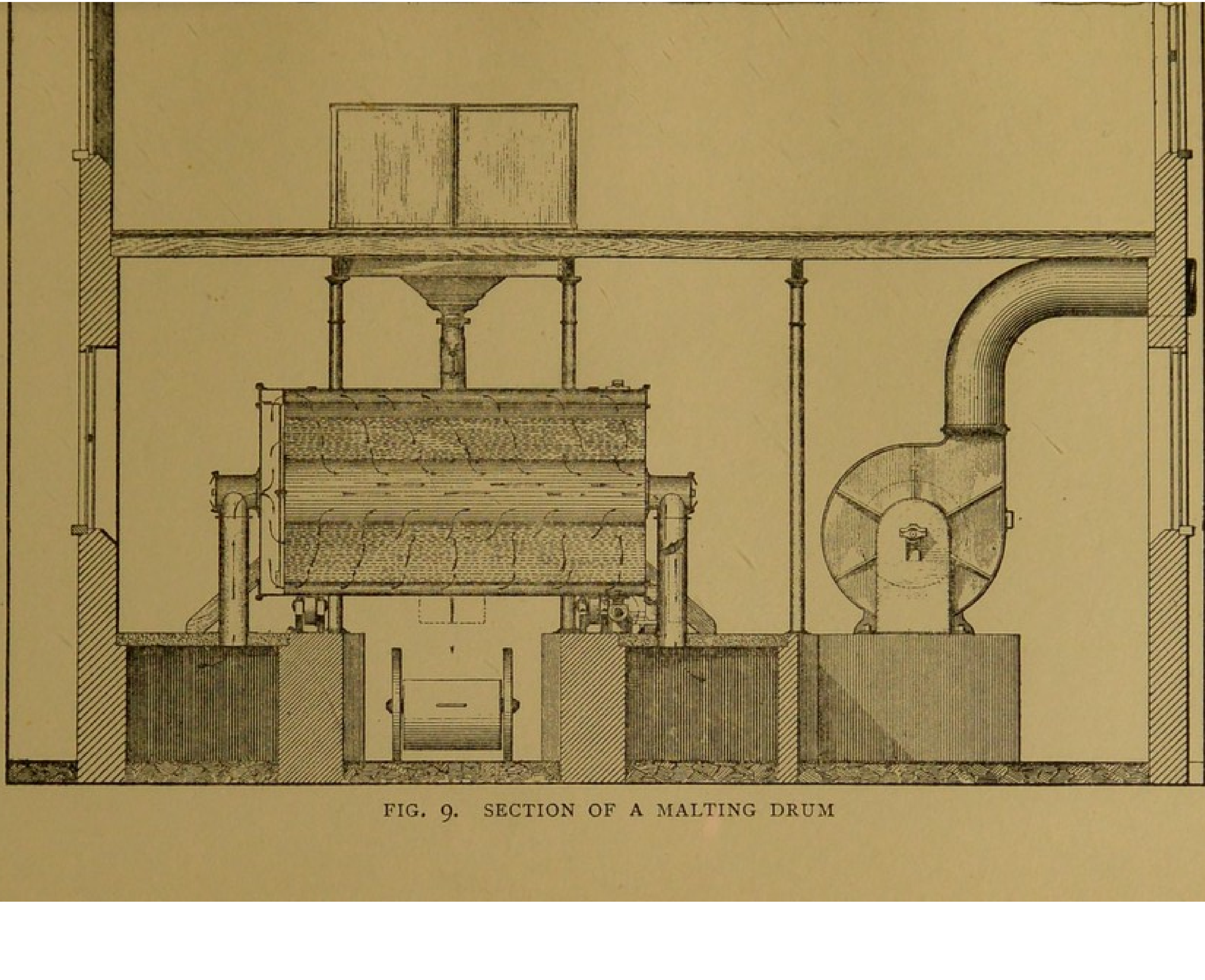

FIG. 9. SECTION OF A MALTING DRUM

drum has an aperture closed by a cover, which serves for the introduction of the steeped grain from the steeping cistern above the drum, and for the removal of the green malt. The drums, which are usually of thirty-quarter capacity, rest upon rotatory wheels. A complete rotation of a drum takes from thirty to forty minutes. The drums are also fitted with a sprinkling device. The barley is steeped for the usual time, and is then introduced into the drum, which is occasionally rotated, and a limited supply of air is introduced. The number of rotations and the quantity of air depends upon the type of grain which is being malted. As germination proceeds, more air passes in. The contents of the drum are sprinkled, if necessary, at the rate of two to five gallons per quarter.

From the ninth to the eleventh day the temperature is allowed to rise to about 62° or 65° F., according to modification or mealiness of the grain, and the indication of withering. During withering the supply of moist air is shut off, and dry air passed through the drum.

Some maltsters, who carry out the germination of barley in drums, have found it advantageous to dry and cure on the ordinary malt kiln. But generally drums are used for the purpose. The drying and curing drums are similar in construction to those used for germination, with the exception that they are fitted with arrangements to allow of large volumes of heated air to pass through. During drying and curing the drum makes one or two revolutions hourly.

Few brewers make all their own malt. A considerable number make only a portion, others none at all. Naturally, the quantity made depends to a great extent upon the situation of the brewery; thus a London brewer would not malt so relatively large a quantity as his *confrère*, whose brewery is situated in a good barley district. Many of the larger breweries make a portion of their malt, and so save the maltster's profit; and, yet, on the other hand, they are able to avail themselves to some extent of the fluctuations in the market price of malt, and the advantages of skilful buying.

Large quantities of malt are made on commission. In this case the maltster buys and makes up the barley into malt, charging a certain sum per quarter (usually about 5*s.*) upon the barley steeped. This arrangement works well for the brewer, as he is in a position to give instructions as to the manner in which the malt is to be prepared. It also assures a fixed profit for the maltster.

The success of a malt-house depends in no small degree on the foreman in charge. He has to see that the deliveries of barley from the farmer are up to the standard of the sale sample, and he is answerable for all the men employed in his particular house. He is responsible for the different malting operations, and has to see that the floors are turned at the right time, that the temperature on the floor is not allowed to rise unduly, and that the sprinkling is properly done. Then, again, much depends upon his careful supervision of withering, loading, and treatment on the kiln. A good foreman is usually paid at the rate of £100 to £120 per annum, and the workmen from 20*s.* to 25*s.* per week.

Malt culms are used as cattle food, and form a by-product of no small value to the maltster. The price paid by the farmer or stock-keeper varies according to the quality of the culms, and the season of the year. Usually they are worth from £3 to £5 per ton, and fetch the highest price in winter.

From consideration of what has been written about the malting process, it will be apparent that 100 lbs. of barley will produce less than 100 lbs. of malt. This loss in dry weight is accounted for by certain soluble constituents being removed during steeping (1 to 2 per cent.), substances removed during germination (5 to 6 per cent.), and loss due to culms (3 to 4 per cent.).

It is, however, usual to speak of the malt increase, and for this reason: The loss in weight from screened barley to malt does not amount to so much as the difference between the weight of a bushel of barley and malt, a bushel of barley weighing 56 lbs., and of malt 42 lbs. This apparent increase varies according to the class of barley malted; the average is about 3 to 3½ per cent. With dry foreign barleys this increase is greater, being sometimes as much as 10 to 15 per cent. When, however, barley is harvested under bad conditions there is frequently no apparent increase at all.

Most malt is sold to the brewer by weight (336 lbs. per quarter), but, occasionally, contracts are based upon measure. The latter arrangement usually works out to the advantage of the maltster.

It is difficult to name a figure for the cost of malting, as it so much depends upon local considerations, such as rent, labour, fuel, etc., but probably most maltsters would write down from 3*s.* to 4*s.* per quarter in their malting account-books.

MALT SUBSTITUTES

Before giving an account of the substitutes which are used by the brewer, it may not be out of place to utter a protest against the many erroneous impressions, which are current among the public concerning the actual materials employed in brewing. It is commonly supposed that much of the beer is brewed almost entirely from malt substitutes, such as glucose, invert sugar, etc., and hop substitutes. Then, again, the idea prevails that most of the beer made nowadays is doctored up with chemicals for preservative purposes. The supporters of the so-called "pure beer" are, no doubt, responsible for many of the flagrant mis-statements which from time to time appear in the press. The dictum of the agricultural party, that beer should mean a beverage made from malted barley, hops, yeast, and water only, is certainly not supported by history. We know that, in times past, beer was made from cereals other than barley; thus wheat and oats have been used, and are used now. It is true that barley is the most convenient grain to malt; but beer brewed from malt in no sense has a monopoly of "purity."

Hop substitutes are practically unused in this country, although they have been employed to a limited extent in years of hop famine. The brewer is obliged to use hops in his own interests, as they contain various constituents, which exert a chemical and physical influence on the substances present in the wort. Supposing hop substitutes were freely used, it would be interesting to know what is done with all the home-grown and imported hops.

The different chemical substances and antiseptics which are used by brewers are necessary accessories; but are obviously not materials from which beer is made. Without the use of such chemicals, it would be impossible to harden or soften water, or to keep the plant and mains of a brewery in a clean condition.

The proportion of substitutes to malt varies in different breweries; but the average appears to be 75 to 80 per cent. of malt, and 20 to 25 per cent. of substitutes. Without the use of substitutes, it may be safely said that the light, cheap family ales and mild beers, now so largely consumed throughout the country, could not be put upon the market.

But possibly the strongest refutation which can be offered to the supporters of "pure beer" is that the consumption of beer does not diminish to the extent it should were it the unhealthy and nauseous beverage that it is so frequently stated to be.

It is interesting to note the practice of other countries regarding substitutes. In Bavaria the use of all substitutes is absolutely prohibited. In the rest of the German Empire brewers are practically unrestricted. The same applies to Austria, Holland, and the United States.

The general use of malt substitutes was a sequence of the repeal of the Malt Act of 1880, although, before that date, the addition of sugar to beer had been sanctioned by Parliament. The expression "malt substitutes," or malt adjuncts, is understood to include:—

Firstly. Corn, and such materials, as unmalted barley, rice, and maize rolled or otherwise adapted by various mechanical and chemical processes for brewing.

Secondly. Cane sugar, invert sugar, and glucose. Strictly speaking, the term "malt adjuncts" should be confined to unmalted cereals, and "substitutes" to cane sugar, invert sugar, and glucose.

Much has been said and written against the use of malt adjuncts and substitutes, especially by the agricultural party in this country; for it was felt, that the large quantities of unmalted material could not fail to be prejudicial to the barley grower. As an outcome of combined protest, a parliamentary committee, known as the "Beer Materials Committee," was formed in 1892, with the object of thoroughly investigating the use of malt adjuncts for brewing purposes.

The Committee reported that they were unable to ascertain that the ordinary materials in the quantities in which they were actually employed in the manufacture of beer were deleterious. The exceptions, if any, were so unimportant that in their case legislation was not required.

The objections urged against malt adjuncts were stated as follows:—

1. That these adjuncts, or some of them, are, or may be, injurious to health.

2. That, even if they are not positively injurious, the beer made with any proportion of them is less nutritious and wholesome than all malt beer.

3. That, apart from the question of wholesomeness, the consumer is entitled to know what he is getting; that the product of malt and substitutes is not of the same nature, substance, and quality, as the product of malt only; that beer means, or ought to mean, a liquor prepared from malt and hops alone; and that, therefore, on the principle laid down by the Sale of Foods and Drugs Act, the consumer is prejudiced, if beer partly prepared from adjuncts or substitutes is sold to him, as beer, without a declaration of the use of adjuncts or substitutes.

On the first point the Committee concluded that no serious charge had been made against raw grain, or prepared grains other than barley, or brewing sugar made from cane sugar. With regard to glucose, there was some conflicting evidence, more especially with regard to glucose made from potato starch. This has no great importance with regard to beer, for potato glucose is not used in brewing in this country; and, whilst it is more expensive than maize glucose, it has disadvantages from a brewer's point of view. In recent years great improvements have been made in the manufacture of glucose from sago, maize, etc., and all impurities, which might be considered injurious to health, are eliminated.

With regard to the wholesomeness and food value of malt and its adjuncts, the Committee reported that in the present state of knowledge, chemical analysis is by itself an imperfect test of the dietetic value of any article of food. Common sense and experience do not yield any certain and accurate results. It was pointed out that the amount of extract consisting of nitrogenous and non-nitrogenous organic substance found by analysis of beer, and representing approximately the nutritive matter, depends as much upon the method of malting, mashing, and fermenting, as upon the materials used, within the limits which obtain with the proportion of the different materials generally used. The amount of organic extract in beer is, as a rule, small, and it is doubtful whether the food value varies at all directly with the amount of extract that it contains. It is also possible, that a beer with a low proportion of organic extract may be more acceptable as a beverage, than one containing more extract but inferior in flavour, brightness, soundness, and digestive properties.

The third point, as to whether beer is supposed to mean a liquor prepared from malt and hops only, was the most important issue before the Committee. In this connection, it is interesting to quote the words of Mr. Gladstone in relation to the repeal of the Malt Act and the introduction of the free mash tun. He said, "The brewer will brew from what he pleases, and will have a perfect choice of his material and of his methods. I am of opinion that it is of enormous advantage to the community to liberate an industry so large as this with regard to the choice of those materials." The Committee refused to admit the view that the liquor made from malt, hops, yeast, and water only has an exclusive right to the name of beer, or that the purchaser who demands beer of necessity demands an all-malt product. Sugar was intermittently permitted to be used in beer a hundred years ago; for over fifty years its use has been continuously permitted by Acts of Parliament; and, in 1880, complete freedom in the use of all wholesome materials was deliberately granted to brewers by Parliament. The Committee was unable to settle the relative merits of different brewing materials, but stated that "the balance of experience and authority inclines to the view that, while an all-malt brewing from a blend of malt made from the best English and foreign barley is still the most suitable for some descriptions of beer, yet, for other descriptions, which constitute by far the greater proportion of beer consumed, the medium or lower qualities of British barley malt are improved, as brewing materials, by the addition of a moderate proportion of good brewing sugar; and this is especially the case, when the barley from which the malt is made has been imperfectly ripened, or has been harvested under unfavourable conditions.

The practical outcome of the labours of this Committee was the endorsement of Mr. Gladstone's statement mentioned above, and the rejection of the opinion held by so many, that a pure beer is of necessity an all-malt beer. The majority reported in favour of the existing laws, and saw no reason for prohibiting the use of, or for enforcing the declaration of, substitutes.

There is another very important point, that should not be lost sight of. Beer has never been a beverage of approximately constant composition, and from early historical times it has been prepared from different materials, according to expediency. The public taste leads the brewer, and not *vice versâ*, as is so often stated. The greater number of beer-drinkers in England demand a bright and soft round-tasting beer, devoid of the characteristic flavour produced by age; and, to meet this requirement, the brewer has to manufacture a beer which is drinkable and bright, very soon after the fermentation is finished. Such a beer can be made only by the use of substitutes, in conjunction with malt. With pale, bitter, and stock ales the case is somewhat different, the consumer requiring a delicate flavour, which is only obtained by keeping the beer in the cellar for some months. Local considerations are also of interest. Dublin and London have long been famed for their respective black beers. The difference in flavour between the running stouts of the two cities is very marked, and it is a well-known fact that a Dublin porter would not sell in London nor a London porter in Dublin.

MANUFACTURE OF SUBSTITUTES

These may be divided into two classes; firstly, those materials from which the extract has to be obtained by the mashing process in the brewery; and, secondly, those substances soluble in water, in which the extract is already formed. These latter are usually known as brewing sugars.

Class I.—Many cereals other than barley are used for brewing purposes. The object to be attained is to reduce the starch to such a condition, that it can be dissolved by the diastase of the malt during the mashing process. These products are generally known as "flakes."

"Flakes" are often spoken of in the brewery as "flaked malts." The latter expression is not strictly correct, as the word malt implies a germinated grain. Although in the manufacture of flakes the starch of the grain is so altered in its physical character, that it is capable of being dissolved by diastase, yet it has not undergone the modifying process, which is characteristic of the germination of a living seed. Maize and rice are converted into flakes in the following manner:—The grain after being freed from foreign matters is passed through a machine, where the hulls and germs are removed. The starch portion of the kernel is then broken up into small pieces, termed "grits," by a suitable machine, and the resulting granular material is submitted to the action of steam. The steaming thoroughly softens, and partially dissolves, the gummy substances, which bind the starch cells together. When sufficiently steamed, the mass is passed between warm rollers, which flatten out and dry the "grits," the product being in the form of thin, dry flakes. The flakes are generally finished by drying in a revolving drum, heated with hot air.

Some brewers employ "grits," and gelatinise the starch which they contain, under pressure in a vessel known as a "converter." The thick starch paste is then mashed, either by adding to it a certain amount of malt, or the contents of the converter are added to the mash tun.

The following figures show the composition of flaked maize and rice :—

	Flaked Maize.	Flaked Rice.
Starch	79·70 per cent.	81·36 per cent.
Albuminoids	11·38 " "	7·21 " "
Oil	1·12 " "	0·83 " "
Water	7·28 " "	8·13 " "
Cellulose	0·04 " "	1·64 " "
Ash	0·48 " "	0·83 " "

Certain cereals, such as wheat, rice, oats, are sometimes put through the malting process, and are used in conjunction with barley malt. Malted rice is used to some extent in India, and malted oats are employed in the preparation of the so-called "Oatmeal-stouts."

BREWING SUGARS

Class II.—The necessity of treating cereals, before they could be available as a source of extract in the brewery, led to the wide use of materials, that require no preliminary treatment, which moreover are not acted upon or modified during the mashing process. These articles are the different brewing sugars. They comprise glucose, invert sugar, and cane sugar.

Glucose, or saccharum, as it is sometimes called, is prepared by submitting starch derived from maize, rice, potato, or other source, to the action of acid at a high temperature. The processes involved in its manufacture may be arranged in the following order: (1) The conversion; (2) the neutralisation; (3) the filtration; (4) the decolorisation; (5) the concentration; (6) the purification.

(1) The conversion. In this country the materials usually employed in the manufacture of glucose or saccharum are sago, maize, and rice starch. In Germany, potato starch is employed, and in America, green maize. The vessel, in which the conversion is carried out, is termed a converter. It consists of a closed lead-lined iron vessel, provided with stirring gear, manhole, discharging mains, etc. Generally sulphuric acid is used as the converting agent, although other acids may be used. One half of the quantity of acid is mixed with water, and the temperature of the mixture is so adjusted, that it is a little below the gelatinising point of the starch. The acid is then mixed with the starch. The remaining half of the mixture of acid and water is introduced into the converter, and rapidly heated to boiling-point; then the mixture of starch and acid is run in, at such a rate that the temperature does not fall far below boiling. The converter is closed, the stirring gear is set in motion, and the conversion carried to the desired limit. The time for the complete conversion of the starch into glucose varies according to the pressure and temperature in the converter.

(2 and 3) The neutralisation, and filtration. This is effected by mixing chalk with water, and adding it gradually to the solution of sugar. It is generally done

in a separate vessel. The neutralised liquid is kept stirred for some time, and is then allowed to settle and run through filter presses, to separate the calcium sulphate.

(4) Decolorisation. The clear, filtered solution is passed through towers packed with animal charcoal.

(5) The concentration is effected in vacuum pans, until a specific gravity of 1·50 (water = 1·0) is reached; it is then run into moulds, or casks, and allowed to solidify. The solidified mass is broken up into lumps, in which form it is generally seen on the market. The colour of commercial glucose varies from pure white to light brown, and depends upon the nature of the material used, and upon the extent to which the decolorisation has been carried. The product consists of glucose, varying proportions of dextrin, and water, with small quantities of other sugars.

The manufacture of invert sugar is carried out in a manner very similar to that of glucose. The cane sugar is dissolved in water, and is heated with acid in a converter. The acid is neutralised by chalk, and the filtration, purification by charcoal, and evaporation, are conducted in much the same way as described above. Invert sugar as used in breweries is a syrup pale yellow to dark brown in colour, and consists of invert sugar, water, small quantities of unaltered cane sugar, and mineral matter. Some breweries effect economy by preparing their own invert sugar, either by the acid process, or by heating the solution of cane sugar with yeast at a temperature of

140° F. for three or four hours. The inverting agent in this case is an active principle, or enzyme, known as invertase, contained in the yeast cell. For some kinds of beer, more especially for running porters, raw cane sugar is used; but it is generally advisable to employ invert sugar, as cane sugar is unfermentable, so that in addition to fermenting the other constituents of the wort, the yeast has to invert the added cane sugar. Throwing this extra work upon the yeast tends to weaken it. For this reason, the use of untreated cane sugar is resorted to only in the preparation of certain beers. None but the better-class raw cane sugars are employed.

CHAPTER III

HOPS

ONE of the essential conditions of a beer is that it should possess a pleasant bitter flavour to counteract the sweetish taste of malt wort. To acquire this, and to ensure its keeping qualities, the wort is boiled with hops before fermentation takes place.

Little is known of the history of the hop or when it was first cultivated. Long before it was used for brewing, it was famous as a medicinal remedy. Pliny, in his *Natural History*, refers to the hop plant as a salad, and hop gardens are mentioned in French records as far back as the eighth century. In the fourteenth century hopped beer was common on the Continent. Hop culture is supposed to have been introduced into England from Brunswick and Flanders towards the end of the fifteenth century. As mentioned in a previous chapter, considerable opposition was offered to the use of hops in beer, and enactments were passed prohibiting their use. In 1600 hops were grown in considerable quantity, those from Kent being even at that time famous.

FIG. 10

THE HOP (HUMULUS LUPULUS)

(*a*) Portion of a fruiting branch with ripe cones. (*a*) Ripe cone. (*b*) Male flowering branch. (*c*) Male flower. (*d*) Female flowering branch. (*e*) Female inflorescence. (*f*) Bract with two female flowers seen from within. (*g*) Fruit scale (bract) and fruit with lupuline glands. (*h*) Fruit.

The common wild hop (*Humulus lupulus*), a widely distributed plant, and a member of the nettle family, is considered to be the stock from which the cultivated varieties are derived. The hop plant (Fig. 10) is dioecious, the male and female flowers being produced by different plants. The two plants are perennial, the latter only is of value in brewing.

The hop is propagated by cuttings taken in the spring from the stem which has remained in the ground. The hop grower is careful to take the cuttings from mature plants, varying in age from four to six years. Throughout their growth hops require the greatest care and attention. They are very susceptible to climatic conditions, and any district subject to marked contrasts of heat and cold is unsuited for their cultivation. Since the hop is a deep-rooted plant, it requires a rich soil, at least thirty inches in depth. The most favourable situation for a hop garden is a sheltered southern aspect. Hops bear a small crop the first year of very medium quality cones, the weight of the crop increases as the plants mature. The manuring of hops is now attracting much attention, and systematic investigations on this matter are being carried out by our agricultural chemists.

The hop is very liable to the ravages of black and white moulds. Black mould or smut is met with in June and July, when honeydew (vegetable or animal excretions) is prevalent, as a blackish brown covering on the upper side of the leaf which gradually dies and falls off. The mould increases with great rapidity in dry weather, but is destroyed by a good rainfall. White mould is far more serious for the hop plant, as, in addition to the leaves and stems, the cones are attacked and rendered valueless. The mould appears in dirty white patches, which increase rapidly during damp weather. The only cure which seems to be of any use is to dust the plants over with sulphur by means of a bellows or other suitable apparatus.

Hops are unevenly distributed throughout the country. The following table shows the acreage under hops in each county of England in which hops are grown. The statement was compiled by the Board of Agriculture from returns collected in June, 1903:—

Counties.	1901. Acres.	1902. Acres.	1903. Acres.
Kent — East	11,110	10,452	10,438
Kent — Mid	10,696	10,172	10,467
Kent — Weald	9,436	9,025	9,033
Total Kent	31,242	29,649	29,933
Gloucester	46	46	46
Hants	2,133	2,003	1,920
Hereford	7,497	6,915	6,851
Salop	144	125	133
Suffolk	4	4	3
Surrey	1,232	969	901
Sussex	4,800	4,541	4,454
Worcester	4,029	3,779	3,697
Total	51,127	48,031	47,938

FIG. 11

PORTION OF A HOP GARDEN, SHOWING THE WAY IN WHICH THE PLANTS ARE GROWN AND TRAINED

In 1885 there were 71,327 acres under cultivation; consequently between 1885 and 1903 the area under hops has decreased by 23,389 acres.

There are many varieties of hops on the market. The finest and highest-priced hops come from Kent and Farnham; Worcestershire, Sussex, and Herefordshire also produce excellent hops. Bavarian, Würtemburg, Bohemian, Belgian, and Californian hops are used as well in this country.

There is a great tendency for English hops to be prematurely picked, owing to the demand that they should be pale in colour. Maturity is thus sacrificed to appearance. Again, the number of kilns or oast-houses is generally out of all proportion to the acreage of the crop; and, as hops can only be harvested according to the rate at which they are dried, the grower is compelled to start picking before the hops are completely ripe. If time elapses between picking and drying, the hops deteriorate in colour.

The methods of drying hops are very rudimentary in this country. The hops are spread over the floor of the kiln (Fig. 12) to a depth of 12 to 18 inches. The fire is started, and the temperature gradually increased. When hand dry the hops are "hovered," or well moved about, in order to lighten the bottom layer. They are then levelled again by raking. The drying continues, and the hops are again turned. The temperature is raised to 140° or 150° F., and some sulphur thrown on to the fire. The sulphurous acid produced brightens the colour of the hops. After some hours the hops are placed on a floor to cool. When properly cured, the stalk of the hop-flower snaps easily; they contain from 10 to 14 per cent. of moisture. By placing the hops, which have 65 to 75 per cent. of moisture, in a warm kiln the petals open, and the frequent stirring and throwing about displaces a considerable quantity of valuable lupulin, which falls through the perforated floor of the kiln into the fire. To dry hops properly they should be moved about as little as possible. Owing to the low and fluctuating value of the hop crop, the grower finds considerable difficulty in providing any outlay for new kilns; this fact accounts, no doubt, to a great extent for the primitive methods of drying. Hop dryers, like many maltsters, appear to have a profound dislike to the thermometer. The temperatures in the kilns vary considerably, and many hops which reach the market fetch low prices on account of being overheated.

Improvements in some districts are, however, being made, and kilns may now be found provided with devices for preventing the undue moving about of the hops and for drying off at lower temperatures.

Hops used the same year that they are harvested are known as "new hops," the next year as "yearlings," the year after as "old," and after that as "old olds." Most brewers hold the opinion that new hops are improved for brewing purposes by storage for a short period. New hops are not often used alone, as they frequently impart a haze to the beer.

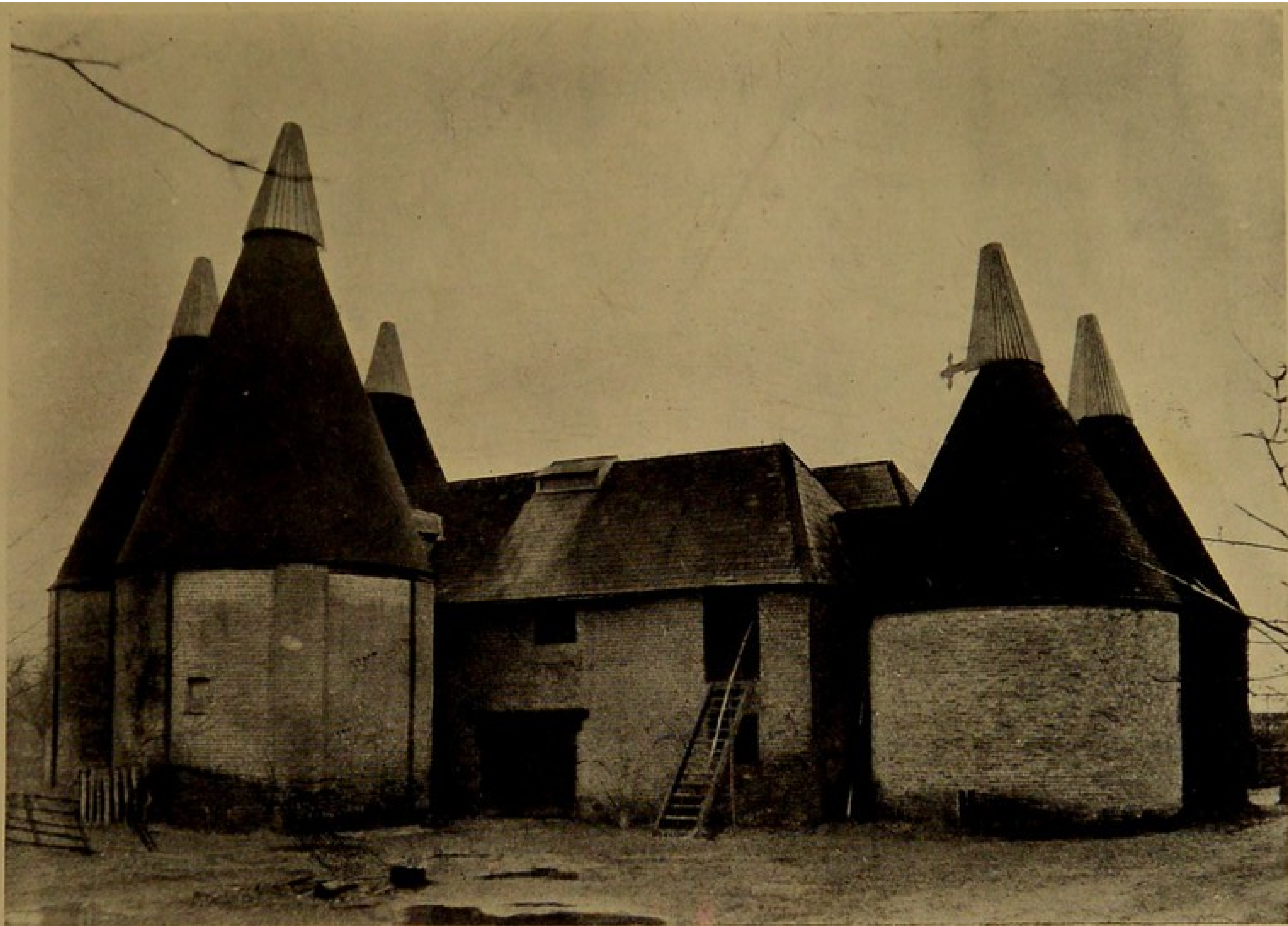

FIG. 12
OAST HOUSES (KILNS)

The hop cone consists of lupulin or hop-flour, which contains the resins, volatile oils, and bitter substances, so valuable to the brewer, and the leaves, stems, and seeds, in the following proportions:—

Lupulin (hop-flour) .	7·90 to 15·70	per cent.
Leaves . . .	69·70 ,, 78·30	,,
Stems . . .	8·50 ,, 17·50	,,
Ripe seeds . .	0·02 ,, 7·80	,,

The active constituents contained in the lupulin, consist of hop oil, to which hops owe their characteristic odour, and hop resin, which imparts the bitter taste to the beer. The latter is antiseptic in its nature, and adds to the stability of the beer. There are said to be three hop resins, two of which are soft, and one hard. The tannic acid of hops is found mostly in the leaves or bracts of the hops. It causes the precipitation of certain albuminoids in the boiling wort. The leaves also contain the enzyme diastase, which, as will be seen later, plays an important part when hops are added to the finished beer (Dry Hopping).

With regard to the valuation of hops, in this country they are bought and sold almost entirely on their physical appearance. The chemist has not yet been able to devise a satisfactory method for their analysis, so that the personal equation is the chief consideration in their valuation. Certain favourite brands of hops are bought by brewers, and high prices are paid for them, simply because they are well known; whereas other brands, less known, and possibly quite as good in quality, will fetch disproportionately low prices.

There is no doubt that, if hops could be valued on their true merits, as are malts and sugars, very considerable sums would be saved by the brewer.

In valuing hops, the expert looks for certain well-defined characteristics. The sample, when broken and rubbed between the hands, should contain a large amount of flour or lupulin, which has become separated from the bracts. In fresh hops the lupulin has a pale yellow colour ; with age this becomes darker.

The hops should have a strong and fragrant smell. Properly ripened hops have a greenish yellow colour, which varies with their origin. Light green hops are unripe, whilst a slightly red colouration is indicative of overripeness, or more likely of overdrying on the kiln. The leaves forming the cone should be packed tightly together ; open cones allow valuable lupulin to fall out. The hops ought to be free from twigs, foliage, and mould ; and when pressed, the sample should be elastic. Hops which are kept for several months soon begin to deteriorate, the colour deepens, and the essential oil to which hops owe their odour gradually disappears. It has been found that hops will retain their qualities practically unimpaired for considerable periods of time, if they are stored in the cold at a temperature of 38° to 40° F. So great is the advantage arising from cold storage of hops, that the custom is now very general ; some 200,000 pockets being stored annually in the United Kingdom.

To maintain stores at the low temperature of 38° to 40° F. refrigerating machinery is necessary. This expense cannot always be borne by the small brewers, and in some districts they combine and keep their hops at a central store. The brewers of Birmingham have formed a syndicate, and established cold storage for 11,000 pockets. Some of our larger breweries erect their own cold stores, others pay the hop factor for storage. We owe this valuable system of cold storage to Prior, and Messrs. Briant and Meacham.

It is surprising that a number of people still labour under the impression that brewers use hop substitutes, such as gentian, camomile, and quassia. These may have been employed during a hop famine, but they impart an extremely unpleasant bitter flavour to beer or other liquids, which is altogether different from that of the hop. Moritz and Morris, in their *Text-Book of the Science of Brewing*, pertinently point out that: "With hops at his command no brewer would think of using these vegetable bitters; competition would soon show him how dangerous a policy this would be. In charging brewers with their continual employment the 'beer-purists' show themselves ignorant of the facts of the case. In spite of specific and emphatic denial they, however, cling to the charge; it is repeated merely to attract the interest of that section of the agricultural class, which seeks to relieve the depression due to faulty technical attainments by means of ill-considered legislative protection."

The following table affords sufficient evidence of the extent to which hops are used by brewers in this country:—

Year ended Dec. 31.	Acreage.	Estimated produce.	Yield per acre.	Average price English hops. Season, Sept. to March.	Imports of foreign hops.	Exports of British hops.
		Cwts.	Cwts.	Per cwt. £ s. d.	Cwts.	Cwts.
1880	66,698	440,000	6·59	4 6 0	195,987	7,213
1885	71,327	509,170	7·14	4 1 0	266,952	7,094
1890	53,961	283,629	5·26	10 9 4	188,028	6,164
1895	58,940	553,396	9·39	3 2 8	217,161	10,145
1896	54,217	453,188	8·36	3 6 4	207,041	10,505
1897	50,863	411,086	8·08	4 13 0	164,154	10,779
1898	49,735	356,598	7·17	7 7 8	244,136	12,955
1899	51,843	661,426	12·76	3 7 0	180,233	11,310
1900	51,308	347,894	6·78	5 18 8	198,494	15,000
1901	51,127	649,387	12·70	2 18 0	116,042	17,796
1902	48,031	311,041	6·48	—	—	—

In 1902 the Commissioners of Inland Revenue reported that 72,515,279 lbs. of hops and 19,422 lbs. of hop substitutes were used.

One circumstance requires explanation. The amount of hops used has not increased in proportion to the output of beer. Thus in 1880 there were about 30½ million barrels of beer brewed, in 1900, 37 millions. In 1880 about 636,000 cwt. of hops were used, in 1900, 546,000 cwt. These figures are accounted for by the change of the public taste from heavily hopped beers to beers of a lighter and fresher character. Moreover, beers are not required to keep for so long a time as formerly; consequently there is no longer the necessity to use large quantities of hops as a preservative.

CHAPTER IV

WATER[1]

WATER being one of the essential materials used in brewing, it is necessary that every brewery and malting should have an abundant and constant supply. In fixing upon the site of a brewery, it is a matter of great importance that the water used for brewing should be of a kind to produce the article that is required. Soft waters are preferable to hard ones for stouts and black beers. For mild running beers, comparatively soft waters containing chlorides and small amounts of sulphates are better than very hard waters. For pale and stock ales, hard waters containing sulphates and alkaline earths are to be preferred.

The amount of water required to produce one barrel of beer has to be carefully considered by the brewer. After allowing for evaporation and the various losses, it may be taken that $1\frac{1}{2}$ barrels of water is necessary for every barrel of beer brewed. For cleaning, refrigerating, and other purposes, an additional 12 barrels may be used.

The sources of brewing-water in this country are wells and springs, but lake or river water is often

[1] In breweries water is always spoken of as liquor.

employed, the latter more particularly in London, where many of the wells do not yield the quantity of water which they formerly did.

The requirements of waters suitable for brewing are quite different to those for potable purposes. In brewing-waters the dissolved saline constituents are of the utmost importance, different beers requiring salts of different kinds, and in varying proportions. In this connection, it is interesting to bear in mind, that the water of Burton-on-Trent is peculiarly suited to the production of light ales of a particular character, whilst the water of Dublin and London is famed for black beers. When these waters were submitted to analysis, it was found that, whilst Burton water contained large quantities of gypsum or sulphate of lime, this salt was present only in a small quantity in Dublin and London water. Again sodium chloride (common salt) is the predominant saline constituent of waters producing the best mild ales.

Waters can now be so modified in character by the addition of certain salts, that they may be used for the production of a class of ale which was formerly not possible. Thus London waters are noted for the production of black beers, and for their unsuitability for pale ales; so much so, that years ago London firms obtained their pale ales from Burton, or had a branch brewery there for brewing them. Now, however, by the suitable saline treatment of waters, it is possible to brew pale ales in London, which may compete with those from Burton.

The following analyses (from Dr. Sykes—*The Principles and Practice of Brewing*) may be regarded as representing typical waters adapted for producing certain beers :—

BURTON DEEP WELL.

PALE-ALE LIQUOR.

Sodium chloride	3·90	grains per gallon.
Potassium sulphate	1·59	,, ,,
Sodium nitrate	1·97	,, ,,
Sodium sulphate	10·21	,, ,,
Calcium sulphate	77·87	,, ,,
Calcium carbonate	7·62	,, ,,
Magnesium carbonate	21·31	,, ,,
Silica and alumina	0·98	,, ,,

DUBLIN WELL.

BLACK-BEER LIQUOR.

Sodium chloride	1·83	grains per gallon.
Calcium sulphate	4·45	,, ,,
Calcium carbonate	14·21	,, ,,
Magnesium carbonate	0·90	,, ,,
Iron oxide and alumina	0·24	,, ,,
Silica	0·26	,, ,,

MILD-ALE LIQUOR.

Sodium chloride	35·14	grains per gallon.
Calcium chloride	3·88	,, ,,
Calcium sulphate	6·23	,, ,,
Calcium carbonate	16·37	,, ,,
Magnesium carbonate	4·01	,, ,,
Iron oxide and alumina	0·24	,, ,,
Silica	0·22	,, ,,

The three classes of brewing liquor mentioned above differ markedly in composition. In the Burton deep well the amount of calcium sulphate is very high. The carbonates would be thrown out of solution on boiling. In the Dublin-well liquor there is little calcium sulphate, the chief constituent being calcium carbonate, which would be precipitated on boiling. The mild-ale liquor contains a relatively large amount of chlorides and carbonates, but very little sulphates.

Some waters, owing to the large quantities of mineral substances dissolved in them, are entirely unsuited for brewing. Thus waters are occasionally met with containing a hundred grains or more of calcium sulphate per gallon, others may be highly contaminated with common salt. In such cases the only thing to be done is to add a purer water until the mineral constituents are sufficiently diluted.

For malting purposes a fairly pure and moderately hard water is necessary. Very soft water is not desirable, as it extracts too much nitrogenous and mineral matter from the barley. It is also important that the temperature of the supply should be fairly uniform for the time of the year, for sudden variations produces irregular steepings, and delays or accelerates germination.

The water for washing tanks, vats, tuns, etc., should be pure and free from decomposing matter. For boiler purposes, pure water free from an excess of dissolved salts is essential. In many parts of the country, water for boiler feeding is so treated, that the injurious constituents are rendered indifferent. The chemicals, which are added before or after the water enters the boiler, depend upon the saline constituents present. Thus, if caustic soda is added, the bicarbonates of lime and magnesia are precipitated, whilst sodium carbonate will throw down sulphate of lime. The precipitated salts are eliminated in the form of a mud, when the boiler is cool.

ARTIFICIAL TREATMENT OF WATER FOR BREWING PURPOSES

The character of some waters can be materially modified by the addition of salts, with other waters this is impossible. Thus, a water of the Dublin type could be made suitable for brewing mild ale by adding thirty-five to forty grains per gallon of sodium chloride, or for pale ales by adding fifty grains of calcium sulphate, five or six grains of magnesium sulphate, and eight to ten grains of calcium chloride per gallon. But a water similar to that from the Burton deep well would be very difficult to convert into one suitable for the production of black beers. The large amount of calcium sulphate would have to be removed; and, although this could be done by boiling with an alkali such as sodium or potassium carbonate, yet the quantity of sodium and potassium sulphate remaining in the liquor (from the interaction between calcium sulphate and sodium or potassium carbonate) would render it quite unfitted for brewing.

Calcium sulphate (gypsum), magnesium sulphate, calcium chloride, sodium chloride, and kainite—a natural mixture of salts consisting of potassium sulphate, magnesium sulphate, and magnesium chloride, which is found at Stassfurt, in Germany, are the principal salts which are used for treating brewing waters. Waters which are to be enriched with calcium sulphate are sometimes run through tanks packed with blocks of gypsum. This procedure does not always give satisfactory results, for varying amounts of gypsum may be dissolved, according to the temperature of the water and the rate of flow. The usual practice is to mix the finely powdered gypsum and other salts with a little water, and then add the mixture to the boiling liquor in the hot-liquor back.

CHAPTER V

THE PREPARATION OF BEER WORT

IN giving the following brief account of the arrangement and construction of a brewery, I would ask the reader to remember that the older breweries have grown in proportion to their increased output of beer; and, as many of them are built on valuable sites, and others have not been able to acquire land for extension of premises, necessity has often compelled an arrangement of vessels and plant, which is open to considerable criticism. This particularly applies to London breweries. Portions are added from time to time, and the result is complicated and bewildering in the extreme, from the point of view of economy of power and labour.

No two breweries are constructed alike; but the essential point is to arrange vessels in such a manner, that the beer in its different stages of manufacture should pass from one vessel to another by gravitation, and to avoid, as far as is practicable, the use of pumping machinery, which, of course, means expense.

The accompanying block (Fig. 13) will convey an idea of the arrangement of a brewery worked on the gravitation system. This system can only be used in small breweries, otherwise the height of the building would be excessive. In large breweries the heavy weights and machinery are placed on the ground and first floor, and the wort is pumped from the hop back to the cooler.

On the top of the building is situated the cold-liquor tank or back A and on the floor below it the hot-liquor back B. These vessels contain the liquor which is to be used for brewing. The necessary quantity of cold liquor passes from the back A to the back B, where it is raised to the desired temperature. C is the upper part of the grist-case, and by it is the elevator or other device which conveys the malt to it. The floor below contains the rest of the grist-case and the mash tun D. Beneath is the under back E, or receptacle for the wort after it leaves the mash tun, the copper F, where the wort is boiled with the hops, and the hop back G, provided with a false bottom, into which is turned the contents of the copper. The hopped wort has to be cooled after boiling, and this is partly effected by allowing it to flow on the cooler H. It is finally cooled to the temperature at which it is decided to start fermentation by passing it over a refrigerator, and thence to the fermenting rounds or tuns which are seen in the fermenting-room R. Situated on the same floor as the cooler is the malt-case J, and below it the malt-mill L, where the malt is ground. The ground malt, or grist, as it is termed in] brewing parlance, is conveyed by an elevator to the grist-case C in the top part of

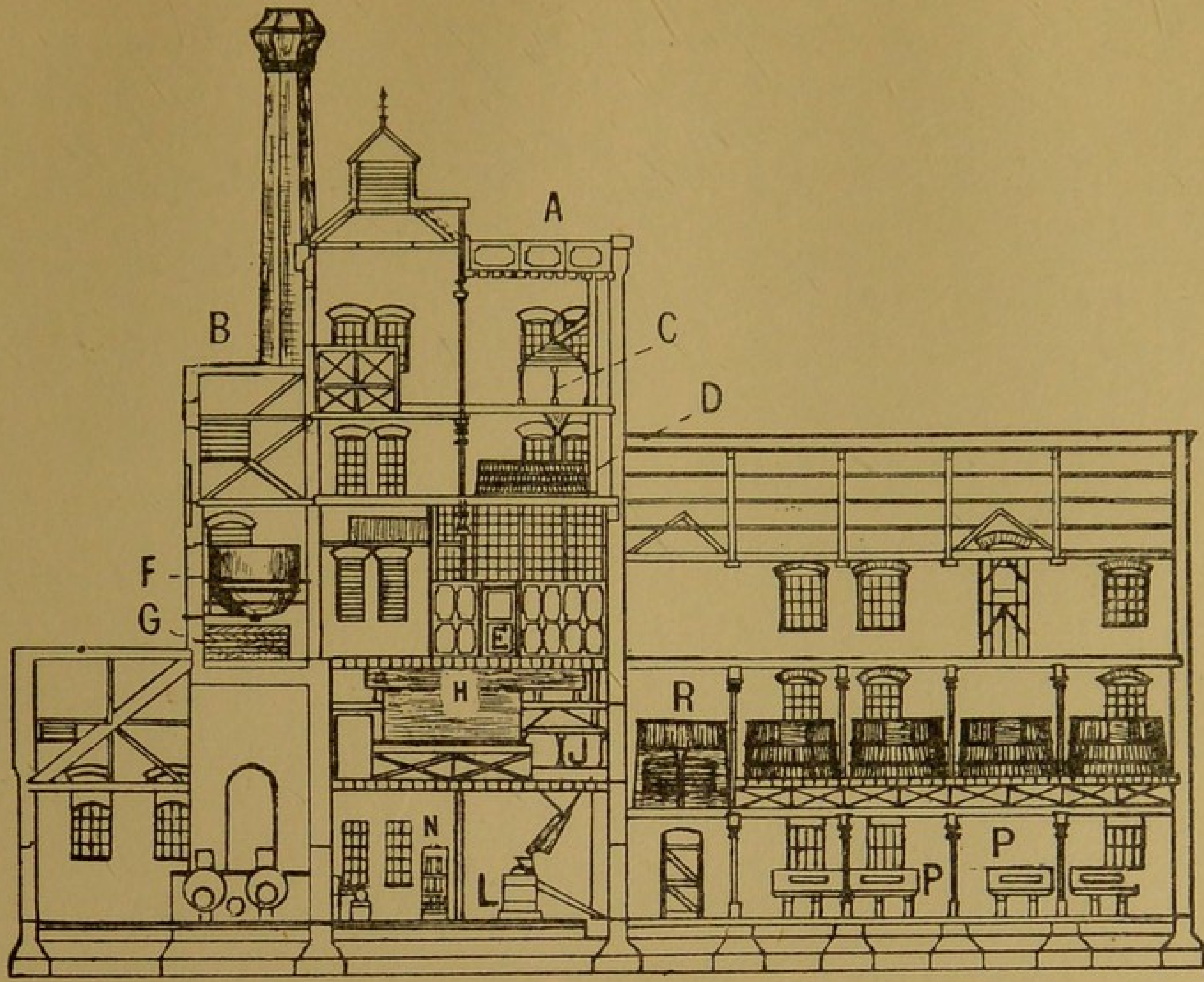

FIG. 13. SECTION OF A GRAVITATION BREWERY

the main building. The steam boilers O supply steam for heating the hot-liquor back, the copper when direct heat is not used, and driving the necessary machinery, The pumps N raise the water from the well and lift it to the back A. The top floor above the fermenting-room is used for storing malt and hops. On the ground of this part of the building the racking tanks and machines P,P, for filling the casks with beer, are placed.

The necessary quantity of malt is placed in the malt hopper, the top of which resembles an open rectangular iron or wooden box, whilst the base tapers to a cone. The object of the malt hopper is to feed the malt-mill. The extreme end of the hopper is generally supplied with an arrangement for measuring the quantity of material which passes to the mill, and with an iron roller, which rotates while the mill is in motion and supplies an even feed. As a mixture of malt dust and air is explosive when brought into contact with a naked flame, and as malt dust about a brewery is a source of contamination and dirt, many breweries use devices to collect the dust which is liberated whilst the malt is ground. They usually consist of revolving cylinders, into which the dust is drawn by suction.

MALT-MILLS

The object of the mill is to crush each malt corn, so that its contents may be readily extracted in the mash tun. The different types of malt-mills vary considerably in details; they generally consist of two smooth rollers, one driven and the other following by friction. The latter can be adjusted, so that the space between the rollers may be regulated according to the nature of the malt which is being ground. Much attention has been given to the construction of malt-mills, and very perfect machines are now obtainable. Frequently the mills work in pairs, the large corns passing through one set of rollers, and the small corns through another set. To grade the corns, the malt is passed through screens provided with apertures of different sizes. Through the smallest of these the dirt and dust pass, in the next size the holes are large enough for the small malt to go through, the large malt being left. The graded malt is mechanically collected, the small malt passing through one series of rollers, and the large through the other. Malt-mills should not be driven at too great a speed, or their action will be a grinding instead of a crushing one. They are carefully boarded in to prevent any loss of flour, and are also provided with contrivances for severing the connection between the mill and receptacle, in the event of the malt dust and air igniting and forming an explosive mixture.

When the arrangement of a brewery necessitates the malt-mill being situated below the grist-case, an elevator is required to raise the grist. This usually consists of a steel band running between pulleys and carrying light steel buckets; these take up the grist and, in turning over the top pulley, empty themselves into a shoot, which leads to the grist-case. Elevators are also used for conveying malt to the mill, if the malt stores are on the ground floor. Flakes (maize or rice) are added to the ground malt by means of a distributor to ensure an even admixture.

Considerable judgment is required in adjusting the malt-mills. If the grist should be too fine, difficulties will arise during the drainage in the mash tun. On the other hand, if the grist is too coarse, loss of extract will result. The aim of the brewer is to obtain a uniform grist.

The grist-case (see B, p. 79), may be made of wood or metal, and is similar in shape to the malt hopper, the upper part being rectangular, and the lower part an inverted cone. The position of the grist-case varies according to the way in which the mashing operation is conducted. If a mashing machine is used, the apex of the case is usually, although not invariably, situated at a short distance from the tun; if the grist is mashed in the tun, the apex of the case is situated a little above the mash tun. A slide is fixed at the tapering end of the grist-case, so that the grist may pass directly into the mash tun or into the mashing machine. In the diagram shown on p. 79 the ground malt is conveyed to the grist-case by the screw (A).

LIQUOR TANKS

These vessels contain the water which is to be used for mashing and sparging. They are situated at the top of a brewery, and the water from the well or other source of supply is pumped up into them. The back is connected by a main with vessels, usually called boiling or heating backs, commanding the mash tuns, where the water is heated by means of steam coils. If the liquor is to be "Burtonised," or treated with salts, these are usually added to the boiling back whilst the contents are boiling. The whole of the liquor used for the brew should be similarly treated. It is usual to boil the liquor the day before it is to be used, and then to heat it to the proper temperature just before starting mashing.

MASHING

There is probably no exaggeration in the statement that the mashing is the most important of brewing processes. Until our knowledge of chemistry threw some light upon the changes that take place in the mash tun, mashing was regarded as a more or less mechanical process of mixing malt grist and water. Fortunately this rule-of-thumb condition of affairs no longer exists, and brewers now understand that, by the skilful manipulation of the mash tun operations, they can ensure uniformity in the different beers which they manufacture.

In addition to English malt, brewers use some kind of malt made from foreign barley; for experience has shown, that beers brewed from a grist containing a proportion of foreign malt drain more easily in the mash tun, come into condition more quickly, and clarify more readily, than if the beer were brewed solely from English malt. Malts made from foreign barleys contain relatively smaller amounts of soluble albuminoids, and their lightness and large amount of husk help to make a buoyant mash, which drains easily. The barleys from which these malts are derived are grown and harvested under ideal conditions, and this, doubtless, accounts in a measure for the light, dry, and delicate flavour which such malts impart to beer.

Brewers fully recognise that two malts mashed separately under identical conditions will produce beers of very different character. Since it is most important that the beer of a brewery should be constant in flavour, the brewer tries to maintain a standard by using a mixed grist comprised of two or more malts. Thus if a brewer should be brewing a pale ale from a grist consisting of a mixture of a Pale English, Hungarian, and Californian malts, the chances of this mixed grist producing a wort of fairly uniform flavour and composition would be greater, than if one of the three malts were used. Again, if one of the malts showed some defect, the result would not be so unsatisfactory as if it were used alone. The proportions in which different malts are mixed calls for great judgment and care on the part of the brewer. Pale malt forms the principal constituent of most grists, London stout being excepted, the colour of the beer being adjusted by adding certain proportions of amber, brown, and black malts, or caramels.

Stock and export beers are mashed at a higher temperature than beers brewed for rapid consumption. The following table shows the approximate composition of the grist used in some typical beers and also the mashing heats :—

Beer.	Mashing temperature.	Grist.	
Pale or stock ale	151° to 153° F.	English pale malt	60%
		Foreign malt (Smyrna or Californian)	25%
		Flaked maize	5%
		Invert sugar	10%
Mild ale	145° to 148° F.	Pale English malt	35%
		Amber malt	15%
		Foreign malt (Smyrna or Californian)	30%
		Flaked maize	5%
		Invert sugar	15%
London stout	148° to 150° F.	Pale English malt	25%
		Amber malt	50%
		Roasted malt	2%
		Foreign malt	17%
		Invert sugar	6%

For London porter a somewhat similar grist would be used. A portion of the roasted malt would be replaced by caramel, and raw cane sugar might be used in place of some of the malt. London porter is usually brewed with from 15 to 20 per cent. of substitutes.

Beer.	Mashing temperature.	Grist.	
Irish stout	148° to 150° F.	Pale English malt	40%
		Amber malt	20%
		Foreign malt (Smyrna or Californian)	22%
		Maize	10%
		Roasted malt or barley	8%

The composition of these grists is, of course, only approximate, and varies according to the discretion of the brewer. There are, however, certain well-defined differences. In the superior beers a smaller percentage of malt substitutes are used than in running beer. In some Irish stouts and porters no substitutes are used, but this is not invariably the case. In Ireland practically no mild ale is brewed, porter and stout being the beverage of the country.

The primary object of mashing is to mix intimately the malt grist and water under conditions, whereby the maximum amount of soluble fermentable extract is obtained. It would be out of place in a work of this size to discuss at any length the complicated chemical changes which take place in the mash tun. But a few words will be necessary for the reader to appreciate to some extent what takes place during the mashing process. Malt contains starch, a certain quantity of sugar, ash constituents, and nitrogenous matters. Amongst the latter is a substance of a proteid nature which is called "diastase." This in the presence of water possesses the property of dissolving starch, when in a suitable form, such as in malt, and of changing it into the sugar maltose and a class of bodies called dextrins. Now the maltose and dextrins are produced in different quantities, according to the temperature at which the diastase acts on the starch. Low temperatures favour the production of maltose, high temperatures that of dextrin. For some beers the brewer requires more maltose than dextrin, for others more dextrin than maltose. The proportions of dextrin and maltose present in a wort can, within certain limits, be adjusted by manipulating the mashing heat.

Malt also contains a certain amount of nitrogenous substances commonly called albuminoids. During the mashing process most of these are rendered soluble in water; and, although they are partially coagulated during boiling in the copper, a portion retain their solubility and remain in the hopped wort, to afford a sufficient food-supply of nitrogen to the yeast in the fermenting vessel and in the cask.

THE MASH TUN

The mash tun (D, Fig. 14) is used for the purpose of extracting the malt and cereals and converting them into materials suitable for the preparation of wort. It is a cylindrical vessel, and is made of iron, steel, or wood lined with copper, and occasionally of wood alone. If the tun is made of metal, the sides and bottom are covered with a non-conducting material to prevent loss of heat by radiation. It has a removable, perforated, false bottom, placed about two inches above the true bottom. The false bottom serves for draining the "goods" in the tun, and the perforations are arranged with the object of affording the largest amount of drainage. The tun is also provided with a stirring arrangement, so that the contents may be thoroughly mixed; with a main (H) for the introduction of hot liquor, sometimes a steam-heating arrangement for raising the temperature, and a sprinkling device termed

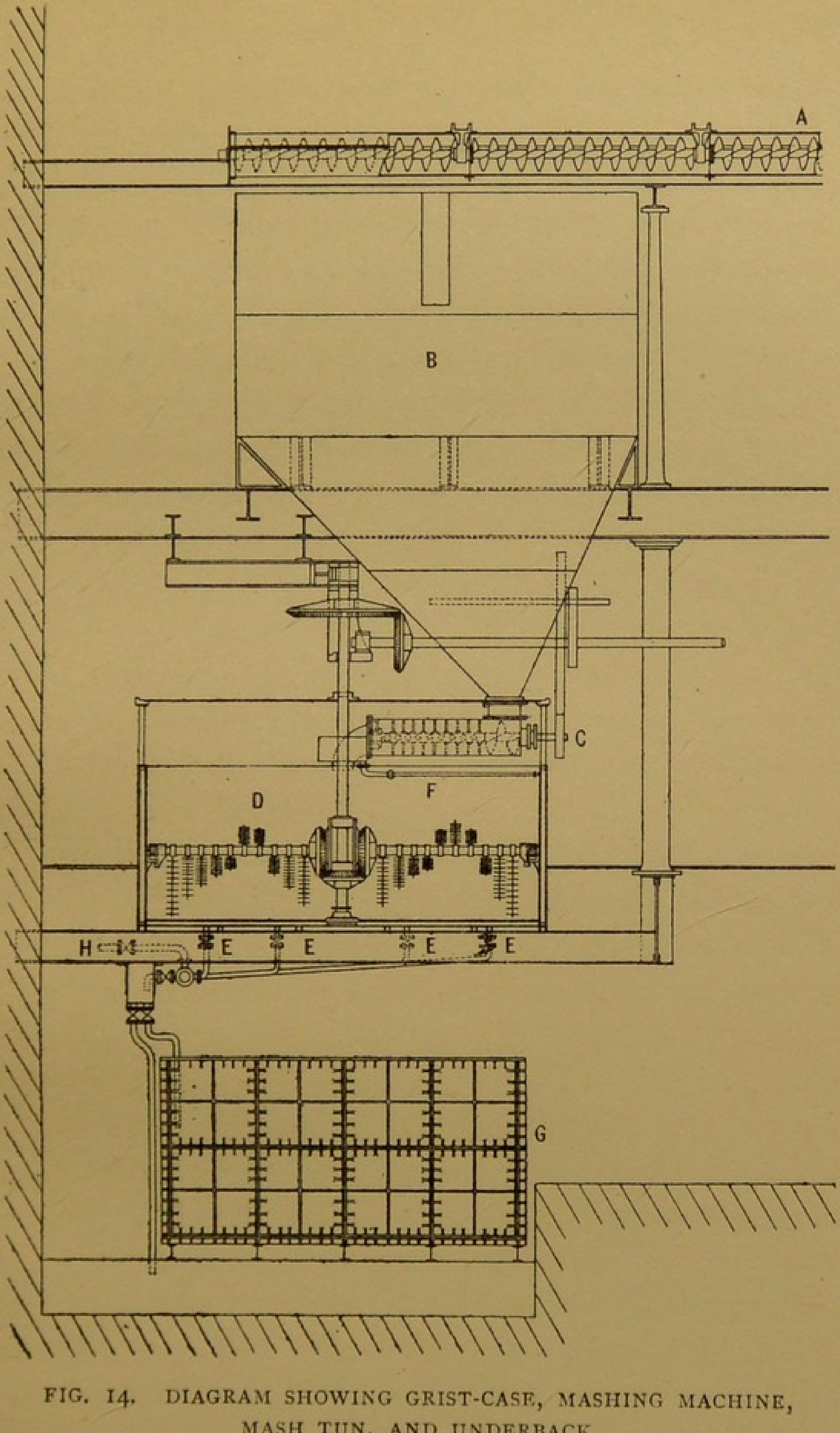

FIG. 14. DIAGRAM SHOWING GRIST-CASE, MASHING MACHINE, MASH TUN, AND UNDERBACK

a "sparger" (F), to enable the grains to be thoroughly washed. The sparger has two, three, or four tubular arms, depending on the size of the tun, attached at one end to a revolving head, which is so pivoted, that the force of the water issuing from the jets causes it to rotate. The arms are perforated in such a manner, that an even spray of liquor is delivered over the entire surface of the goods in the tun, the products of the conversion being thus effectually washed away from the grains. To the bottom of the mash tun are fixed a number of pipes (E E), called the taps, which convey the wort to the copper; or, in breweries where the copper is at a higher level than the mash tun, to the underback (G), which is simply a receptacle for the wort until it can be pumped to the copper. A valve is placed at the bottom of the tun for the removal of the "brewers' grains."

Mash tuns should always be provided with some sort of cover to keep in the heat. In large tuns a common arrangement is a hood-shaped counterbalanced cover, working on pulleys, which can be easily raised or lowered.

MASHING MACHINES

When a large volume of water is rapidly added to the grist contained in the mash tun, or, when the grist is run into the hot mashing liquor in the tun, it is difficult to get a thorough admixture of the materials. The ground malt frequently cakes together in large lumps, the outside being wet and the inside dry. It is often some time before these become broken up; frequently they escape the action of the rakes, and the result is either a wort not homogeneous in composition, or loss of extract. To overcome this difficulty, Steele in 1853 invented an external mashing machine. The contrivance is known as Steele's mashing machine, and is used in most breweries, either in its original form or modified to meet some special requirement. The principle involved is the admixture of grist and liquor in the machine instead of in the mash tun. The construction of the machine is seen on referring to the figure (C, p. 79). The outer horizontal cylinder is made of iron or copper, and is from 3 to 6 feet in length and from 8 to 24 inches in diameter. One end is closed with a cap carrying a stuffing box, through which passes a shaft; the other end is partly closed by the cap. The shaft is driven by a pulley, and is provided with a series of arms, fixed at right angles, and a screw blade. The grist is admitted through the opening above the screw blade which communicates with the grist-case (B), the supply being controlled by a rack-and-pinion arrangement. The hot liquor, which is regulated by a cock, passes in through an opening just behind the screw blade. The grist and the hot liquor thus meet at the end of the cylinder, and, during their passage down it, are thoroughly mixed by the revolving screw and arms. The shaft rotates at a rate of 150 to 180 revolutions per minute.

The mashing machine gives the most satisfactory results, for the mixing of the grist with the liquor is carried out under conditions which ensure a uniform mash.

The mashing process is carried out in the following manner. The grist has probably been ground the day before, and is contained in the grist-case which commands the mashing machine, or mash tun. The first operation in mashing is to intimately mix the grist with a known quantity of water at a certain temperature. The temperature at which the mash is made varies according to the diastatic power of the malt. Most malts contain an excess of diastase, and this has to be checked in the mash tun. If the diastase were not thus checked, the wort would contain too great a proportion of maltose, and the resulting beer would be thin in character, owing to lack of "body," arising from the small quantity of unfermentable matter. It will be apparent that careful control in the matter of temperature is necessary.

There are several methods of mixing the grist and hot liquor. In most modern breweries a mashing machine similar in form to that just described is used, the false bottom of the mash tun being covered beforehand with water at the mashing temperature. In older breweries, where methods are more primitive, the grist is placed in the mash tun, and the liquor introduced from the bottom of the mash tun. The rakes are set in motion and the "goods" are well mixed. Another method is to have the quantity of mashing liquor in the mash tun, the grist being then run in from the grist-case, the rakes going simultaneously to ensure an efficient mixing. Some brewers take the precaution of filling the mash tun with hot liquor before mashing, and then emptying it again, so as to avoid loss of heat in the mash.

A quarter of malt (336 lbs.) is generally mixed with from sixty to ninety gallons of water. It is the object of the brewer not to use too much liquor for mashing, otherwise he will not be able to add enough sparge liquor for washing the extract out of the malt. When the malt is mixed with the hot liquor, the temperature is carefully taken. This "initial" temperature, as it is termed, varies between 140° and 160° F., and upon it depends the type of wort which will be produced.

When the contents of the mash tun are thoroughly mixed, it is customary to let them stand for two hours before opening the taps and sparging. Frequently, however, a quantity of liquor some degrees above the mashing temperature is run in from the underlet taps situated in the lower part of the tun. The underlet is known as "piece liquor." The goods are now thoroughly mixed, and allowed to stand until the brewer considers that conversion of the malt starch into soluble products consisting of maltose, dextrins, etc., is complete; the normal stand is about two hours. The taps are then "set," or, in other words, the cock controlling the spend-pipes leading from the bottom of the mash tun is opened, and the wort run off. Simultaneously, the sparge liquor, at a rate approximately equal to the discharge of sweet wort from the taps, and at a temperature varying between 160° and 200° F., is turned on, which washes the extract from the grains. The wort flows either into a collecting vessel termed the underback, or, in a gravitation brewery, directly into the copper.

In breweries where the copper is not large enough to boil the whole wort at once, the taps are set after the stand of two hours, and a portion of the sparge is run over the goods in the tun. Fresh mashing liquor is then run into the tun, either by sparge or underlet, and the goods are allowed to stand, until the portion of the wort in the copper is sufficiently boiled. When the copper is empty, the taps of the mash tun are again set, and the copper filled a second time. This is known as the "second mash." Similarly, in some breweries, a third mash is made. The whole wort is spoken of as a "length," the second and third mashes being second and third "lengths" respectively. The liquor which finally runs through the taps has a low specific gravity, usually about 1004° to 1005°. If the mashing operation has been properly carried out, the last runnings should contain no starch. Some brewers use these last runnings for sparging the spent hops in the hop back, or employ them for mashing in the succeeding brew (return wort).

There are other modifications of the mashing process in vogue in this country, but space will only allow of a brief reference to them.

THE LIMITED DECOCTION PROCESS

The object of this process is the combination of the continental decoction process with the English infusion method just described. The mash tun is provided with a steam coil, and the mash is made at a somewhat lower temperature than in the infusion process. A portion of the first wort is run off, and stored in a vessel until it is required. Steam is turned on through the coil, and the contents of the mash tun are brought to boiling point, and maintained at this temperature for fifteen to thirty minutes. The temperature is then reduced to 150° to 160° F. by sparging with cold water, the rakes are set working at the same time, and the goods are thoroughly mixed. By this treatment, any starch which remains in the malt is gelatinised, and is then in a condition to be dissolved by the diastase. To effect this solution, the reserved first wort is returned to the mash tun, and the whole allowed to stand for about half an hour. The subsequent operations are the same as with the infusion method. The limited decoction process is of value, when steely and poorly modified malts and raw grain are used. In the ordinary infusion method, any steely ends of the malt corns represent loss of extract, as the diastase is unable to act upon them; but during the boiling in the limited decoction process they are gelatinised, and subsequently dissolved by the diastase in the reserved portion of first wort.

THE FILTER-PRESS PROCESS OF BREWING

During the last few years a new process for preparing beer-wort has been brought to the notice of the brewing trade. At the present time the process can only be said to be in the experimental stage, but it is so important, and possesses so many inherent advantages, that a few words descriptive of the method will not be out of place. The first plant was designed by Meura, a Belgian engineer. The mashing process is carried out in the usual mash tun. When the mash has remained for a sufficiently long time at the final temperature, it is ready for the filter-press, to which it is removed by pumps or gravitation, according to the relative position of mash tun and press. The filter-press is of the ordinary type, consisting of a series of frames and grooved plates, the filter-cloths being stretched over the latter. The mash on passing into the chambers, filters through the cloths, the wort flowing down the grooves and passing to the receiving vessel, which may be the underback or copper. When the flow of wort slows down, a little pressure is applied. The washing which replaces the sparging in the ordinary mashing operation then begins. By a suitable device, the washing liquor reaches the filter-press by a conduit, which passes into each alternate compartment of the press. Thence it enters the layer of grains, washing out the extract, which escapes by the grooves of the opposite plate. The washing is continued until the goods are completely extracted.

By filtering the mash in this manner, very finely ground grists may be used; consequently greater extracts are obtained than by the present system of mashing. At present a brewer has to be careful that, not only is the grist well converted, but that the mash will also filter through the plates of the false bottom of the mash tun. With the filter-press there is no difficulty in filtering, however finely the grist is ground. Since the process warrants the use of finely ground malt, it is probable that brewers will be able to use a certain proportion of malt made from the poor barleys which have hitherto been unsuited for malting. The advantage of this will be reflected on the English farmer. The saving of time is considerable, and less washing water is required for the complete extraction.

BOILING

The boiling of the wort with hops is the next operation involved in the manufacture of beer. The copper is the vessel in which this is carried out. There are two kinds in use, the "fire-copper," which is directly heated by fire, and the "steam-copper," heated by steam.

Fire-coppers are built over a brick furnace; the lower end is pan-shaped. Half-way up it widens out slightly, thence to the top the sides are vertical or sloping. The old-fashioned coppers are open, but in many breweries they are closed, and the contents are boiled under a slight pressure. Some brewers prefer to boil pale ale worts in open coppers.

Modern breweries are often fitted with steam coppers. Each of these has a jacketed bottom forming the steam-chamber, where steam is injected under pressure, and, the wort thus heated in the copper above. The copper may also be heated by a steam coil placed inside near the bottom. Steam coppers may be open

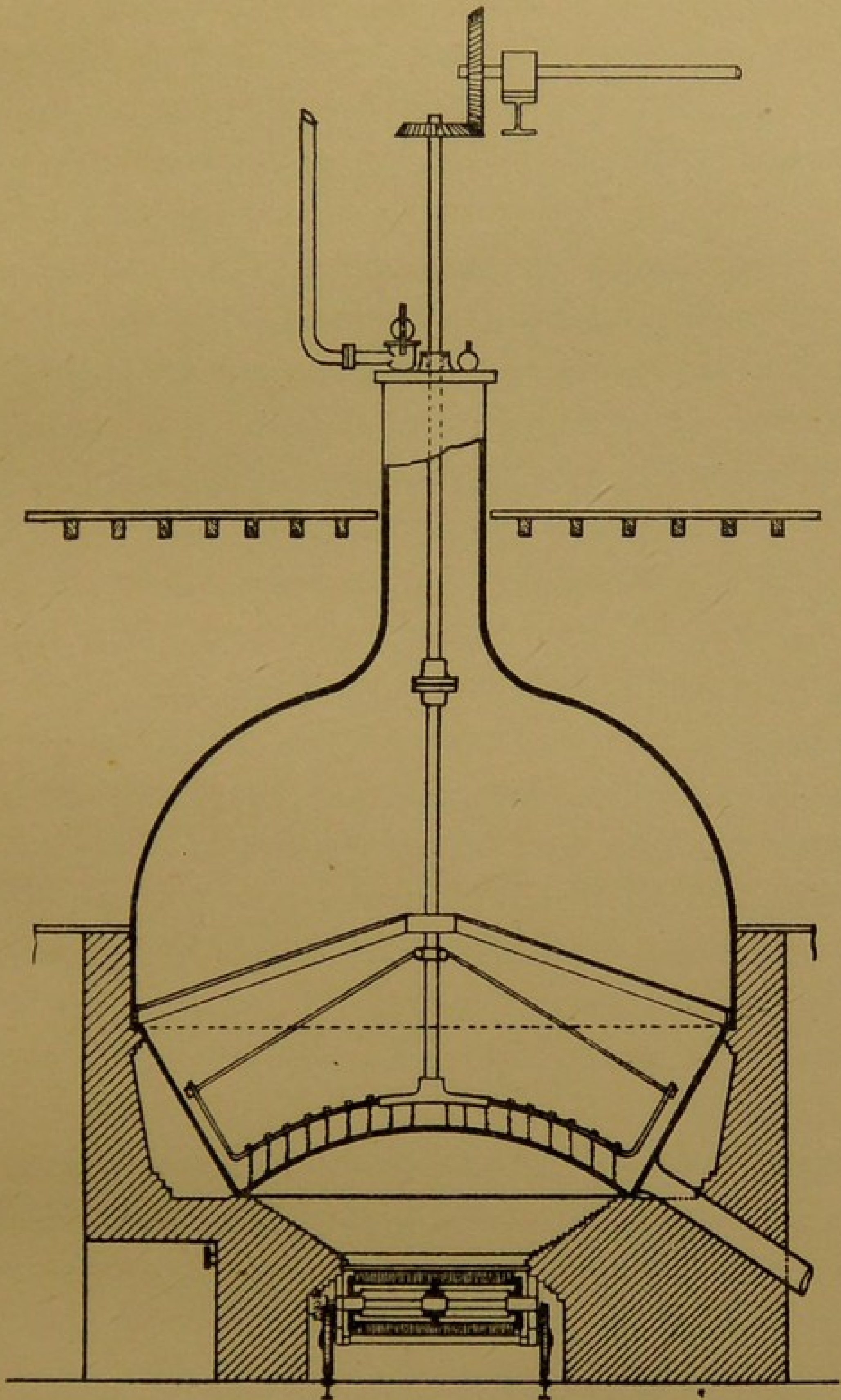

FIG. 15.

BREWER'S COPPER

at the top, but often they are closed. The accompanying figure shows the construction of a modern form of a closed copper heated by a furnace. It is provided with stirring gear so that the contents of the vessel may be thoroughly mixed.

The wort is either pumped to the copper from the underback, or it flows into the copper by gravitation. As soon as the bottom of the copper is well covered, the fire is made up, or steam is turned on, and the contents brought to the boil as soon as possible. If the wort is boiled in a single length—in other words, if the whole brew is contained in the copper—all the hops are added when the wort boils. But, if the wort is boiled in two or three lengths, the hops are divided, the first length being boiled with a larger proportion than the second length. In some cases the hops used in the first boiling are used again in the second boiling. As the boiling eliminates the delicate aroma obtained from the hop oil, it is usual in the case of the better beers, more particularly of the pale ales, to reserve a portion of the hops, and to add them shortly before the coppers are "turned out" or emptied.

It is most necessary to boil thoroughly, and there is not much doubt that many of the troubles that the brewer has to contend with in the finished product are due to insufficient boiling. When worts are boiled in one length, from two to three hours is the usual time; in two lengths about two hours for the first length, and two and a half hours for the second length suffice. During boiling several important changes besides the absorption of the constituents of the hops take place. The wort undergoes diminution in volume due to evaporation ; it is thoroughly sterilised, whereby bacteria and organisms inimical to yeast and to the flavour and stability of the beer are destroyed ; some of the albuminoids of the wort are coagulated, and the diastase is destroyed. If the coagulation of certain of the albuminoids of the wort is not complete, cloudy and "sick" beer will result. The tannin in the hops combines with some of the dissolved proteids in the wort, and the compound formed separates out partially when the wort cools, and also during the fermentation.

The following table shows the average amount of hops used in the different types of beers brewed in the United Kingdom :—

Beer.	Specific gravity before fermentation.	lbs. of hops per barrel of wort.
Mild ale	1050°–1058°	$\frac{3}{4}$ to $1\frac{1}{2}$
Pale ale	1048°–1055°	2 " 3
India pale ale	1055°–1064°	3 " 4
Strong ale	1065°–1083°	3 " 4
Porter	1050°–1056°	$\frac{3}{4}$ " $1\frac{1}{2}$
Single stout	1063°–1070°	2 " 3
Double stout	1075°–1083°	$2\frac{1}{2}$ " $3\frac{1}{2}$
Imperial stout	1085°–1098°	3 " 4
Export stout	1060°–1098°	3 " 5

Brewing sugars, such as glucose, invert sugar, or cane sugar, are added to the wort as it passes from the underback to the copper or to the copper itself.

When the boiling is completed, the fires are drawn, or steam turned off, and the contents of the copper run into the vessel known as the hopback.

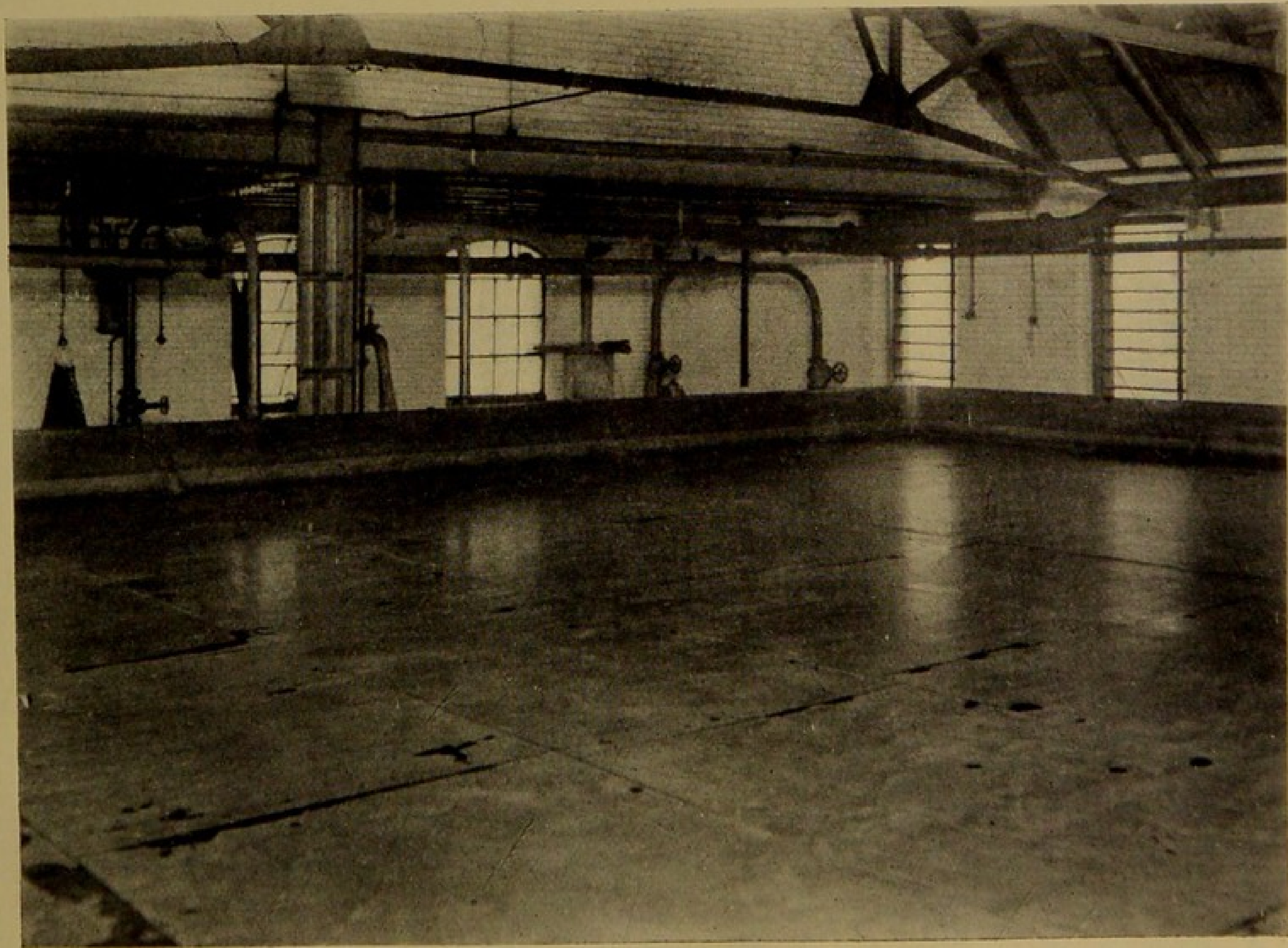

FIG. 16
COPPER COOLER

THE HOP BACK

Some coppers are provided with a false bottom, thus enabling the hopped wort to pass directly to the cooler. The usual custom is, however, to turn the contents of the copper, after they have been boiled for a sufficient length of time, into the hop back. This consists of an open rectangular-shaped vessel, provided with a perforated false bottom to enable the boiled wort to drain away from the spent hops. The false bottom is situated some distance above the true bottom of the hop back, so as to allow a rapid drainage, and to prevent the spent hops remaining too long in contact with the wort. The hop back is frequently provided with a sparging arrangement to wash out the wort which adheres to the hops, and sometimes with a filter-press to remove the adhering wort from the spent hops.

COOLING

From the hop back the wort flows by gravitation or is pumped to the coolers, which are large and very shallow vessels (Fig. 16), made of iron, copper, or wood, and so situated that air can be freely admitted on all sides. It is here exposed in a thin layer to the air. The wort, whilst on the cooler, absorbs a considerable amount of oxygen, which is necessary for the subsequent fermentation, and also helps in the further deposition of albuminoids and tannates (cooler sludge or grounds). The wort remains on the open cooler, until the temperature drops 20° or 30° F., when it passes over the refrigerators. It will be apparent that there is one very weak point in the cooling process, namely, that the wort is exposed in a thin layer to large volumes of more or less infected air. Years ago this did not matter, as stronger beers were brewed, more hops were used, and substitutes were unknown. Now these conditions are altered, and there is no doubt that the poor-keeping qualities of modern light beers arise from bacterial and other infection, and that the open cooler and refrigerator are the places in which the danger of infection is greatest. Some few breweries filter the air through cotton-wool or other suitable medium, before the wort comes into contact with it. Cost and conservatism prevent the system being generally employed, but judging from the successful results now obtained in the United Kingdom, and more particularly on the Continent, the filtration of cooler air will ultimately come into general use. It is obviously, from the common-sense point of view, one of the improvements most needed in breweries. In some breweries the cooler is replaced by an open and fairly deep tank, where the wort is aerated by some suitable arrangement. The wort passes from the tank to the refrigerators at a higher temperature than from the open cooler; the idea being, that the wort should be hot enough to destroy any organisms, that may have come into contact with it whilst in the tank. Under these conditions additional work is thrown on the refrigerators.

From what has been said about the dangers on the open cooler, it will be clear that the object of the brewer will be to get the wort off the cooler as soon as possible;

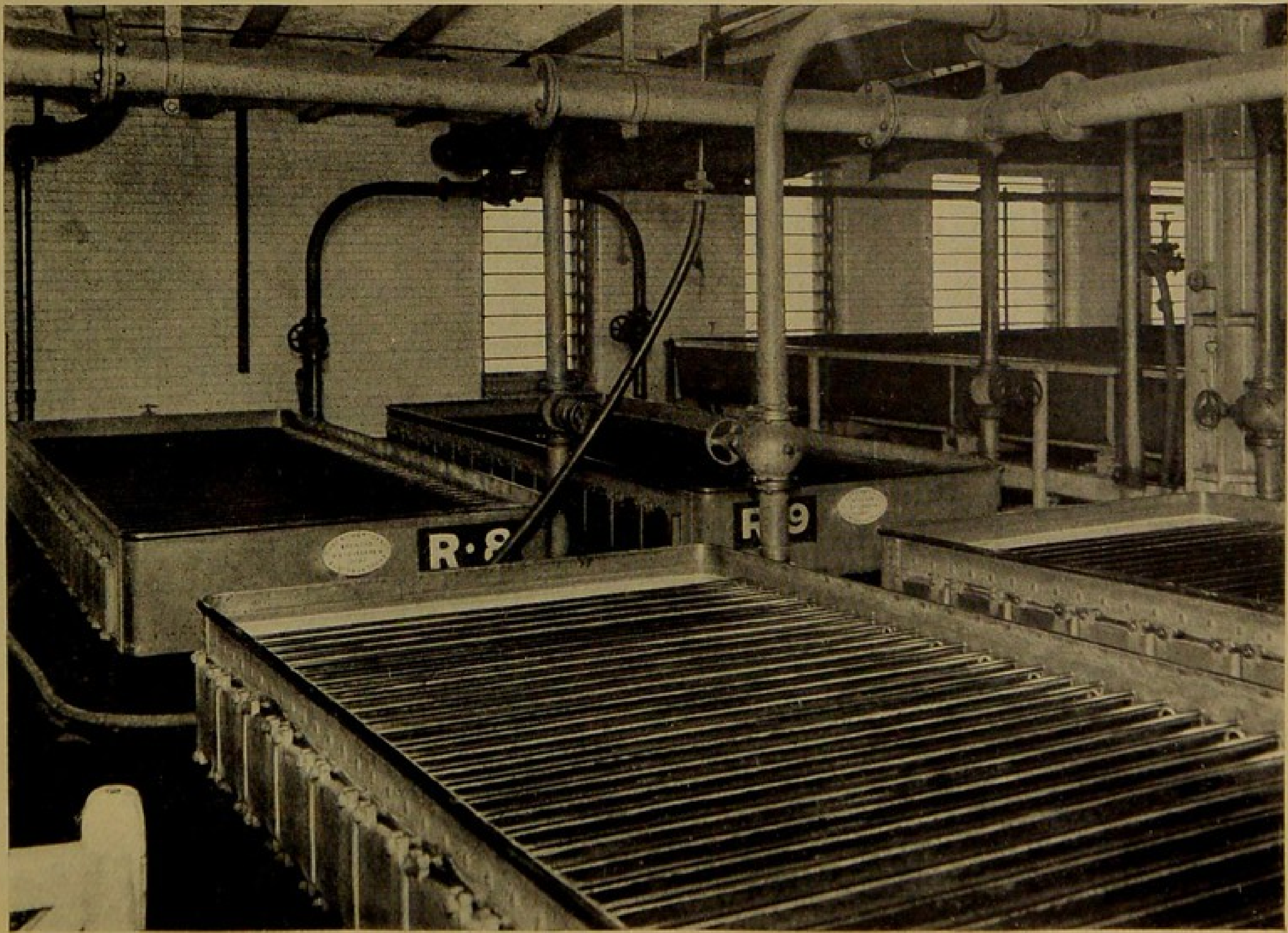

FIG. 17
HORIZONTAL REFRIGERATORS

for the longer it remains on, the greater will be the risk of contamination from air-borne organisms. The cooling process is finished by the refrigerator.

REFRIGERATOR

There are many forms of this apparatus in use. Essentially it consists of a number of small copper pipes over the outside of which the wort flows, whilst through the inside cold water circulates. Refrigerators are arranged horizontally (Fig. 17), or vertically, according to the requirements of the brewery, the former being more general. The temperature of the cold water passing through the refrigerator is adjusted, so that the cooled wort passes to the fermenting vessel at the temperature at which the brewer has decided to start the fermentation. In some refrigerators ordinary supply-water circulates through the top, and ice-water through the lower part.

CHAPTER VI

THE PRODUCTION OF BEER FROM BEER WORT

FERMENTATION

THE primary object of fermentation is to convert the hopped wort into the alcoholic beverage beer. This is attained by submitting the wort to the vital action of yeast, whereby a portion of the saccharine constituents of the wort is converted into alcohol and carbonic acid gas. At the same time the yeast reproduces itself at the expense of a small quantity of sugar and of certain nitrogenous and mineral matters.

The process of fermentation in the preparation of wine, vinegar, beer, and bread was known and practised in prehistoric times. The alchemist used the term fermentation in a most confusing manner. Any reaction in which chemical energy was displayed in some form or other, such for instance in the addition of an acid to an alkaline substance, was spoken of as a "fermentation." Putrefaction and fermentation were used synonymously. The alchemical idea of the Philosopher's Stone setting up a fermentation in the common metals and developing the essence or germ, which should transmute them into silver or gold, further complicated the conception of fermentation. In this connection the views of the alchemist Basil Valentin, who lived in the fifteenth century, are interesting. He stated that "the yeast gives to the beer an internal inflammation, so that it raises in itself, and thus the segregation and separation of the feculent from the clear takes place."

Becher, in 1669, first found that alcohol was formed during the fermentation of sugary solutions; he distinguished also between fermentation and putrefaction, and between true alcoholic fermentation and acid fermentation.

Boerhave regarded fermentation as depending upon internal motion, and this investigator first asserted, that true fermentation takes place only in vegetable substances, but putrefaction in animal substances.

The eminent French chemist, Lavoisier, showed that alcoholic fermentation consisted of a chemical transformation of sugar into alcohol and carbonic acid.

It is curious that up to Lavoisier's time no investigations had been made regarding the active cause of fermentation. It had been known from prehistoric times that the barm or froth, produced during fermentation, would again excite fermentation in a suitable medium. Leuwenhoek, in 1680, by means of a very rough microscope, found that yeast consisted of a number of cells, but did not realise the importance of his discovery. The connection between microscopic organisms first found by Leuwenhoek, and the formation of alcohol and carbonic acid, was finally established in 1836 by

Cagniard de la Tour, and Schwann. The latter found that fermentation depended on the presence of yeast, and that no further fermentation took place in a fermenting liquid, in which the yeast-cells had been destroyed by boiling, and which was protected from the entrance of fresh yeast cells. This chemist further showed that, when air was admitted to the boiled solution, fermentation started again; and he was thus enabled to prove the germs producing fermentation to be present in the air.

Liebig, in 1830, enunciated his mechanical theory of fermentation. He regarded it as a process of disintegration of the molecule by a chemical decomposition of the body which induced the fermentation. Yeast was a lifeless albuminoid matter, and fermentation was in no sense dependent on the vital activity of the yeast plant. Liebig's theory was controverted by Pasteur, who, in 1857, wrote that "fermentation is a phenomenon which is connected with a vital process beginning and ceasing with the latter." There could be no alcoholic fermentation without a simultaneous organisation, development, and propagation of yeast cells, or a further continued existence of already formed cells.

It may here be pointed out that there are two great classes of ferments, "organised" and "unorganised"; of the organised ferments, yeast may be taken as a type; of the unorganised, diastase, the active principle of malt, pepsin, etc. Now Liebig included in his theory the action of both kinds of ferment, whereas Pasteur's theory was purely biological, in that fermentation was

FIG. 18
MICROPHOTOGRAPH OF BREWERS' YEAST
(Saccharomyces Cerevisiæ)
$\frac{500}{1}$

associated only with organised ferments. A distinction had to be made between the two classes of ferments: the unorganised ferments were termed "enzymes" and their action spoken of as "enzymic action." Later it was shown that organised ferments, such as yeast, contained unorganised ferments within their cell walls, so that the assertions of both Liebig and Pasteur are in a measure correct. Recently the German chemist, Buchner, by submitting yeast to great pressure, obtained a liquid, which brought about a true fermentation in solutions of sugar. This discovery supported Liebig's mechanical theory. There is also truth in Pasteur's assertion that Liebig was incorrect, when he stated that fermentation was not dependent on living organisms.

Chemically considered, the yeast cell absorbs the constituents of the wort, and converts part of the saccharine matter into alcohol and carbonic acid, which may be regarded as excretory products of the living yeast; whilst other portions of the sugar, the nitrogeneous and mineral matter, are used up by the cell for purposes of reproduction.

When viewed under a microscope, the yeast cell appears as a round or oval body (Fig. 18). Each cell is an individual plant. The outside wall of the cell consists of a thin membrane, whilst the interior is filled with protoplasm. If the outer wall is sufficiently thin, one or more circular shapes are seen; these are termed vacuoles, and contain protoplasm. The yeast cell varies in diameter from three to ten micromillimetres.

Reproduction can proceed in two ways, by budding and sporulation. In the fermentation industries yeast reproduces itself by budding. If a drop of fermenting fluid be examined under a microscope, the cells are seen to have one or more protuberances. These are daughter cells in process of formation. The new cell is not always detached at once from the parent cell, but often many cells remain attached one to the other, forming chains and clusters.

When kept under starvation conditions, many varieties of yeast provide for the perpetuation of their species by forming spores. If a sample of yeast be kept on a block of gypsum or unglazed porcelain in a moist atmosphere, the cells will gradually become pitted, or granulated, in appearance. This is followed by lines of cleavage, and one or more spores are ultimately formed. The spores, when grown under suitable conditions, develop into cells. The varieties of yeast differ markedly in their capability of forming spores, and also in the shape of their spores, and this is one of the means of differentiating between the varieties.

Brewers' yeast (*Saccharomyces cerevisiæ*) is divided into two classes, top fermentation and bottom fermentation yeast. The former is typical of the fermentation systems of the United Kingdom, the latter of the Continent. The varieties of *S. cerevisiæ* differ in many other respects, such as the extent to which they will carry the fermentation of the wort, the rapidity and extent of reproduction, the flavour they impart to the beer, the shape of the cells, etc.

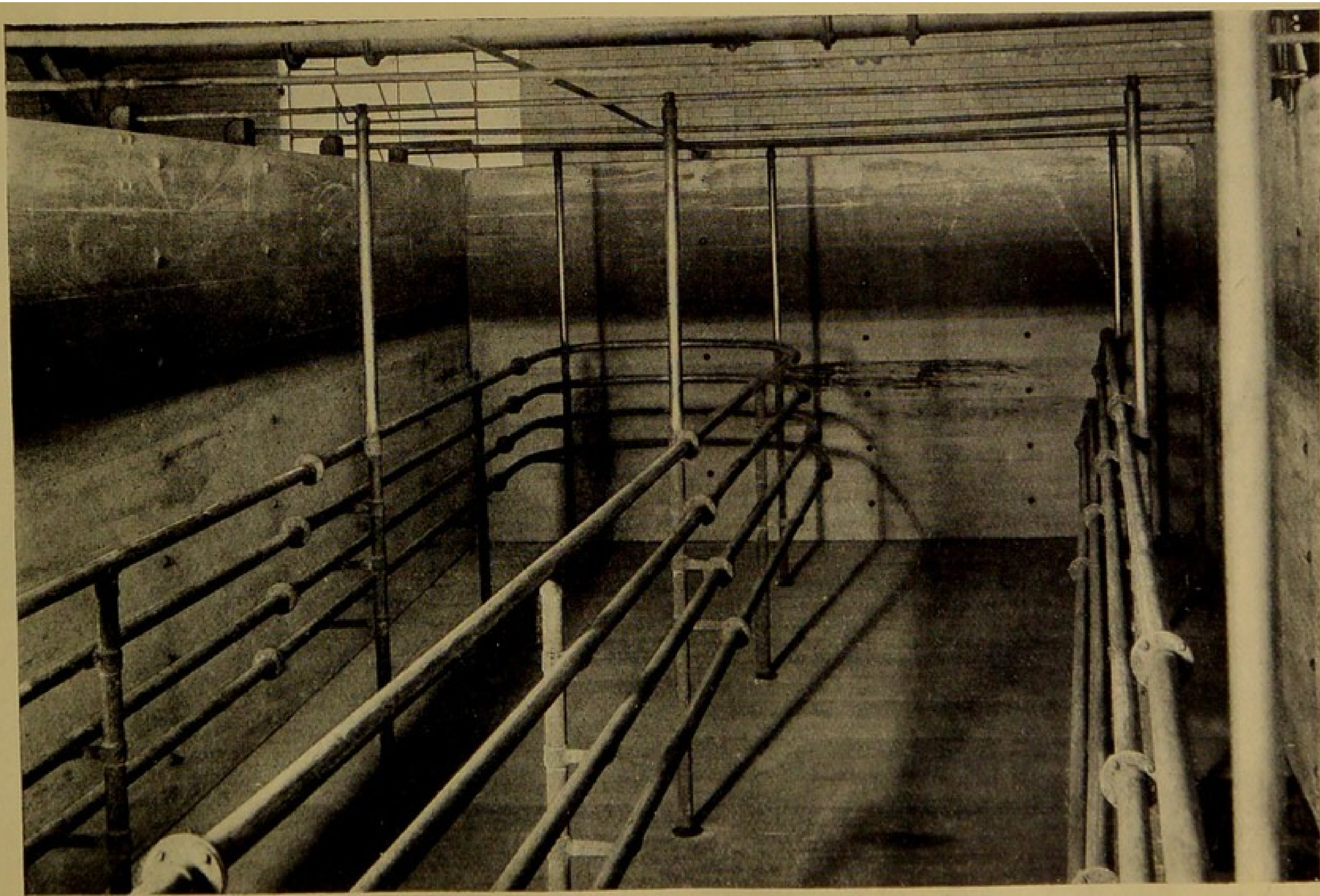

FIG. 19

INTERIOR OF A FERMENTING SQUARE SHOWING ATTEMPERATING PIPES

FERMENTING VESSELS

In this country there are practically two systems of fermentation :—

(1) The cleansing system.

(2) The Yorkshire stone square system.

Each system employs a different form of plant.

In the cleansing system, which is more generally in use than the other, the wort flows from the refrigerator into deep rectangular or circular vessels called "squares" (Fig. 19), or "rounds." Squares are constructed of wood varying from 2½ to 3 inches in thickness. Frequently they are lined inside with copper. "Rounds" are generally made of oak staves bound together by iron hoops, and somewhat resemble a large cask.

The amount of yeast to be added per barrel of wort depends on many considerations, the most important being the gravity of the wort, and the system of fermentation. In a rapid fermentation, of which the cleansing system (p. 103) is a type, more yeast is used for pitching than in the Yorkshire stone square system, which is a slow fermentation. Again, more yeast is used for high-gravity than low-gravity worts. A 15 lb.* wort requires about 1 to 1¼ lbs. of good thick yeast per barrel, a 20 lb. wort 1½ to 2 lbs., a 25 lb. wort 2½ to 3½ lbs., a 35 lb. wort 3½ to 4½ lbs. The best yeasts for "pitching" are those grown in beers of about 18 to 20 lbs. gravity. The crop of yeast from very strong worts is usually sluggish in its fermentative activity, and is not generally used for fermentation.

* See page 130.

The method of starting a fermentation varies in different breweries. A common practice is to run a portion of the wort into the tun at a temperature slightly higher than the fermentation is to be conducted. The yeast is then added, and, when fermentation starts, the remainder of the wort is run in. Other brewers mix the yeast with the wort as it flows into the tun, or add the yeast to the wort when it has finished running in. Fermentation is usually started at about 60° F., and is not allowed to rise above 70° to 75° F. As a general rule, the lower the fermentation temperature, the sounder the resulting beer will be. As the fermentation proceeds, the yeast on the surface of the beer undergoes certain well-defined changes in appearance. These are known as "heads" (Fig. 20). When the fermentation has proceeded for five or six hours, a skim or froth extends over the head of the liquid, until it is completely covered. The head increases, until it resembles the top of a cauliflower. This stage is called the "cauliflower" or "curly head." The head becomes more irregular and bolder in shape, and is then described as the "rocky head." As more yeast is thrown up, it begins to fall together, and to form a compact covering or "yeasty head." Large quantities of carbonic acid gas are disengaged, and the bubbles as they rise to the surface break, and impart a slow, throbbing motion to the head. At this stage, which usually occurs from 30 to 50 hours after pitching, the wort will have lost from $\frac{1}{2}$ to $\frac{2}{3}$ of its gravity. It marks the separation of the yeast from the beer, and, in brewing

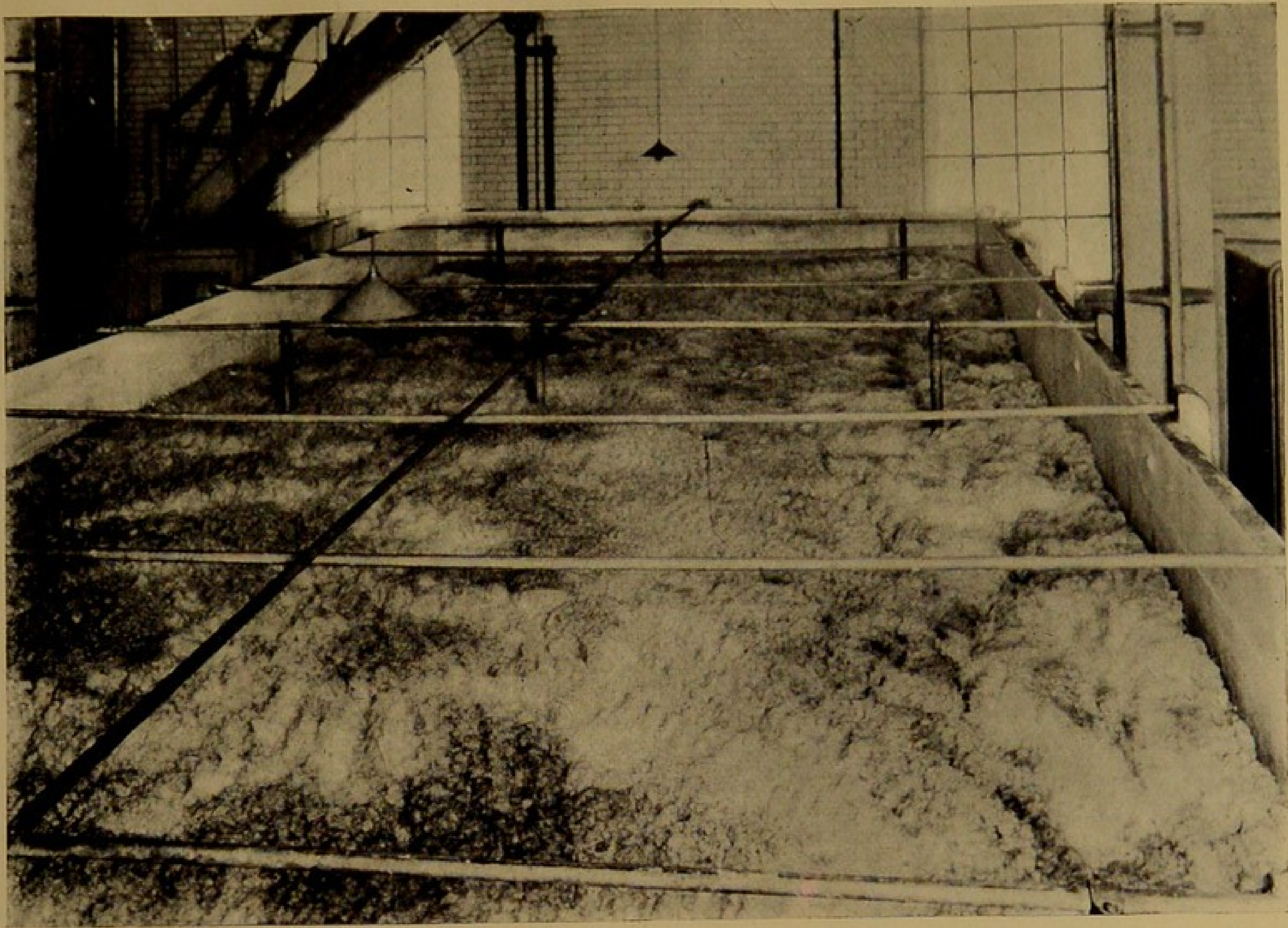

FIG. 20

SQUARE CONTAINING FERMENTING BEER SHOWING HEAD OF YEAST

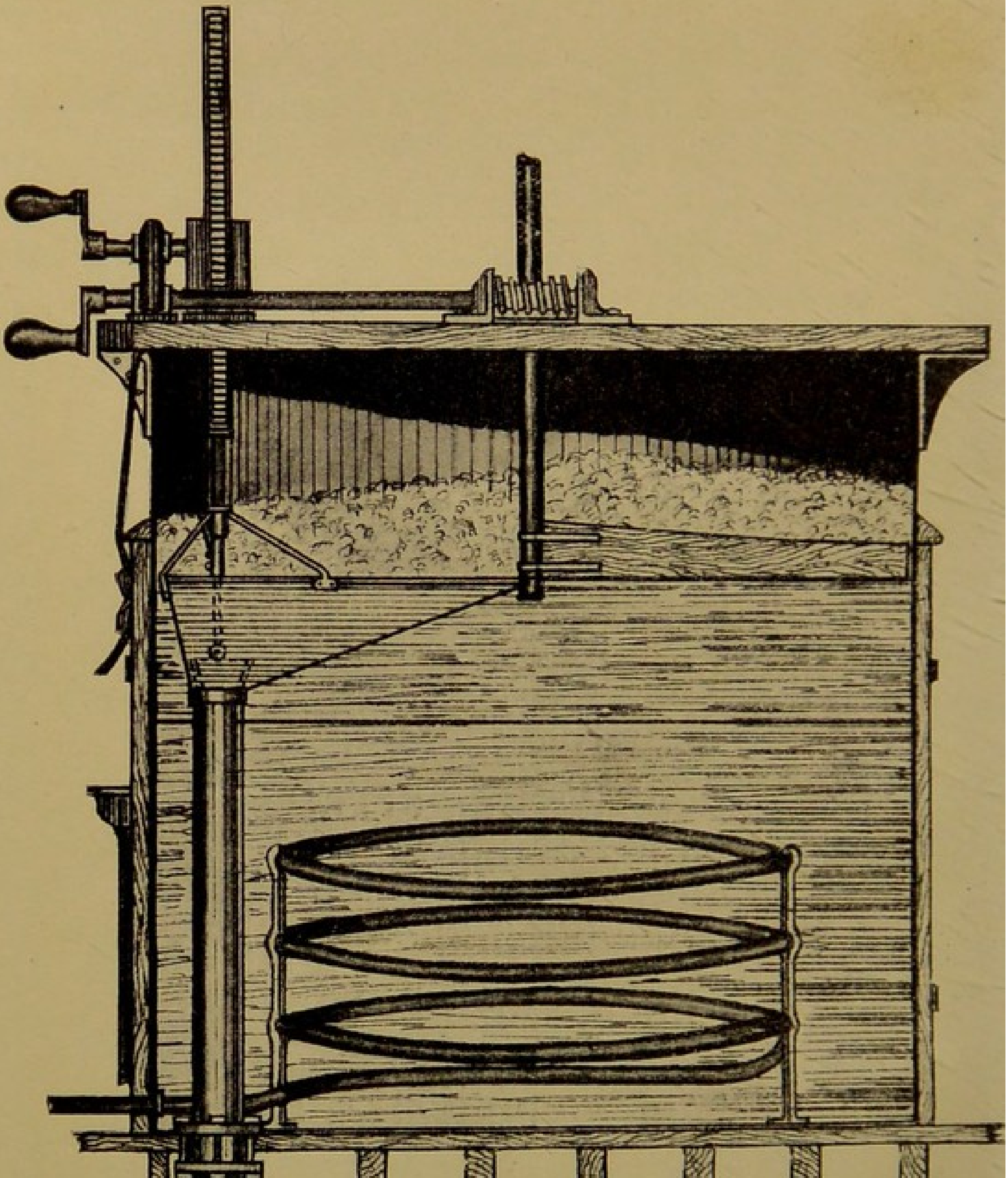

FIG. 21
SKIMMING ROUND

parlance, the beer is said to have "cleansed." The beer is then let down to the dropping-back, pontos, or unions, where the fermentation is finished.

In the cleansing system two courses of procedure are adopted. In the first (Fig. 21), the fermentation may be continued, until it is ended in the "square" or "round." This is known as the skimming system. In some breweries the skimming is done by hand, but generally a parachute is fixed inside the round. This consists of a funnel connected with a tube passing through the bottom of the fermenting vessel. The funnel or parachute is so arranged that it may be raised or depressed. When the beer is "cleansing" itself from the yeast, the parachute is lowered a little beneath the surface of the yeasty head. The yeast then flows through the parachute and tube to the collecting vessel beneath. Attemperators, or pipes through which cold water circulates to enable the temperature of the fermenting beer to be controlled, are usually fixed inside the square or round.

In the second case, the wort, after being fermented to a certain stage in the square or round, is run off into a series of barrel-like vessels called pontos (Fig. 22), which hold from four to six barrels (144 to 216 gallons), where the fermentation is completed. Whilst the fermentation progresses, the yeast forces itself out through a lipped opening in the head of the ponto, and flows into a slate gutter below, lying between rows of pontos. As the yeast works its way out, the pontos are kept filled with fermenting beer, by a "feed-back" situated above them. It is necessary to refer to the ponto system, as it is still often met with in old-fashioned breweries, more particularly in London. There is, however, practically no control over the temperature, and these vessels are now generally being replaced by the dropping tank or skimming-back (Fig. 24). This vessel is usually rectangular in shape and made of wood, it is larger in surface area than the square, and is provided with pipes, through which cold water passes (attemperators), whereby the temperature of the fermenting beer may be regulated. It also has an arrangement in the centre, or at the side, for automatically skimming off the head of yeast, as it rises to the surface; this consists of a tinned copper parachute of the width of the dropping-back, which is worked in the same manner as the parachute in the skimming system. The arrangement works well in practice, for it enables the brewer to reject the first "heads," which are generally contaminated with bacteria and other impurities, and to reserve the better portions for future fermentations.

BURTON UNIONS

This system is similar in principle to that of the "ponto." The casks (Fig. 23), which hold about 144 gallons, are mounted on wooden stands by means of two axles on bearings, one being attached to each head, so that the cask can rotate on its axis. The bung-holes are fitted with brass sockets which carry bent tubes (swan necks) to convey away the yeast. These are carried up

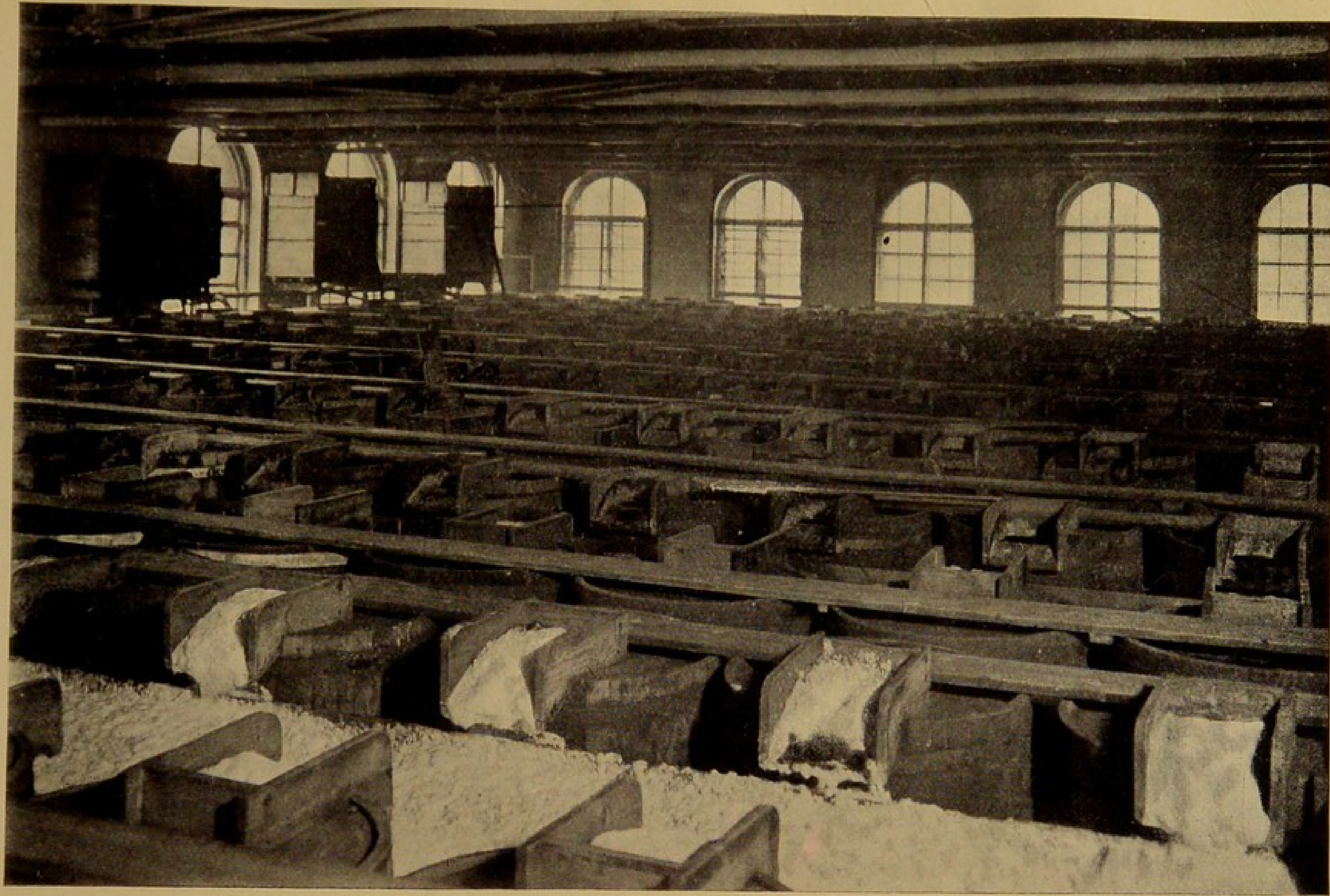

FIG. 22
PONTO SYSTEM OF FERMENTATION

for about two feet, and curve over into a long wooden yeast-trough A, which extends between two rows of casks. At one end of this another vessel, B, is placed, called the "feed trough," which contains from five to six barrels. At the bottom of this a tap connects with a small main, which extends along the row of unions. This main is fitted to the head of each cask by means of a union joint and a tap. A cock is fixed to each cask, and carries a tube projecting a little distance

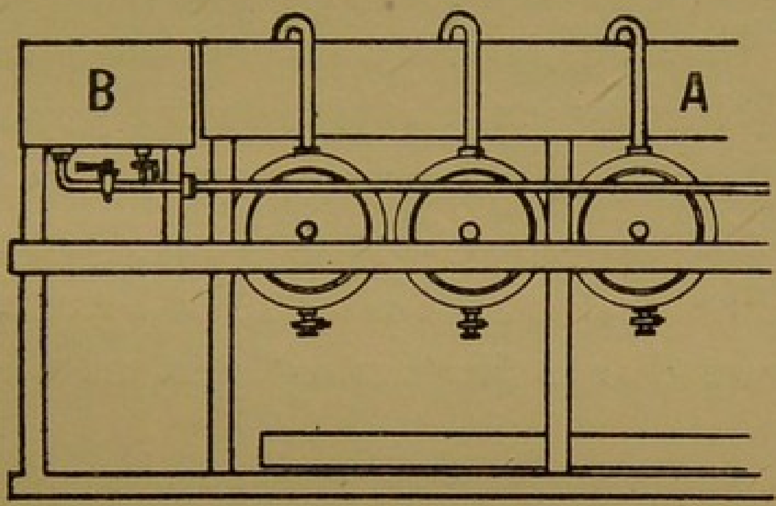

FIG. 23. BURTON UNIONS

inside the cask, and which can be raised or lowered. This serves for the removal of the fermented beer and retains the bottoms. By lowering the tube, the bottoms then flow out. Each union and also the feed-trough is provided with an attemperator arrangement, so that the temperature is under admirable control.

The unions are worked in the following manner: when the cleansing point is reached in the "square" or "round," the beer is run into the feed-tank, and each cask is filled. As the fermentation proceeds, the yeast works itself up through the swan necks. Whilst the yeast is being removed in this manner, the casks are kept filled until fermentation is finished in one of two ways. In the first, the taps are opened and the fermenting wort from the feed-trough run in until the casks are filled with beer and the floating yeast removed. The second method is a continuous one, the beer passing into the cask from a small cistern, which is maintained at a constant level by means of a ball-cock.

These unions, which are for the most part used at Burton, although generally regarded as the most perfect vessels for cleansing, possess certain disadvantages; the difficulty of cleaning perhaps is the worst point. There can be no doubt that plant exercises a considerable influence on the flavour of beer, and the Burton brewers claim that the characteristics of their beers are in no small measure due to the "union" system.

THE STONE SQUARE SYSTEM

The stone square, which is used in Yorkshire and the north of England, is a rectangular vessel made of slate or stone. The stone square is generally a jacketed vessel. The jacket is filled with water for controlling the temperature of the fermenting beer. Sometimes internal attemperators are used instead of the jacket. The square is covered by another rectangular slate vessel B, having the same superficial area as the square but more shallow; at the bottom of this a manhole C is provided, and during part of the working this hole is covered with a stone slab carrying a valve. In one of the bottom corners of the upper vessel two smaller

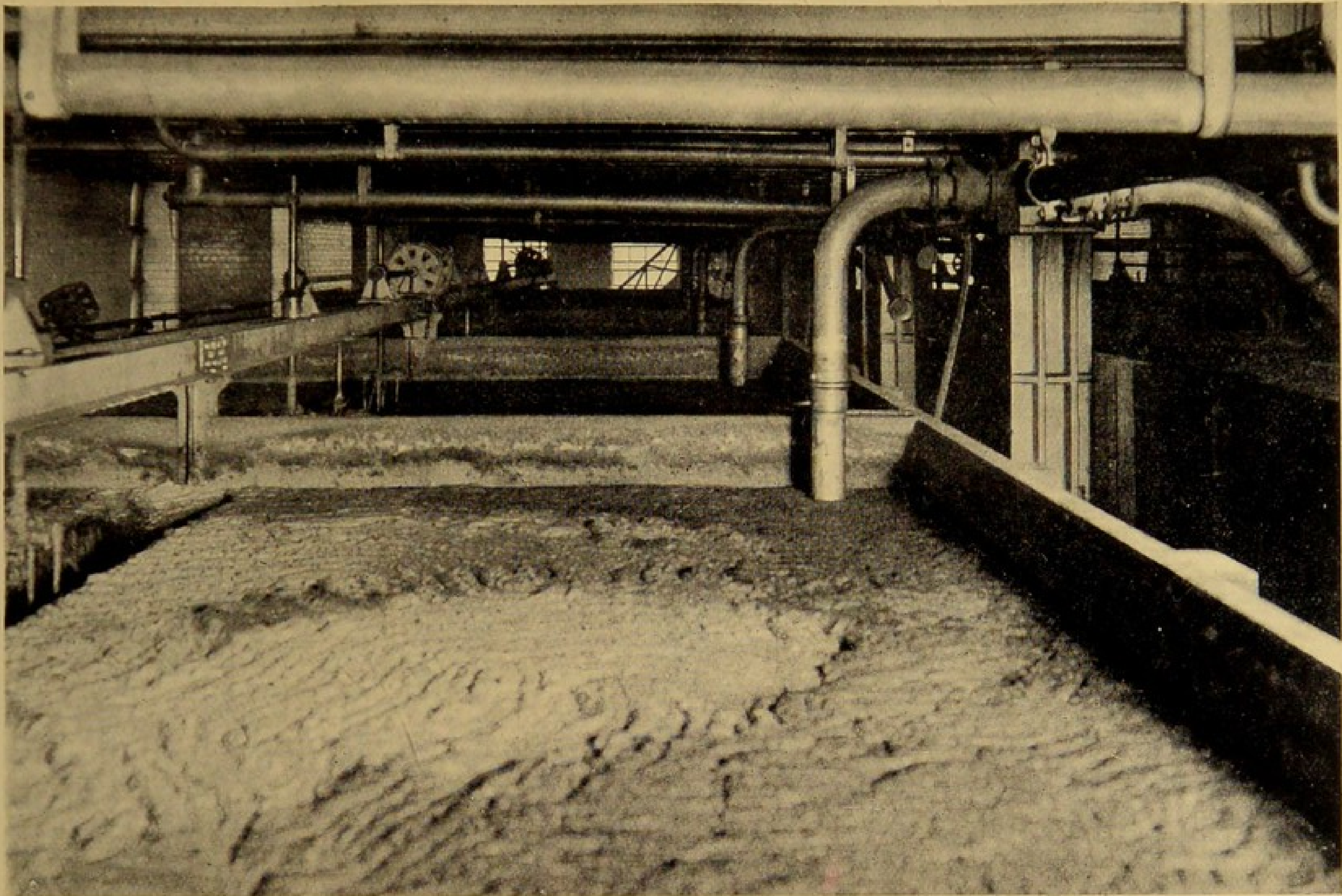

FIG. 24

DROPPING TANKS CONTAINING FERMENTING BEER SHOWING YEASTY HEAD AND PARACHUTE

openings are situated, and fitted into them are valves attached to chains. From the under side of one of the valves an "organ" tube D extends to within a few inches of the bottom of the square. The second valve is used for conveying the yeast at the end of the fermentation into the vessel, which is ready to receive it. The stone

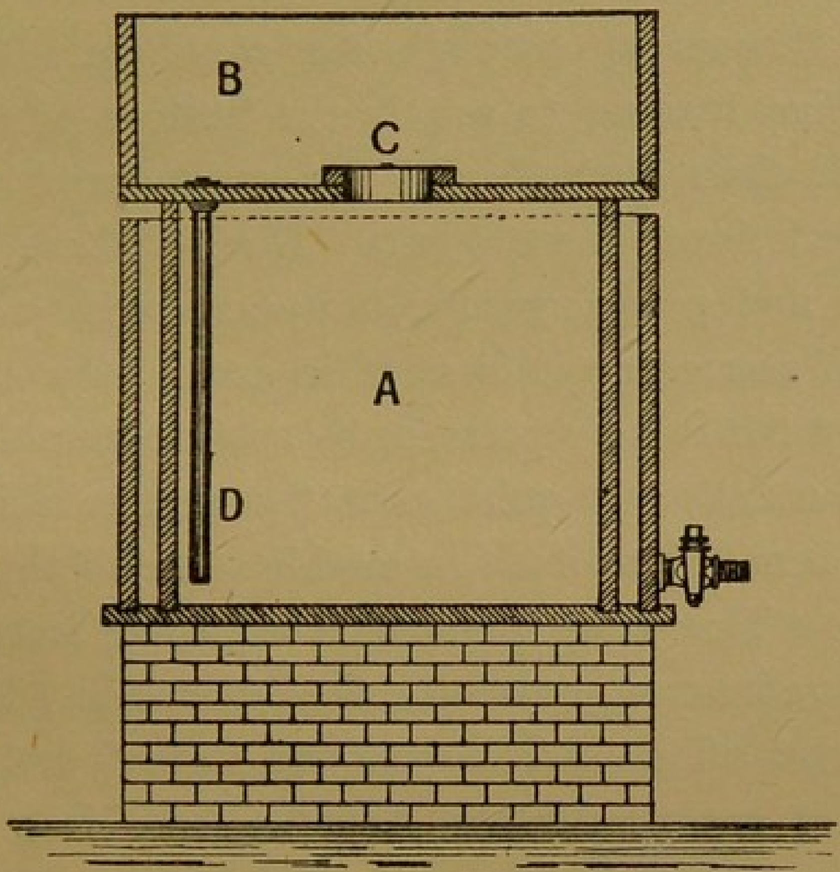

FIG. 25. STONE FERMENTING SQUARE

squares are comparatively small vessels, seldom exceeding fifty barrels in capacity.

The worts are run from the refrigerator at a temperature of 58° to 60° F.; and yeast is added, whilst the wort is running down at the rate of 1 to 1½ lb. per barrel. Enough wort is run in to completely fill the lower square A and to have an inch or two in the upper square B. The temperature is not allowed to drop;

and, after about twenty-four hours, the fermenting liquid is well roused every ninety minutes or so, in order to aid the fermentation.

At the end of another twelve hours, a pump is placed in the manhole C, and at intervals of ninety minutes an increasing quantity of wort is pumped on to the top square. This wort is well mixed with the yeast already thrown up through the manhole. The valve of the pipe leading to nearly the bottom of the lower square is then opened, and the yeasty wort from the top vessel flows down again. During these repeated rousings and pumpings, the temperature is continually rising; if necessary it is kept in control by the water jacket on the lower square, or by attemperators. Before the fermentation is quite over the manhole is closed, and the beer left to itself to enable some of the yeast to separate. The yeast passes through the second valve into the yeast-troughs on the floor beneath. The yeast is skimmed off as it comes to the surface, until only a thin layer remains to protect the beer from the air. The temperature is lowered to about 55° F., and the beer racked. The fermentation takes from six to eight days, according to the gravity of the wort which is being fermented.

SETTLING

When the fermentation is finished, it is customary in some breweries to run the beer to a settling-tank, where it deposits a portion of its suspended yeast, before it is racked into the trade casks. The use of the settling-back is also of advantage, as preservatives and primings can be added in bulk, instead of to the individual casks, thus economising labour. The great drawback to the use of the settling-back is that the beers, being exposed to a large surface, rapidly flatten. When the beer has remained in the fermentation vessel or settling-back for at least twenty-four hours after fermentation is completed, it is racked off into storage vats or the trade casks.

PURE YEAST

Before closing this description of the different processes of carrying out the fermentation of wort in breweries, reference must be made to a system which is used very largely on the Continent. In 1883, Hansen, the well-known Danish investigator, showed that some of the commonest diseases of beer which are believed to arise from water, bacteria, malt, the particular method of brewing, etc., were in reality due to the pitching yeast used. In fact, brewers' yeast is a mixture of a number of different species, and Hansen showed that circumstances might arise, which could alter the proportionate numbers of one of the species, with the result that an irregular fermentation would ensue.

An apparatus (Fig. 26) for preparing pure yeast on an industrial scale was devised by Hansen and Kühle. It consists of a cylinder D for holding the wort, and a fermenting cylinder C. The cylinders are provided with steam cocks, so that each can be sterilised. The air, which is supplied under pressure, passes through the sterilised cotton-wool filters M and G. The wort cylinder is connected by a small main directly with the wort main. When the wort and fermenting cylinders are thoroughly sterilised by steam, the connecting cocks KK are closed, and boiling hopped wort is run into D. The wort is thoroughly aerated by forcing filtered air through, and cooled by the water jacket surrounding D. When the right temperature is reached, a portion of the wort is forced by air pressure into the fermenting cylinder. At the side of the cylinder is a small side tube J, fitted with an indiarubber connection, pinch cock, and glass stopper. This opening is carefully connected with the side tube of the glass flask containing the pure culture of yeast, and the contents poured into the cylinder. The opening is then closed, and more wort is run in from D. The temperature of the fermentation is controlled by a water jacket, which surrounds the fermenting cylinder.

The carbonic acid gas evolved during the fermentation escapes through the cock E, which carries a tube dipping into water contained in F. This serves as a trap and prevents any unfiltered air reaching the interior of the apparatus. There is also an arrangement L for stirring up the settled yeast, and a cock N for drawing off the beer and yeast.

By means of this apparatus it is possible to obtain, at short intervals, absolutely pure pitching yeast, sufficient for about six barrels of wort. After being emptied, the cylinder still contains enough of the original yeast to produce a fresh crop when fermented with more sterile wort supplied from the wort cylinder

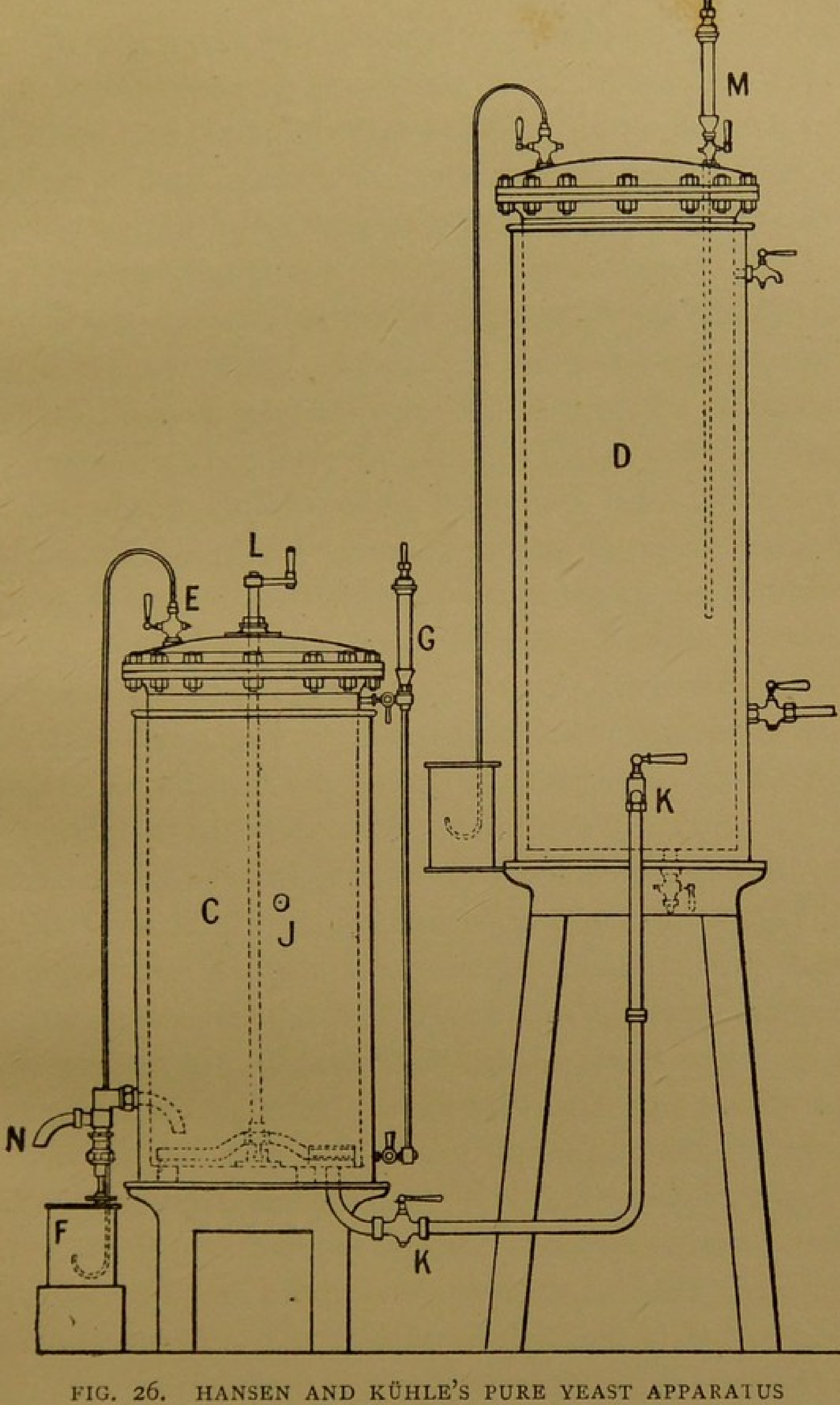

FIG. 26. HANSEN AND KÜHLE'S PURE YEAST APPARATUS

D. In this manner the same type of yeast may be kept in the brewery year after year. After the pure yeast has been in use in the brewery from one to three months, it may become contaminated; in such a case a fresh stock can be at once obtained in a few days from the Hansen apparatus.

The rational application of pure yeast to breweries has other advantages which are of great use to the brewer. In certain breweries varying types of yeast are required at different seasons of the year. Thus in the winter months beers may have an amount of unfermentable matter present, which in the summer would be dangerous owing to the troubles occasioned by an excessive cask fermentation. But by skilful selection the chemist can isolate types of yeast, which will carry down beers to varying stages of attenuation. Thus a low-attenuating yeast may be used in winter, and a high-attenuating yeast in summer.

The application of pure yeast, which is now so general on the Continent and in America, has not yet found a footing in this country, the reason probably being that English beers are fermented under conditions very different to the Continental beers. In English top fermentations the wort is pitched and fermented at a temperature varying between 55° and 70° F. in large vessels exposed to all sorts of aerial contamination. The Continental bottom fermentation beers are pitched and fermented at a temperature rarely exceeding 50° F. in small vessels. The primary fermentation is finished in ten or twelve days as compared with our five to eight days; the beer is then racked into larger casks and kept at 32° to 40° F. for periods extending from five to six weeks to a year, according to the quality of the beer. The conditions of the English fermentation, particularly the high temperature which is so favourable to the development of wild yeasts and bacteria, soon deteriorate and weaken pure yeast. It is also contended that pure yeasts will not bring about that secondary fermentation which is so essential to our better beers. This objection has not yet been fully proved, but if it be admitted there is no reason why pure yeasts should not be used for fermenting running beers where there is no true secondary fermentation. Judging from the rapid strides which Hansen's system continues to make, there is but little doubt that some suitable modification of the method will be devised to meet the peculiar conditions in English breweries.

STORAGE OF YEAST

The tanks where the pitching yeast is kept are made of slate, and are water jacketed so that they can be kept cool. These tanks should be removed from all possible sources of contamination. Too often this point is lost sight of, and whilst every care may be taken of the cleanliness of plant and mains, and in the brewing operations, yet any odd unventilated corner will do for the yeast-back. Yeast is a most delicate material to deal with, and when lying in the tank for the two or three days before it can be used for pitching, it is peculiarly susceptible to bacterial contamination. Careless-

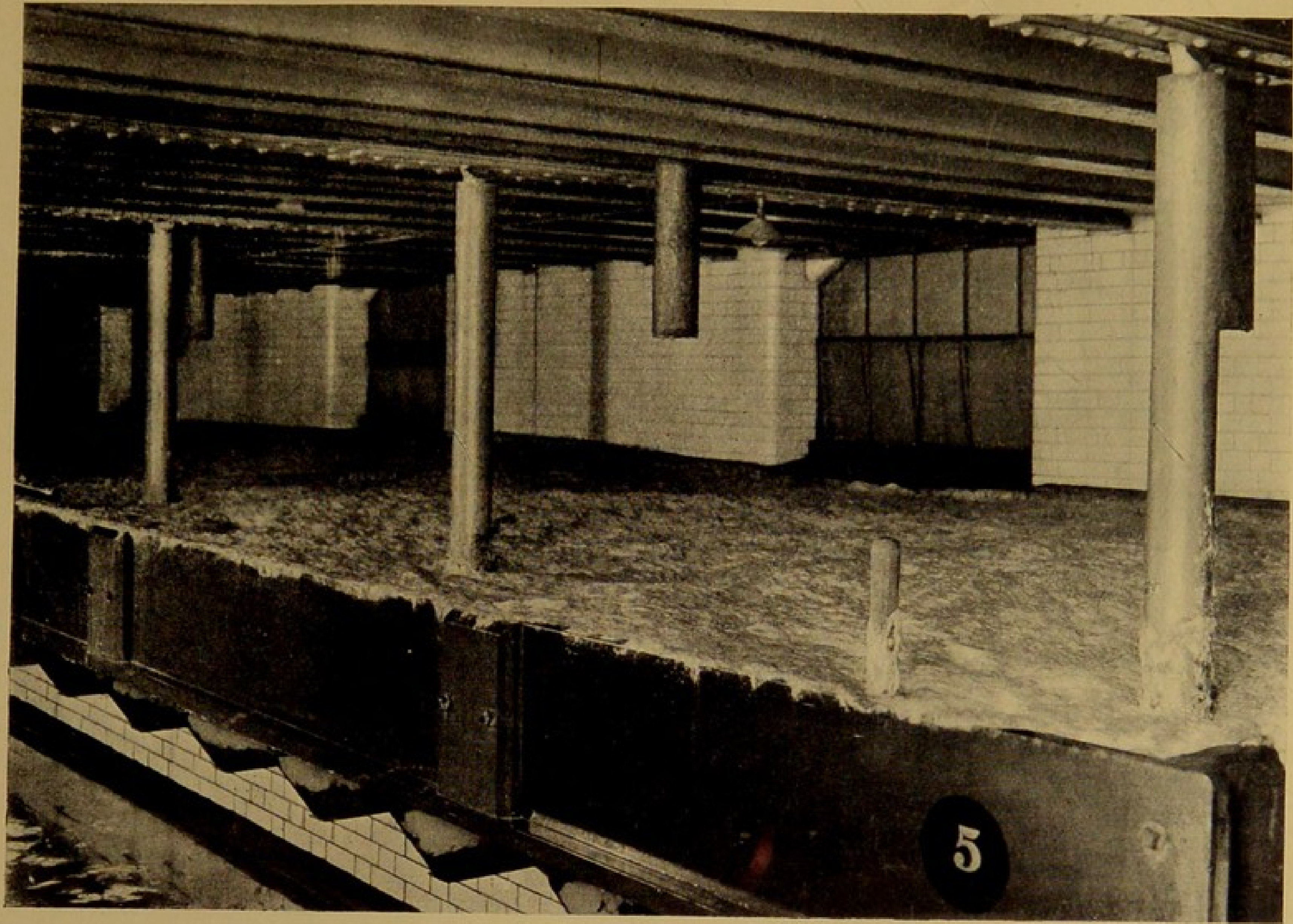

FIG. 27
YEAST STORAGE TANKS

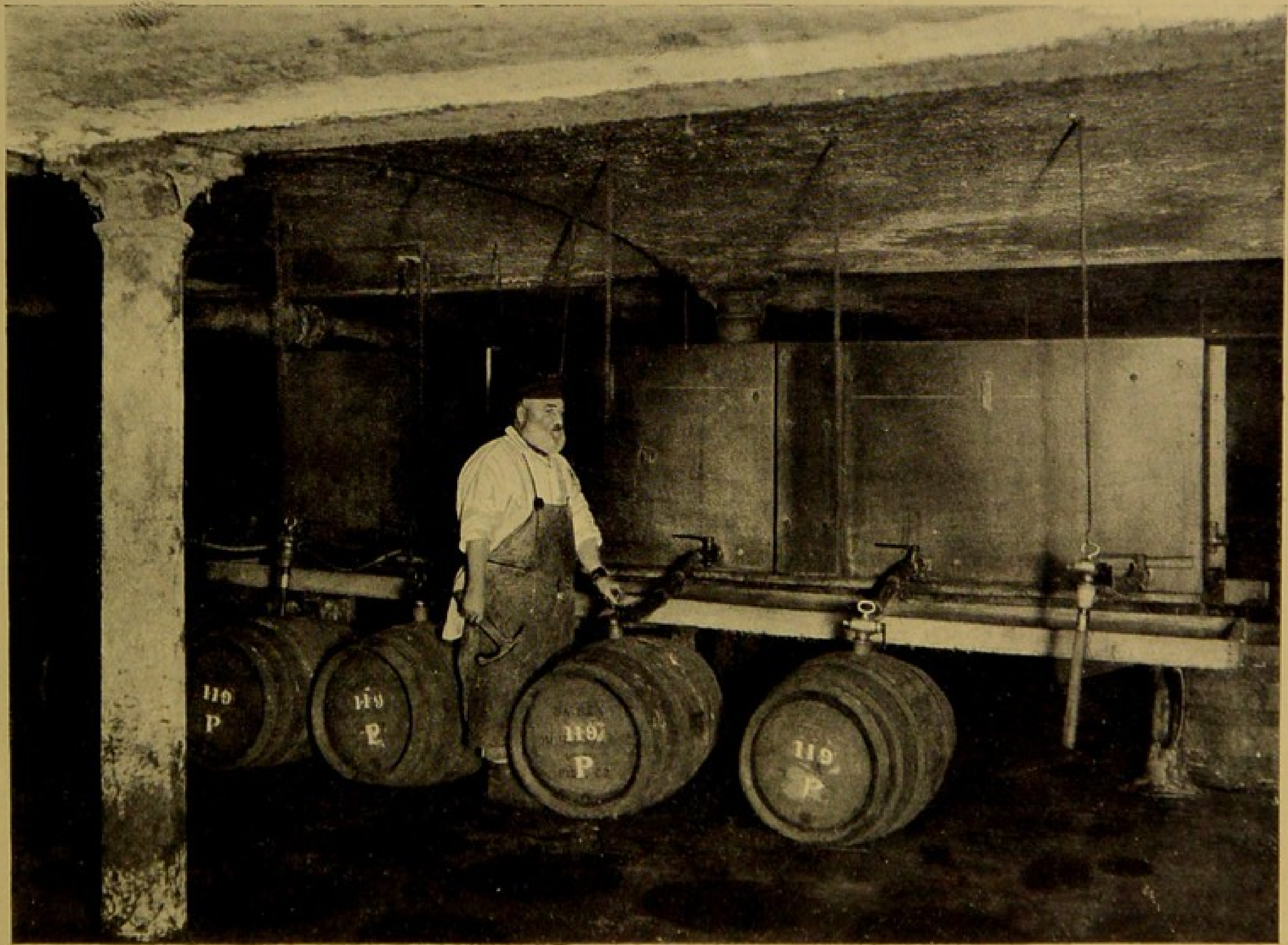

FIG. 28
RACKING BEER

ness in the management of yeast is one of the most fertile sources of trouble in a brewery.

RACKING

When the fermentation of the beer is ended, it is placed in the casks. This operation is termed "racking." There are numerous racking machines on the market, most of them being constructed with the object of introducing the beer into the cask with as little possible agitation and exposure to air. The beer may be racked either direct from the fermentation vessels or through the intermediary of a settling-square. The settling-square is a convenience, for finings, primings, and antiseptics may be more thoroughly mixed with the bulk of beer, than when added to each cask. In most breweries mains connect the fermenting vessel or settling-square with the racking machine (Fig. 28), which is a comparatively small cistern provided with a ball-cock. From this cistern a number of taps carrying rubber hose long enough to reach to the bottom of the casks, are attached. The cistern is kept automatically full of beer by means of a ball-cock. The foreman in charge of the racking machines is careful to see that the end of the hose reaches the bottom of the cask which is being filled, otherwise "fobbing" would occur.

The beer produced in this country may be roughly divided into two classes, firstly, running beer, *i.e.* beer which is sent out into the trade as soon as possible after being racked, and secondly, beers which require to be stored some time, so that they may be sufficiently matured for drinking. Such beers when kept develop a slow fermentation, which is termed "secondary," to distinguish it from the primary fermentation in the tun. It is usual to add ¼ lb. to 1 lb. per barrel of the best quality of hops, just after racking, to the beers which undergo this secondary fermentation. This operation is known as "dry hopping." During the secondary fermentation certain constituents of the solid matter of the beer are further acted upon and slowly fermented. This action is undoubtedly assisted by the diastase present in the hops, which degrades the unfermentable dextrins and converts them into fermentable substances. When the fermentation is over, the beer is "fined," and is then ready for consumption. To promote and hasten the secondary fermentation the casks are rolled daily for several days in the cellar.

The tendency of the time is for the brewer to produce running beers, or, at any rate, beers which can be drunk at once; as it means a quick turnover, and a larger production of beer. If all the beer were required to be vatted and stored some weeks or months before it was ready for consumption, the brewer's output would be considerably lessened.

Most running beers, such as mild ale, porter, thin stouts, and lighter pale ales, are "primed." Quantities varying from one pint to a gallon per barrel of invert sugar or other sugar solution of a gravity of 1150° are added to the beer in the cask after racking, or, in some cases, to the beer before racking. Priming increases the palate fulness of the beer, and also induces an after-fermentation, which helps to keep the beer in condition. In the winter months of the year it is customary to add small quantities of old beer to the mild ale and porter. The old beer, which should be perfectly bright, will have developed a certain amount of acidity. Some brewers neutralise this before adding it to the new beer. In the opinion of many this blending greatly improves the flavour of the beer. Certainly it adds to the profit of the brewer.

In Ireland, and to some extent in England, stout and porter are treated with $\frac{1}{2}$ to $1\frac{1}{2}$ gallon per barrel of unfermented wort, taken from the underback or copper. A very rapid conditioning is effected by this process, the suspended yeast in the beer rapidly fermenting the added wort. This operation is known as "gyling." Some brewers "gyle" with fermenting wort taken from the squares.

The public now demand that beer should be bright and clear. A good beer will become bright if stored long enough. But, in these days of quick consumption, sufficient time cannot be allowed for natural clarification; consequently other means have to be adopted to brighten and clarify the beer. For this purpose a solution of animal gelatine, known as "finings," is added. The fining material employed in this country is isinglass. Isinglass as used by brewers is a gelatinous substance contained in the swimming bladder or "sounds" of the sturgeon and other fishes. Finings are made in the following manner: From 2 to 4 lbs. of isinglass, according to the quality, is weighed out the system has not been adopted. A limited amount of success has attended the lining of casks by means of paraffin wax. This material presents a tasteless and impervious film to the beer, but is not easy to keep clean, as only cold or luke-warm water can be used for washing out. Lining casks with pitch has been tried, but the process is an expensive one. The ideal cask has yet to be made.

Casks are not the least important vessels in a brewery, and much depends upon the efficient management of this department. The care which brewers exercise in the manufacture of beers is absolutely wasted if faulty or dirty casks are used. Too often the cleaning and "passing in" of the casks is left to a workman.

Then, again, casks receive an unnecessary amount of rough handling and tumbling about at the hands of the draymen, during the unloading of the drays. A common custom is to break the fall of the cask from the dray by means of a striking pad, which is a large leather bag filled with corks. Sometimes the cask misses the pad, and it receives a blow, which of necessity seriously weakens it. An average price for a barrel is 21*s.*; and, when the large number which a medium-sized brewery uses is borne in mind, it will be plain that care and economy in the cask department should receive more than a casual consideration.

Below are the different-sized casks used in breweries and the approximate cost of each. The average life of a town trade cask is about fourteen years and an export cask ten years.

	s.	d.
Pin ($4\frac{1}{2}$ gallons)	6	0
Firkin (9 gallons) . . .	8	6
Kilderkin (18 gallons) . . .	15	0
Barrel (36 gallons) . . .	21	0
Hogshead ($1\frac{1}{2}$ barrels = 54 gallons) .	26	0
Puncheon (2 barrels = 72 gallons) .	35	0

THE STORAGE OF BEERS

The cellar of a brewery is by no means one of the minor of the many responsibilities that are attached to the brewer. During storage the better beers acquire mellowness and condition, whilst the running beers are manipulated to suit the requirements of the trade.

Cellars should be scrupulously clean, and of an even temperature. They should not get too hot in the summer or too cold in the winter. Many cellars are provided with arrangements for raising or lowering the temperatures. Most breweries endeavour to maintain a temperature of about 55° to 60° F. The cellars should be dry, as damp air rusts the hoops of the casks, and gradually causes the timber to perish.

As before mentioned, it is customary to rack beers into the trade casks, storage casks, or vats. These latter vary in size in different breweries. In some cases beer is stored in the trade barrel of thirty-six gallons, in others, puncheons, hogsheads, and occasionally enormous vats are used, such as may be seen at Messrs. Guinness and Son's famous Dublin brewery. These have a capacity of 90,000 gallons, and their storage-room occupies many acres in area. The brewer regulates his cellar work according to the class of trade with which he is associated. If much of his beer is sent out in small casks, he does not rack the beer direct into these, but fills them as required from large vats. Beers do not keep so well in small as in large casks, owing to changes which, though negligable where a large bulk of beer is concerned, may be harmful, when a small volume of beer is exposed to a relatively large surface of wood. On the other hand, it is undesirable to move beer from one vessel to another, for this means a loss of beer, and of carbonic acid owing to the agitation.

When the primary fermentation is over and the beer is racked, there is still a considerable quantity of yeast in suspension. After the cask is filled at the racking machine, it is closed and conveyed to the storage cellar. The bung is usually removed, and the yeast is allowed to gradually work itself out at the bung-hole. When this is finished, the cask is again bunged. The excessive development of carbonic acid in pale and stock ales and stouts is prevented by putting in a porous spile in a hole bored in the piece of wood, which fills the bung-hole. They are made of a porous wood, conical in shape, about one inch long, and have both ends flattened. The accumulated gas escapes slowly through the tubular cells of the wood. Before leaving the brewery the porous spiles are replaced by those made of hard wood.

THE BOTTLING OF BEER

Great changes have taken place, during the last decade, in the manner in which beer is distributed to the public. The demand has been gradually increasing for beers of light gravity, and, unless the consumption is a rapid one, beers of this class occasion much trouble and annoyance in the private household. The beer, although often excellent at first, rapidly loses condition, and towards the end of the cask drinks flat. A cask of beer in the private house requires as much management as in the public-house, a fact which is too often lost sight of. Then, again, the light family ales drunk nowadays have only a limited life. The public have taken these circumstances into account, and, as a result, the sale of bottled beers is increasing to an enormous extent.

At first, the brewers regarded the increase in the sale of bottled beer as compared with draught beer with many misgivings; for the increased labour attending large bottling departments, the necessary outlay of capital, and the heavy expenses in freightage and breakages, were in no measure followed by proportionate pecuniary profits. The brewer makes far more out of the sale of draught beer than that of bottled beer. Thus it was that most breweries were content to do their bottling in the most perfunctory fashion. All this is now more or less changed: most of our big breweries are seriously grappling with the subject, and there is, as must be apparent to the public, a very keen competition in the bottled trade.

Formerly, bottling beer was a very different process to that which obtains at the present time. Specially brewed beers were matured in casks or vats, and were bottled and stored to develop flavour and condition.

There are three systems of bottling in this country:—

1. The old-fashioned system of brewing a special bottling beer, maturing it, and then bottling.

2. Recently brewed beers are clarified by finings, and after bottling are got rapidly into condition by storage at a relatively high temperature.

3. The beer is chilled, then filtered, and bottled under artificial pressure of carbonic acid gas. These are known as carbonated beers.

System I. The beers should pass slowly and regularly through their secondary fermentation, and should drop bright, without finings. They are allowed to become flat by porous spiling, are bottled in clean and dry bottles, and corked at once with corks previously soaked in beer. The bottles are then stored at a temperature of about 55° F. Light beers will be in condition in a month, whilst heavier beers may take six or nine months.

System II. New beer is treated with finings, allowed to settle, bottled off, and stored at a temperature of 65° to 70° F. A secondary fermentation rapidly sets up, and the beer is ready for consumption in about a week. This is considered by many a simple and useful system of bottling, provided that the brewer knows approximately how long the bottles will remain in the trade. Such beers do not keep well, and, after a certain stage, rapidly deteriorate. They are peculiarly susceptible to a sudden rise of temperature, the beer becoming flattened and losing its flavour. A rise of temperature frequently causes the bottles to burst.

System III. In this system the beer is cooled to a low temperature, filtered, and bottled under pressure with carbonic acid gas. The flavour due to the carbonic acid in carbonated beers is very different to the gas formed during secondary fermentation in the bottle, although it is improved to an extent by keeping. Such beers are now greatly in demand by the public for home consumption. Although the less that is said about the fine flavour of carbonated beers the better, they are palatable to those who are not "connoisseurs," and possess the great advantages of being in high condition, and of pouring out bright to the last drop.

In the different systems employed for bottling beer, there are certain requirements common to each. The margin of profit is so small on bottled as compared with draught beer, that the bottling department must be managed on strictly economical lines. Many make the mistake of confounding cheapness with economy, with the usual inevitable result.

A bottling department should be suitably arranged, and all double handling of bottles, boxes, etc., avoided.

The returned bottles are first soaked in one of the many soaking machines, or soaking tanks, which are now used. The object of the soaking is to soften the dirt and sediment contained in the bottle, so that it may readily be removed in the washing-machine. Usually soda (2 to 3 ozs. per gallon) is added to the soaking liquor, because it considerably hastens the cleaning process. The tanks are usually rectangular, and so devised that they may be filled with slanting layers of bottles. This prevents any trapping of air in the bottles.

Soaking machines are now commonly employed, as they diminish the labour connected with the soaking tank, and are also more efficient. In a soaking tank the bottles are stationary, whereas in a machine the soaking liquor is continually flowing in and out of the bottle. Very dirty bottles can be left in the machine as long as desired, without interfering with those requiring only a shorter soaking. Another advantage is, that the solution used for soaking can be made much stronger than when a tank is used, the machines being mostly automatic in their action, and there is no occasion for the workpeople to immerse their hands in the solution.

After being thoroughly soaked, the bottles are washed and rinsed. This may be done by means of revolving brushes or shot. In the brushing machines the washing is done by brushes which rotate at a high speed, and, owing to centrifugal action, spread against the inside of the bottle. In shotting machines, shot or small particles of sharp-edged metal, or other material, are placed in the bottles. By means of machinery suitable motions are given to the bottles, a very effective cleansing action being thus obtained. Machines are constructed on the single or multiple system. The single system is very popular on account of its rapid and convenient manipulation.

The following account will convey an idea of how a single bottle-washing machine is manipulated. The brush, which is made of bristles and rubber, forms the end of a rapidly rotating shaft. To facilitate the entry of the brush into the neck of the bottle, and to prevent it spreading from centrifugal motion, the brush is surrounded by a ferule, which moves backwards and forwards along the spindle. This ferule carries a flanged lip, so that, when the mouth of the bottle is pressed into it, the casing around the brushes recedes, and the brushes immediately spread and thoroughly cleanse every part of the bottle. As soon as the brush enters the bottle, a supply of water is automatically turned on, which passes from the hollow revolving shaft, and enters the bottle in the form of fine jets. By removing the bottle, the water is shut off, so that none escapes except during the washing.

After being washed, the bottles are rinsed, to remove any adhering wash water. Rinsers consist of a series of upright tubes, each having a nozzle at its upper end to convert the stream of incoming water into a spray. Each tube has a support, usually covered with rubber to prevent chipping, to take the mouth of the bottle; it is arranged in such a way, that there is free egress for the rinsings.

The bottles are now placed mouth downwards in crates, and allowed to drain and dry in a room which is free from dust. When dry, they are filled with beer by one of the many machines, which are used for this purpose.

The barrels have first to be tapped in such a manner that there is no loss of beer or gas. A tube is introduced into each barrel, which has openings in its lower end for the passage of the beer; connected with this tube is an arrangement for the passage of compressed air, to enable the beer to be forced to the filling machine. The tubes from the different barrels are connected together, and a continuous flow of beer is obtained.

There are a number of different makes of filling machines used in the bottling of beer. Many of them are very perfect, and show great ingenuity on the part of the designers. Most of them are automatic in their action, thus the effect of placing a bottle in the machine is to turn on the supply of beer; on removing it the supply is stopped.

Some machines produce a vacuum in the bottle, the beer is then turned on, and the bottle filled without any production of froth; others work in conjunction with filtering and saturating devices, when carbonated beers are bottled. The demands on a good filling machine are numerous, the most important desideratum being rapidity, for a brewer has to sell large quantities of bottled beer, before he gains a reasonable profit.

When the bottle is filled, it is corked and wired, in the case of superior beers, such as high-class pale ales, stock beers, and stouts, the cheaper beers being bottled in screw-stoppered bottles. Most forms of filling machines screw the stoppers home. The bottle has now to be labelled. No doubt the way in which this is done considerably enhances or detracts from the quality of the beer in the imagination of the consumer. Our English brewers are sadly behind their Continental and American *confrères* in this respect. Much of the labelling is done here in an extremely slovenly and careless fashion.

The Lager beers of this country, that is beers brewed on the Continental system, are "pasteurised" or steamed in bottle. The filled bottles are packed in cases and placed in a tank of water, the temperature of which is slowly raised to 140° F., and maintained for at least an hour. The water is then gradually cooled. The object of the heating is to kill any yeast cells or organisms, and to prevent any further fermentation or decomposition of the beers. Pasteurisation imparts a somewhat characteristic cooked flavour to the beer.

COST OF BOTTLING BEER

A barrel of beer containing thirty-six gallons should fill twenty-four dozen bottles containing a pint each, but in filling there is always a small loss, amounting possibly to one dozen pints. The labour, power, labels, and breakages may amount to 3*s.* 6*d.* to 4*s.* per barrel of beer bottled. Assuming that a beer cost the brewer £1 per barrel, the cost of twenty-three dozen bottles would be 23*s.* 6*d.* to 24*s.* This would be sold to the retailer at 2*s.* per dozen, or to a private customer at 2*s.* 6*d.* Calculated per barrel, this would show a profit of 22*s.* 6*d.* and 33*s.* 6*d.* respectively. From these figures must be deducted the cost of freight and breakages whilst in the trade, both of which are heavy items.

CHAPTER VII

BREWERY OPERATIONS AND THE DUTIES AND QUALIFICATIONS OF A BREWER

BREWERY OPERATIONS

IN this chapter the different operations involved in a typical brew will be described. The first thing the brewer has to do is to calculate the quantity of materials which will produce the quantity of beer of the desired gravity.

It will be necessary to explain briefly certain expressions which are used in the brewing rooms of this country. One barrel contains thirty-six gallons of water or 360 lbs. by weight. One quarter of malt equals eight bushels of 42 lbs. each = 336 lbs.

Gravity, in a brewing sense, implies degrees of specific gravity compared with water at 60° F. as 1,000. Thus a wort having a specific gravity of 1050° is said to have a gravity of 50°. The term "brewers' pounds" expresses the number of pounds that a barrel of wort weighs more than a barrel of water of 360 lbs. at 60° F. Thus, if a barrel of wort weighs 380 lbs., the wort would be called a 20 lb. wort (380 - 360 = 20). After fermentation the resulting beer would still be termed a 20 lb. beer.

From this it is apparent that 1,000 bears the same relation to degrees of specific gravity as 360 does to brewers' pounds. To convert degrees to pounds the brewer multiplies the degrees by $\frac{360}{1000}$, or ·36. To convert pounds to degrees he divides the former by ·36.

We will suppose that a brewer has received instructions to brew approximately a hundred barrels of mild ale at 55° gravity. In brewers' pounds this equals 19·8 ($55 \times \cdot 36 = 19 \cdot 8$). The number of barrels is then multiplied by the number of brewers' pounds: $100 \times 19 \cdot 8 = 1{,}980$ brewers' pounds will be required for the brew. Malts vary in the extract they yield; but, assuming the malt or malts used give an extract of 86 lbs. per quarter, the brewer divides the number of pounds by the pounds in extract per quarter of the malt. In this case it will be $\frac{1980}{86} = 23$ quarters of 336 lbs. each. If the malt weighs less than 336 lbs. per quarter, it must be calculated into quarters of 336 lbs. An adjustment of this 23 quarters would be necessary if sugar, maize, or other substitutes are used. Supposing 20 per cent. of invert sugar is used, then 20 per cent. on 1,980 lbs. = 396 lbs. of extract due to invert sugar. Invert sugar usually yields 36 lbs. of extract per cwt. Therefore $\frac{396}{36} = 11$ cwt. of invert sugar will be wanted. Then 1,980 lbs. − 396 lbs. = 1,584 lbs. of extract will be required from the malt. As stated above, a quarter of malt yields 86 lbs. of extract, hence $\frac{1584}{86} = 18 \cdot 41$ quarters of malt.

Thus if an all-malt mild ale is to be brewed 23 quarters of malt will be required, or, if 20 per cent. of sugar is to be used, 18·41 quarters of malt and 11 cwt. of invert sugar. These quantities are entered in the Excise book. Since there are many losses arising from different causes during the preparation of beer, more liquor is needed for a brew than the actual volume of beer to be made. These losses vary in different breweries; but according to Dr. Sykes (*The Principles and Practice of Brewing*) about 28 to 30 gallons of liquor for every quarter of malt are absorbed by the spent malt (brewers' grains) left in the mash tun. In the boiling of the wort with hops an average loss of 8 per cent. per hour occurs. During cooling another 8 per cent. is lost and 2 per cent. adheres to the different vessels through which the wort passes. Then, again, about half a gallon is retained for every pound of hops used.

These losses are more or less constant for individual breweries, and the brewer knows from experience the amount of liquor to use. We will assume for the 23 quarters of malt 152 barrels of liquor, or for 18·41 quarters 148 barrels will be required to make 100 barrels of beer. These quantities and particulars of the materials are entered by the brewer in his brewing book, and the brewing operations are started. The mashing liquor is usually heated to boiling in the hot liquor-back some hours before the time of brewing and allowed to cool. Any salts that are required are added when the liquor is boiling. The temperature is then adjusted by turning on steam. The malt has been ground the afternoon before, and is contained in the grist-case commanding the mashing machine or mash tun. If a mashing machine is used liquor at the mashing temperature is run into the tun until the plates of the false bottom are covered. The slide of the grist-case is then opened, and the ground malt passes into the machine, where it is mixed with the mashing liquor at the rate of 70 gallons of liquor per quarter of malt. When the mashing is carried out in the tun the total quantity of liquor is run into the tun at a temperature a little higher than required for mashing. This is done to warm the mash tun. When the liquor in the tun has reached the desired temperature the slide of the grist-case is opened, and as the grist falls into the tun the rakes are set going. In another old-fashioned method of mashing which is occasionally used, the grist is run into the tun first, the hot liquor following, the rakes being set in motion at the same time. The rakes are stopped when the grist and liquor are thoroughly mixed. When the mixture of grist and liquor is complete the temperature is carefully observed. Usually this will be a little higher than the mashing liquor, owing to the grist liberating heat when in contact with water. The mash, which rapidly changes from a thick viscid mass to a thin mixture of malt husks and wort, is now allowed to stand about two hours, during which time all the available starch is converted into maltose and dextrinous bodies and a portion of the albuminoids dissolved. An alternative practice is to let the mash stand for about half an hour, and then admit liquor at a temperature ten or twelve degrees higher than that used for mashing by means of the underlet pipes. This is known as piece liquor. After it is all added the rakes are given a few turns and the mash allowed to stand for one and a half to two hours. When the mash has stood for the requisite time the taps are opened or "set" and the wort run off to the underback or to the copper. Simultaneously with this the "goods" are sparged. The temperature of the sparging liquor varies in different breweries. The limits are from 160° to 212° F. If the copper accommodation suffices, the sparging is continued until all the extract is washed from the grains. But often the volume of wort may exceed the capacity of the copper. In such cases the first wort which runs off is sent to the copper or underback at once and the taps of the mash tun are closed; more liquor is added either by the underlet or sparge, and the whole allowed to stand until the boiling of the first wort is finished. When the copper is empty the taps of the mash tun are "set" once more, and the second mash passes to the copper and is boiled. Similarly a third mash is sometimes made.

For the sake of simplicity, it will be assumed that the quantity of wort necessary to prepare the hundred barrels of beer is boiled in one operation. The quantity and quality of the hops vary according to the class of beer which is being brewed. Suppose that the brewer is using hops at the rate of 3 lbs. per quarter of brewing material. This will amount to 69 lbs. of hops. The quantity is weighed out and placed by the side of the copper, and as soon as the copper is well on the boil the hops are thrown in. Some brewers keep back a small portion and add them to the copper a short time before the boiling is completed. The usual period of boiling is from one and a half to three hours. If the wort is boiled in two lengths the hops are apportioned according to the relative strengths of the two worts.

When the contents of the copper have been sufficiently boiled, the fire is drawn or the steam is shut off, and the hops and wort turned out into the hop back. After standing for a few minutes to allow the hops to settle on the false bottom, the taps of the hop back are opened, and the wort flows, or is pumped to the cooler.

The invert sugar is generally added to the copper shortly before turning out.

The brewer endeavours to keep the wort on the open cooler for as short a time as possible owing to the risk of contamination from air-borne organisms. Practice varies in different breweries, but usually when the wort has cooled down to a temperature of 150° or 140° F., which may take from fifteen to thirty minutes, the valve for emptying the cooler is opened and the wort passed over the refrigerators at such a rate that it leaves at the temperature at which the fermentation is to be started. This temperature varies between 50° and 60° F.

The wort now enters the fermenting tun, where it is pitched with yeast. Some brewers do not add the weighed quantity of yeast until all the wort is in the square; others run down a small portion of the wort at a temperature of 65° to 70° F. and mix the yeast with this; the remainder of the wort is then run in. The latter process has the advantage of at once starting a vigorous growth of yeast and of inhibiting the development of inimical organisms. For beer of a gravity of 1055° yeast will be added at the rate of 2 lbs. per barrel.

When all the wort is in the fermenting vessels the Excise officer records its quantity and gravity for the purpose of levying the duty.* The present duty on beer is *7s. 9d.* for each barrel of a specific gravity of 1055°. On a hundred barrels this would amount to £38 15*s.* But as the duty is calculated on the wort before fermentation and not on the finished beer, and as, moreover, there are certain losses during fermentation, we may assume that the Excise officer finds that there are ninety-eight barrels of wort at a gravity

* The quantity of wort in the fermenting vessel is found by the dipping rod, which is a graduated boxwood rule. Excise officials determine the capacity of every fermenting vessel in a brewery and calculate the number of gallons corresponding to each inch of depth of the dipping rod. Then by ascertaining the depth of wort in the vessel the volume of the wort in gallons can be directly estimated.

The gravity of the wort is determined by the hydrometer, which is a thin glass or hollow metal cylinder with a weighted bulb beneath to keep it in an upright position when in a liquid, and a stem above carrying a divided scale. The wort is poured into a glass or metal cylindrical vessel and the hydrometer put in. The higher the gravity of the wort, the more buoyant it will be, and the higher the hydrometer will arise from the liquid. When the instrument is at rest the mark on the scale is read off at the level of the liquid. The temperature of the wort is also observed, and a correction of the observed gravity made if necessary, as the Excise charge is based on the gravity of the wort at 60° F.

of 1055° in the collecting vessel or the fermenting tun. The Excise authorities make an allowance of 6 per cent. for waste and loss during fermentation.

Six per cent. allowance on 98 barrels = 5·88 barrels. Therefore duty will be levied on 98 − 5·88 = 92·12 barrels; and 92 × 7*s.* 9*d.* = £35 13*s.*

The duty on the odd 0·12 of a barrel is carried on to the following month's account. The Inland Revenue collect the duty monthly, the amounts brewed each day being added together and 6 per cent. allowance deducted.

According to the regulations of the Excise, the brewer has to enter, twenty-four hours before starting brewing, in a book supplied by the officer for the purpose, (1) the day and hour of brewing; and two hours before the time entered for mashing or dissolving he must enter separately, (2) the quantity of malt and unmalted corn, rice, flaked maize, grits, etc., and sugar to be used, and (3) the hour when all the worts will be drawn off the grains in the mash tun. The quantity of hops and hop substitutes have also to be declared. In the same book the brewer records the quantity and gravity of the worts, and the vessels in which they are collected. The entry must be made within one hour of the collection, and if the worts are not collected before nine p.m. the entry must be made before nine a.m. next morning. In the event of fermentation having begun before the entry is made by the brewer in the brewing book, he must declare the true original gravity of the worts. The worts must be removed successively and in the ordinary order of brewing, and all the produce of a brewing is to be in the collecting or fermenting vessels within twelve hours from the time they began to enter the vessels. As mentioned above, the beer duty is charged at the rate of *7s. 9d.* per barrel, of a specific gravity of 1055°. But when owing to very indifferent material being used, some irregularity in the brewing process occurs, what is known as the material charge is levied. In levying this charge it is assumed that the brewer will have made one barrel of wort of a specific gravity of 1055° from every two bushels of malt, or 56 lbs. of sugar.

The officers are at liberty to enter the brewery at any time of the day or night, and to take samples when they wish to. No vessels may be altered in shape or position without giving notice to the officer, and every vessel must be distinctly and legibly marked. Grains must not be removed from the mash tun until an account of them has been taken by the officer. There are other Excise regulations with which the brewer is concerned, but those enumerated above are the most important.

From thirty to fifty hours after pitching, the fermenting wort cleanses itself; by this time it will have lost about two-thirds of its original gravity. The fermentation is concluded by one of the different systems described in a previous chapter. The course of the fermentation is followed by taking the gravity of the beer at stated intervals.

When the primary fermentation is completed the beer is allowed to remain either in the fermenting vessel or settling-back for twenty-four hours, so that most of the yeast which remains in suspension may be deposited. The beer is now ready to be "racked" into the trade casks. Each cask after being filled is closed with a bung and removed to the cellar. If the beer is to be primed a solution of invert sugar of a gravity of 1150° is added at the rate of a pint to a gallon per barrel. The cask is then bunged and sent out to the public-house. When it reaches the publican's cellars the bung is removed and one to two pints of good finings added to the barrel. In a few hours the beer becomes perfectly bright, the finings and other matter being ejected from the bung-hole. Another practice is to fine the beer before it leaves the brewery, the finings being retained in the cask.

In the summer weather it may be considered desirable to add a small amount of preservative, such as calcium sulphite, calcium bisulphite, or salicylic acid, either to the settling-tank or to each cask. In many districts the porter and mild ale are blended with a small percentage of beer returned to the brewery which has been allowed to settle and become bright. If the beer is acid it is neutralised with carbonate of potash before being used. The amount of beer so added by different brewers varies, but it probably never exceeds one gallon per barrel. Blending is said to soften and improve the palate fulness of the beer; it is only carried out during the winter months.

It will be clear to the reader that a brewer has to be a man of many parts. A knowledge of engineering, chemistry, and biology is essential to one who takes an intelligent interest in his work and who wishes to be well provided for in the keen competitive struggle of the present times. But most important of all, he must be a judge and manager of men, for untold damage may be done by a discontented and malicious workman. The training of brewers leaves much to be desired. The usual custom is for a young man of fair position and education to pay a considerable fee, which may vary between £50 and £300, and become a pupil for one or two years to a brewer; at the end of that time he may obtain an appointment as under-brewer at a salary of anything between £50 and £150 per annum. Or, he may enter into an agreement and become an improver in a brewery for one or two years, exchanging his services for the opportunity of acquiring knowledge and experience. When the term of improvership is over he looks about for a position as under-brewer, or, if he is well advised and can afford it, he should enter one of our many educational institutions and obtain such a knowledge of chemistry, engineering, biology, and economical science as will help him in his future career. As in all other great industries, the man of superior knowledge in brewing is bound to come to the front. Considering how important the brewing and malting industries are, and the enormous capital they represent, it is certainly remarkable that the country possesses only one institution, namely, the School of Malting and Brewing at the University of Birmingham, where a young brewer can be trained in the scientific principles and special branches of his work. Compared in this respect with the other great beer-producing countries, we are sadly behind. As the brewer continues to gain knowledge both in the technical operations of brewing and in his knowledge of materials, such as malts, hops, etc., he may be appointed a head-brewer, his salary in this capacity being proportionate to the size and importance of the brewery.

The brewer has to be careful that the different materials which he uses are up to the standard of the sample on which the contract for their purchase was based. Some of our large breweries employ the services of a trained chemist or chemists for this purpose, but too often a rough hand examination suffices. A small brewery cannot afford to engage the sole services of a chemist, and in such cases occasional samples of materials and products may be sent to the consulting chemist to be reported on. But in large concerns the case is different, and a capable chemist may save his employers considerable sums of money annually by systematically testing the deliveries of barley, malt, hops, sugar, antiseptics, etc. Uniformity in materials means uniformity in the resulting beer, a matter of prime importance for the reputation of a brewery. The chemist also analyses the beers which for some reason or other are returned to the brewery, and reports whether they have been adulterated by the publican and to what extent an allowance should be made. Sometimes a brewer receives sufficient chemical training to describe himself legitimately as brewer and chemist. This is a most desirable combination, for brewing is essentially a chemical industry, and the brewer who is a chemist may avoid many errors and pitfalls which the brewer pure and simple through lack of knowledge may fall into.

If a brewing concern is of any size it is usual for the proprietors to employ a manager as well as a brewer. The manager concerns himself with the administrative side of the business, buys all materials, makes contracts, and generally controls the sales. He has usually been a brewer, and is consequently fitted to maintain a general supervision of the brewing operations, to see that the full extract is obtained from the malt, and that the beers are of uniform quality. He keeps a close watch on the returns and tries to minimise the quantity as far as is possible. In a well-conducted business these should not exceed 2 per cent. Other departments of the brewery, such as the malting, bottling, stables, etc., come under his general control. Further, he has to see that the travellers are successfully selling the beers and expanding the trade of the brewery, and that the tied and management houses are diplomatically handled.

CHAPTER VIII

LICENSING AND TIED HOUSES

THE LICENSING SYSTEM

THE licensing system of this country is based on an Act passed in the year 1828, which provided that justices of the peace should hold special sessions for granting licenses for the sale of beer, wines, and spirits. From the wording of the Act it is clear that Parliament intended that the public should have all reasonable facilities for obtaining the drink that it requires, and that all unnecessary difficulties in obtaining licenses should be done away with. In 1830 fresh legislation provided for the introduction into the trade of greatly increased capital under the assumed protection of the law. The essence of this measure, which was passed to encourage beer drinking in the hopes of lessening the drinking of spirits, was free trade and a full competition, and it was effected by withdrawing from the justices the granting of the licenses for the sale of beer only and transferring it to the Excise authorities. These licenses were to be granted to all persons without limit. The public-house full licenses were left, as before, to be granted at the discretion of the justices.

In 1869, the Wine and Beer-house Act transferred the granting of new beer-house licenses from the Excise to the licensing justices. This Act also provided that the renewals of beer-house licenses existing prior to May 1st, 1869, could not be refused by the justices unless the beer-house was improperly conducted, or the applicant for renewal was a person of bad character. When this Act was passed there were over 9,000 fully licensed public-houses and about 49,000 beer-houses, of which over 31,000 remained in 1894. As the Government granted to more than 40 per cent. of the whole of the licensed houses the right of renewal, it is obvious that it could not have intended to put them on a superior footing to the more responsible and admittedly better conducted fully licensed houses.

The proceedings of the licensing justices of to-day are chiefly regulated by Acts passed in 1872 and 1874. The applicant for renewal is not required to attend personally unless notice of opposition has been served to him. From this it follows that the Act never intended that a person should lose a license without having a hearing.

Another important section in these Acts provides that when any person interested in any premises about to be constructed for the purpose of being used as a licensed house has applied to the licensing justices for the provisional grant of a license in respect of such premises, and the justices, being satisfied, have accepted the plans submitted to them, and have made such grant, it is imperative on them to grant the final license on the original plans being carried out and the character of the applicant being satisfactory.

It should be further borne in mind that under the Act of 1902 alterations which give increased facilities for drinking, conceal from observation any part used for drinking, or affect the communication between the portions which are used for drinking with other parts of the premises or the street, are not allowed to be made in a licensed house without the sanction of the justices to the plans being first obtained. Houses being thus altered to suit the requirement of one trade are obviously unsuitable for other kinds of business.

The wording of these Acts clearly presupposes a continuous use of a licensed house, otherwise it would have been absurd for Parliament to have accepted the responsibility of authorising large sums of money to be expended on alterations and improvements if the licences could be taken away at the caprice of the justices. The rights of the owner and mortgagee are also recognised by enabling them to appeal against the refusal to renew a license.

In view of the reiterated demands which are made by certain classes of the community for the wholesale rejection of licenses, the following facts, which are so apt to be lost sight of in the heat of controversy, should in common fairness be remembered by them. The heirs and successors of both owner and tenant of licensed property are made to pay estate, succession, and death duties on the permanent value of the license. It would be most unjust that the nation which has drawn this tax from the heirs or successors to an estate should repudiate the value. Again, the Government and local authorities assess public-houses for taxes and rates respectively, on the assumption that the license will be renewed from year to year. The following extract from the *Case for the Trade* (Brewers' Hall) admirably describes the injustice and hardship which would be done to the brewing trade if a new set of oppressive conditions were imposed upon them:—

"It is now the practice in many licensing courts for the justices, before granting a new license, to require the applicant to buy and surrender one, two, or even three existing licenses in exchange. Is this man who, under their authority and at their instigation, has thus invested his capital in buying out existing licenses, to be told that, though he has committed no fault, he has no claim to consideration?

"It is thankless work quoting the words of statesmen who may have changed their minds, but they have terrible significance to those who have invested their capital on the faith of them; neither can those who made these utterances altogether absolve themselves from the responsibility they have thus incurred, seeing that on the security of the licensing system created, reared, fostered by the Legislature, and strengthened by such utterances, the capital of the publican, of the British public, and of the brewer has been invested. Should the State now desire to impose upon the trade absolutely new conditions and risks to which they were not exposed when they embarked on their business, it is only just that such changes should be accomplished after equitable consideration of their claims."

THE LAW RELATING TO THE SALE BY RETAIL OF INTOXICATING LIQUOR IN ENGLAND AND WALES

It is, of course, well known that no person may sell beer, wine, or spirits without a license. There are, however, a few exceptions to this rule; thus, members of the Vintners' Company may sell wine, and medical practitioners and druggists may sell spirits made up in medicine.

The Excise authorities grant the following licenses for the sale by retail of intoxicating liquors, provided that the applicant has a justice's license or certificate, as it should more strictly be called, for that purpose.

(1) For consumption on the premises where sold. These are called on-licenses; they authorise the sale by retail of the same kind of liquor for consumption elsewhere than on such premises:—

(*a*) *Spirits and all other intoxicating liquors.*—This is the so-called full license, and the holder of it is permitted to sell all kinds of intoxicating liquors.

(*b*) *Beer.*—A license is granted to a beer-house keeper for the sale of beer to be consumed on the premises.

(*c*) *Wine.*—A license for wine is granted to a keeper of a house where solid food is supplied to customers to be eaten on the premises.

(*d*) *Beer and wine.*—A license authorising the sale of both beer and wine is granted to beer-house keepers who fulfil the conditions entitling them to hold the wine license.

(*e*) *Cider.*—A license is granted for the sale by retail of cider to the beer-house keeper, and to the holder of the beer and wine license. In addition there is a retail cider license.

(*f*) *Sweets* (*made wines, mead, fermented fruit, and sugar decoctions, etc.*).—A license is granted on the same conditions as a wine license, but the wine license and the beer and wine license also authorise the sale by retail of sweets.

There are certain exceptions: thus holders of theatre licenses, packet boats, and canteens can obtain licenses without any justices' license.

(2) For consumption elsewhere than on the premises where sold (these are called "off licenses"):—

(*a*) *Spirits and liqueurs.*—This license is only granted to holders of the wholesale spirit dealer's Excise license. It authorises the retail sale of spirits in bottles only and in quantities not less at one time than one reputed quart bottle. Foreign liqueurs may be sold in the bottles in which they have been imported.

(*b*) *Beer.*—There are three kinds of "off" licenses granted for the retail sale of beer: first, that which is granted in respect of premises in which the holder resides; second, the beer dealer's additional retail license, which is only granted to the holder of a wholesale beer dealer's Excise license; third, a table-beer license, which authorises the retail sale of beer at a price not exceeding three halfpence per quart.

(*c*) *Wine.*—A wine dealer's license is granted by the Excise for the sale of wine in any quantity and in any manner. There is also the so-called grocer's wine license, which authorises the sale of wine in bottles and half-bottles only, and in quantities less than one dozen reputed quart bottles at one time, and not less than one reputed pint bottle.

(*d*) *Beer and wine.*—A composite license is granted under conditions necessary for holding a retail beer license or a retail wine license.

(*e*) *Cider.*—The sale of cider is covered by the beer and wine license. A retail off cider license is also granted.

(*f*) *Sweets.*—The wine license applies to the sale of sweets. A license is granted also for the sale of sweets only.

The retail "off" spirit license, the liqueur license, and the wine dealer's license may be taken out by a spirit or wine dealer without a justices' license for premises which are exclusively used for the sale of intoxicating liquors, mineral waters, and non-intoxicating beverages, and which has no communication with the premises of any person who is carrying on any other trade or business.

Justices' licenses or certificates are only granted at the general annual licensing meeting sometimes called the Brewster Sessions, which are held within the first fortnight of February. The justices are those who act for the division or place where the Brewster Sessions are held. Included in these justices are any stipendiary magistrates acting outside the metropolis. No one interested in brewery property, save a shareholder in a railway company which is a retailer of intoxicating liquor, may serve on the Brewster Sessions, and no justice must act with bias. In the fortnight preceding the holding of the Brewster Sessions the justices of the borough who are qualified to act, meet and appoint a Committee commonly known as the borough licensing Committee. The business of the Committee is to sit at the Brewster Sessions and hear and determine applications for new licenses and removal of licenses.

The justices have practically no limit fixed to the exercise of their discretion to grant or withhold the license; but the discretion which they exercise must be judicial, and not founded on caprice. A license must not be granted unless the applicant is a fit and proper person to hold it. The justices also consider the needs of the locality and whether it is advisable to add to the existing numbers of licensed houses.

When a license is granted it is not valid until it has been confirmed, in the case of a county division, by the County Licensing Committee, which is a body annually appointed by county justices in Quarter Sessions; by the justices of a borough, where there are ten or more justices of the peace; and by a joint committee in boroughs where there are less than ten justices of the peace. The discretionary powers of the confirming authority are the same as those of the justices at the

Brewster Sessions or at the Borough Licensing Committee; no fresh opposition can, however, be offered to the granting of a license.

A provisional "on" license, but not an "off" license, may be granted where premises are being built or about to be built. The license has to be confirmed in the usual manner.

There is no appeal from the decisions of justices or confirming authorities relating to a new license or provisional license or in declining to make a provisional license final.

There is, however, an appeal to the Quarter Sessions of the county if the justices refuse to renew a license; or, upon hearing the application for the renewal of an "on" license by any duly qualified person, make an order directing alterations in the licensed premises; or, if the justices at special sessions refuse to transfer a license.

The justices' license for holding an Excise license is available for one year only, and then has to be renewed. A provisional license also has to be renewed if it is not made final within a year. A holder of a license is entitled to the renewal of it as a right unless he has been served with a written notice stating in general terms the grounds of intended opposition to renewal, or, if at the General Annual Licensing Meeting objection is made in open court to the renewal. Except in the case of beer-houses which have been continuously licensed since May 1st, 1869, and "off" licenses for wines, spirits, liqueurs, sweets, or cider remaining in the possession of those who held them on June 25th, 1902, the justices may refuse to renew any license under the above-mentioned conditions.

A license may be transferred from one person to another, and in some instances from one house to another, by making application at a Special Session of the licensing justices held for that purpose. A license may, under certain conditions, be transferred before its expiration from one person to another in the event of the death, sickness, bankruptcy, change of tenancy, if the occupier of the licensed premises shall have neglected to apply for renewal, or, if the holder of the license has been convicted of certain specified offences.

It is apparent to most people who have studied the licensing question that the efforts of legislation during the past few years have certainly not been directed in favour of the licensee. In a number of instances the licensing justices would appear to act on the assumption that the facilities for procuring alcoholic beverages are more numerous than the genuine demand warrants. No doubt this is true in many districts, but the public should remember in this connection that brewers frequently surrender licenses. In the present craze for reduction of licenses it is by no means uncommon for the magistrates to show a decided tendency to seize upon any trivial offence as an excuse for instituting proceedings of objection to renewal. The Legislature has given the justices great discretionary powers, but it was never intended that every trivial conviction should be used as an argument that a particular license is not required. Lord Halsbury in one of his judgments uses the following language: "An extensive power is confided to the justices in their capacity as justices to be exercised judically, and discretion means, when it is said that something is to be done within the discretion of the authorities and that something is to be done according to the rules of reason and justice, not to private opinion; according to law, and not humour. It is to be not arbitrary, vague, and fanciful, but legal and regular, and it must be exercised within the limit to which an honest man, competent to the discharge of his office, ought to confine himself." It is to be feared that private opinion and humour by no means infrequently weigh in many of the decisions given by licensing magistrates and justices. There is, however, another side to the question. If the number of licensed premises is reduced, can it be reasonably hoped that less alcoholic liquor will be consumed? If the reduction is effected it follows that the remaining licensed houses secure the trade of the dispossessed ones. The tirades of the teetotal party in this country are too extreme to be worthy of much consideration; they would urge total abolition of alcoholic beverages, and consequently licenses, and it is not probable that their energy is likely to be inimical to the brewing trade. With the temperance party the matter is different, and most people are in sympathy with their aims. But then the question arises: Supposing the number of licenses were reduced in this country by 50 per cent., would the convictions for drunkenness be materially reduced?

It is doubtful, for police evidence shows (p. 170) that the numbers of licensed houses stand in no direct relations to arrests for drunkenness. Moreover, it would in all probably be harmful, for competition would be less keen and, as stated above, the remaining licensed premises would practically hold a monopoly. Under such conditions the Swiss Commission found that the demand for ardent spirits was increased. The public-house plays a part in our national life, for it is the club and common meeting-ground of the working classes. The man there is his own master, and within legal limits says and does what he likes; of course, excesses frequently happen, more so than in the restaurants and clubs used by the more educated classes. The habit of taking alcoholic liquor to excess will never be overcome by simply removing the source of supply. In individual cases it may be done, but in a free community it is impossible. Increase of education and improvements in habitations and surroundings, and rigid control of the kind of beverage offered for sale, more particularly with regard to spirits, are the chief factors which will militate against the desire of abnormal quantities of alcoholic beverages on the part of the labouring classes.

TIED HOUSES

Tied houses may be defined as licensed premises whose tenants have made a contract to purchase their liquors from certain specified firms. The tied-house system is so often attacked by opponents of the brewing trade that a few words may not be out of place in laying before the reader the relations which exist between the brewer and the license-holder. The following account is an abstract of a publication, issued by the Brewer's Hall, entitled *The Case for the Trade*, 1893–94. The custom relating to tied houses varies a little in different parts of the country—those of London may be taken as fairly representative. There are two classes of tied houses: (A) Freehold public-houses, owned by the license-holder, and leasehold public-houses, the property of private individuals unconnected with the trade, and leased to the license-holder; (B) Freehold and leasehold public-houses, the property of the brewer.

In Class A, which in 1893–94 comprised the bulk of public-houses in London, a license-holder, on purchasing a freehold or leasehold public-house, contracted a loan with the brewer in the event of his not having sufficient capital to pay all the purchase money. This loan is secured to the brewer by the license-holder executing a mortgage on his house. The deed of mortgage contains no clause binding the mortgager to deal with the mortgagee for beer or any article, but follows the ordinary form of trade mortgage at 5 per cent. per annum, a rate of interest which is commonly charged in any trade where a wholesale dealer advances money to a retail dealer with the expectation of obtaining trade.

During the life of the loan it is usual for the mortgager to deal with the mortgagee for beer. The brewer does not supply wines, spirits, or other articles. Another important point which is so often overlooked by the adversaries of the tied-house system is that the license-holder is quite at liberty to pay off the loan without notice and to transfer his trade to any other brewer he may wish. This is not uncommonly done by the license-holder contracting a fresh loan with another brewer, a bank, or private individual. From the foregoing it is clear that the license-holder has perfect freedom of action.

In Class B the brewer grants a long lease, not determinable, containing a clause that the lessee shall deal with him for beer. Now, in justice to the brewer, it should be remembered that such leases command high prices in the open market, and that they are the property of the lessee, who has invested his own money in them. He has the exclusive right to hold or sell, and any loss or gain consequent on the fluctuation in value of the property belongs to him. Usually there is no restricting clause inserted in the lease except for beer, and the lessee thus has the right of purchasing wines, spirits, etc., where he likes.

In other instances the brewer lets a house on a yearly agreement, under which the license-holder is tied for beer but for no other articles. These houses are let by the brewer at a rental without premium; and the goodwill, the fittings, and fixtures are the property of the license-holder and not the brewer.

It is also the custom for the brewer to make no difference in the price charged for beer to any license-holder, no matter under what conditions the house is held, although in some cases a larger discount is allowed to free customers than to tied. From this it follows that it is very much to the interest of the brewer to keep up the quality of the beer supplied, so that he may retain his customer. The license-holder having such an interest in his house, is bound to conduct his business in strict accordance with the law in order to prevent the depreciation of the value of his property.

The system of "management" is common in some provincial towns. In such cases the brewer is the owner of the property, and the business of the licensed premises is carried on by a manager who is paid wages.

The allegations against the tied-house system, and the reply to such allegations, are succinctly and admirably set forth in the following statement in the Brewer's Almanack for 1902:—

"Teetotal societies and other bodies and persons who are opposed to the trade frequently bring various charges against the tied-house system, the allegations usually taking some or all of the following forms. And most of these were advanced, and answered, before the Licensing Commission appointed in 1896 to inquire into the operation and administration of the laws relating to the sale of intoxicating liquors, and to examine and report upon the proposals that may be made for amending the aforesaid laws in the public interest, due regard being had to the rights of individuals.

"(*a*) That the publican or beer-house keeper is the manager and mere 'slave' of the brewer, dismissable at short notice; and that unless this state of things is altered the license ought not to be renewed.

"(*b*) That thus his interest in keeping good order in the house is very small, and to make a living he is under pressure to sell all the drink he can, even to customers who are obviously drunk; to allow his house to be used as a resort for bad characters, to the danger of the public; and to adulterate and dilute his liquors.

"(*c*) That the brewer supplies tied tenants with an inferior quality of beer and spirits, different from and higher in price than that which he supplies to other customers, and that the tied tenant is bound to accept such articles. Sometimes, that the beer is adulterated by the brewer with deleterious and poisonous ingredients, with the object of inducing thirst. Also that the tied tenant pays a higher rent than the 'free' tenant.

"(*d*) That it is to the brewer's profit to make a change of tenants, as on each change, in some way never clearly explained by those making the charge, he seizes the fixtures, etc., and resells them to the new tenant.

"(*e*) That the tenant of a so-called 'free' house is his own master, and therefore sells good beer, and does not, and is not likely to do, any of those things which a tied tenant does, to the detriment of the consuming public.

"The following are brief answers to the above charges, applicable to the majority of cases:—

"(*a*) The tenant of a house owned by a brewer, or tied to a particular firm, is not a mere manager, except in a comparatively small number of instances in certain parts of the country, where such a custom has grown up; nor is he a 'slave.' It is true that often there is a clause in his agreement which provides that the tenancy shall determine at once in the event of his allowing misconduct on his premises such as would be considered by the magistrates a ground for their refusal of the license. As is stated later on, the brewer is most desirous of keeping a good tenant, but it cannot possibly be to anyone's advantage that a bad one should be retained. No doubt the objection to this clause in the agreement arises from the wish of the teetotalers to see the house deprived of its license. If a bad tenant were allowed by the owner to continue in the house and misconduct it, such misconduct would certainly not be to the benefit of the public, but the house would stand a good chance of losing its license. The brewer and his tenant voluntarily enter into a personal and perfectly lawful contract as to the terms of the tenancy, with which the public have nothing to do, and which forms no reason in law or equity why the license should not be renewed.

"(*b*) The tied tenant's interest in his house is the same as that of any other man in his means of livelihood, and is relatively considerably greater than the brewer's. When he had the license transferred to him he must have been a thoroughly respectable man—to the satisfaction of the magistrates, the police, and his landlord. This character he forfeits if he misconducts his house; and to lose his good name is to lose his livelihood. This must tend to make him cautious and by no means callous to his own interests, which are identical with those of the brewer or wholesale firm from which he buys his beer, etc., viz. to make his trade safe and profitable. It is as inimical to his own as to the brewer's interests to supply drunken persons, harbour bad characters, or sell adulterated liquor. In addition, the supervison of the brewer, in his own interest, is directed to secure the good conduct of the house, lest the license should be endangered.

"(*c*) The charge as to the supply of inferior or adulterated liquors can at once be met by a challenge for proof —which, so far, in no single instance to our knowledge, has ever been taken up. The tied tenant, of course, need not accept goods from the brewer which are not merchantable; and the Sale of Food and Drugs Act, 1875, and the Inland Revenue authorities deal with adulteration and dilution. Besides all this, a house that sold bad liquors would lose its custom by the natural laws of competition. It is generally true that the tied tenant pays more for his beer than other customers. But the additional price is counterbalanced by the rent being very much *less*, instead of *more*, than the house would fetch in the market as a licensed house. Besides this saving in rent, the tenant, as a rule, pays nothing for goodwill, and the brewer does repairs and alterations—a very considerable item. Even if the brewer *did* charge a high rent no one would have a right to complain, because there is no compulsion on anyone to contract to pay it. The chief reason why a low rent is usually paid is because the brewer finds it difficult, in many cases, to collect a large sum quarterly, but by practically adding on to the price of the beer, which is paid for at frequent intervals, he is able to collect it, as it were, by small instalments, the payment of which is not so much felt by the tenant. It is asserted that the rent is kept low with the deliberate object of defrauding the rates by obtaining an assessment below the real value. If there were any truth in this, the attempt would obviously be useless. Surveyors of taxes and assessment committees are not to be hoodwinked by so simple a stratagem, being indeed only too prone to raise the assessment unduly, and the rent is not a proof of annual value.

"(*d*) This charge is refuted by perfectly obvious considerations. The brewer, as before stated, is anxious that a good tenant should remain in the house and make a fair living. On a change in the tenancy there is usually an account owing for goods supplied which the brewer loses entirely or in part. And the change is very often, apart from this, a source of monetary loss.

"(*e*) A free house is not merely one owned by the licensed tenant or a private individual, but is one where the tenant is free to buy his beer, etc., where he likes. Many are called free on which mortgages exist, and continue only so long as the mortgager takes his beer, etc., of the mortgagee or mortgagees. In London this custom prevails to a very large extent, and a would-be tenant has nearly always to pay a large sum for the lease and goodwill. To say, without proof, that a free tenant sells better liquors than a tied tenant is mere assertion. If he did, the free tenant ought to do all the business in a street where there are, say, two other public-houses which are tied. But he does not; a matter which is sufficiently proved by the patronage given to tied houses in the same street. If this is admitted, and the charge is still made, it can only be accounted for by supposing that the tied-house customers do not know what good liquor is, and so do not go to the public-houses where they can obtain it, but are foolish enough to consume beverages which are stated to be at least inferior, if not deleteriously adulterated. Such a hypothesis is ridiculous. The public know quite well which are good and which are bad liquors. This supposed preference for bad, when good liquor is as accessible, is especially absurd in the case of houses which have what may be called their *clientèle* and are not much used by strangers. Some exceedingly interesting evidence was given by Mr. Bannister, then Deputy-Principal of the Government Laboratory, before the Royal Licensing Commission touching this subject, which entirely supports the view that improvement has accrued in beer from the growth of large breweries; that there is no foundation for saying tied houses have worse liquor; and that brewery-made beer is far superior to any brewed by licensed victuallers on their own premises. Turning to the point of character, in the absence of proof, the assertion that free houses are in any way preferable to or are conducted more respectably than tied houses, is mere matter of opinion based on prejudice. A free publican is not likely to be less greedy of gain than a tied publican or the brewer, and the last has always to keep up the reputation of his beer, which is conspicuously advertised as being his both outside and inside the house. In the case of a free house, an unscrupulous brewer might possibly be tempted to urge a publican in his debt to adopt illegal methods of increasing the sale of his beer, because the forfeiture of the license would only mean to the brewer the loss of a customer—and that a doubtful one. But, if the house was his own, the brewer would be risking the loss of a customer and a valuable property. In the case of a tied house, both the tenant and owner are interested in conducting it respectably in every way to the satisfaction of the magistrates and the police. There is some analogy between a brewer's house and the premises belonging to large firms or bodies, such as the Aerated Bread Co., in London, the International Tea Co., and, we may add, the new Public-House Trusts. These businesses, however, are in every case conducted by salaried managers. These tied, or managed, shops receive as much, if not more, patronage than those carried on by individuals—and no one ever says that the things sold are impure. If they were, of course the public would take their custom to other shops, and thus the evil would be fairly remedied, because the establishments could only then be carried on at a loss to their proprietors. In these days of competition it is not possible to trade profitably for any length of time unless a good article is offered."

CHAPTER IX

THE PRESENT POSITION AND FUTURE PROSPECTS OF THE INDUSTRY IN THE UNITED KINGDOM

DURING the last three years there has been a slight decrease in the consumption of beer in the United Kingdom, which has been ascribed to diminished trade, the late South African War, and unseasonable weather. The following table shows the number of barrels of beer brewed in the United Kingdom for the last ten years, the materials used in brewing, and the amount of beer duty :—

Year.	Barrels brewed in United Kingdom.	Malt and corn used in Brewing. Bushels.	Sugar, etc., used in Brewing. Cwts.	Beer Duty. £
1893 ...	32,104,330	55,654,980	2,122,611	9,839,472
1894 ...	32,182,738	54,776,749	2,193,746	9,934,321
1895 ...	31,678,486	55,389,095	2,274,148	10,494,329
1896 ...	33,825,959	58,033,175	2,440,985	11,130,854
1897 ...	34,202,064	59,188,084	2,569,457	11,320,358
1898 ...	35,632,131	60,844,419	2,773,512	11,826,129
1899 ...	36,498,204	62,487,495	2,943,752	12,085,822
1900 ...	37,090,986	61,506,673	2,979,712	12,345,150
1901 ...	36,394,565	61,382,325	2,858,911	13,940,536
1902 ...	36,013,392	60,617,182	2,824,699	13,718,438
1903 ...	35,978,699	...	...	13,706,012

In 1903 England and Wales brewed 30,714,536 barrels; Scotland, 1,939,881 barrels; and Ireland, 3,324,282 barrels of the total quantity.

The amount of beer exported has not advanced to any extent during the last thirty years. The imports, however, are gradually increasing, although the trade done in this respect is very small. In 1903, 520,853 barrels were exported and 58,612 barrels imported.

The next set of figures are of interest in showing the acreage under barley, the estimated crop, and the average price per imperial quarter during the five years 1899–1903:—

Year.	Acreage.	Estimated crop in quarters of 400 lbs.	Average price per quarter. s.	d.
1899	2,159,414	9,316,550	25	7
1900	2,172,129	8,568,236	24	11
1901	2,140,908	8,455,398	25	2
1902	2,083,014	9,304,900	25	8
1903	2,021,823	8,163,710	22	8

There is a marked tendency towards a diminution in the acreage under barley. Coincident with this decrease there is a corresponding increase in the quantity of foreign barley imported. Thus:—

Year.	Imports of foreign barley in quarters of 400 lbs.
1899	4,813,020
1900	4,775,397
1901	6,124,560
1902	7,059,067

The increase in the amount of imported barley from 1899–1902 is striking. When Mr. Gladstone gave the free mash tun to the brewers, it became possible for farmers to sell barleys for malting purposes which before 1880 would have been unsuitable. This utilisation of second-grade English barleys has of necessity been followed by an increasing demand for foreign malts and malt substitutes, for malted low-grade English barleys will not alone yield the fresh, brilliant ales which the public increasingly demand.

Moreover, the bulk of the imported barley is grown and harvested under ideal conditions, and the crops are rarely subjected to the climatic ordeals that the English barley has to undergo. The result is that malts made from foreign barleys are generally far more uniform in character than English malts and materially help to correct any irregularities that the latter may impart to beer. These facts, no doubt, account for the increasing attention which brewers give to foreign barleys.

The supply of hops has been discussed in an earlier chapter.

Much is said and written against the brewing and allied industries with regard to the manner in which these are represented in the Legislature of the country. Enthusiastic reformers are apt to forget the enormous revenue derived from beer and spirits. In 1903 "the trade" supplied a quarter of the Exchequer receipts. If the prohibitionists were given a free hand the decreased revenue would have to be made up by some other form of taxation. Then with regard to the parliamentary power of the brewers. This is doubtless much exaggerated, but considering the vast capital invested in the brewing trade, the number of people to whom it gives employment, the revenue derived from it, and the fact of its being one of the largest industries in the country, may reasonably account for 5 per cent. of the members of the House of Commons being connected with the brewing and spirit trade.

The following figures, which are taken from the Reports of the Commissioners of Inland Revenue and Customs, show the magnitude of the trade:—

Year.	Total taxation from the beer, wine, and spirit trade. £	Total Exchequer receipts. £	Percentage of trade taxation to Exchequer receipts.
1899	34,564,273	108,336,193	31·90
1900	37,834,297	119,839,905	32·36
1901	39,138,995	130,384,684	30·01
1902	37,138,588	142,997,999	25·97
1903	37,875,956	151,551,698	24·99

The number of licenses taken out by brewers in the United Kingdom is steadily diminishing:—

Year.	Brewers' for sale.	Brewers' not for sale.	Total.
1899	6,888	14,009	20,897
1900	6,447	12,734	19,181
1901	6,110	12,410	18,520
1902	5,898	11,872	17,770
1903	5,692	11,752	17,444

This, so far as the licenses for brewers for sale is concerned, is in a measure accounted for by the absorption of small breweries by larger ones, and by the decrease in trade. The table below shows this, also the relation of licenses for brewers for sale to barrels of beer brewed.

Year.	Under 1,000.	1,000 and under 10,000.	10,000 and under 20,000.	20,000 and under 100,000.	100,000 and under 500,000.	500,000 and over.
1899 ...	5,167	945	259	318	42	8
1900 ...	4,759	910	262	308	42	9
1901 ...	4,448	911	263	295	42	9
1902 ...	4,254	904	240	302	41	9

Owing to the difficulties of preparing a fairly sound and bright beer in the primitive plants that private brewers use, it is probable that the number of these licenses will continue to decrease. Most of the licenses are taken out by farmers and other employers of agricultural labour for brewing beer during the harvest season.

It is difficult to arrive at the amount of capital invested in the brewing and distilling industry in the United Kingdom. According to the "Brewers' Almanack" (1904), the capital of limited liability brewery companies is about £185,000,000. In addition there are a large number of breweries about which no data can be obtained, as well as distilleries. The total probably amounts to £240,000,000. The brewing, distilling, and wine industries of the United Kingdom are computed to give employment to 2,000,000 persons, or roughly to one-twentieth of the whole population of these islands.

The relation between the brewing trade and agriculture is a close one, and, so far as this country is concerned, was more intimate twenty-five years ago than it is at present. The agricultural party were strenuous supporters of the "free mash tun" Act of 1880, for it was felt that the malt tax seriously affected barley growing, and was an excessive burden on agriculture. One result of the repeal of this tax was that second-grade English barleys, which before were sold at far lower prices for feeding purposes, became available for malting, and an increased acreage under barley resulted. But, as was previously pointed out, the use of second-grade English barleys necessitated an increasing use in foreign barleys and substitutes. Thus the farmers did not get as much benefit as they anticipated by the repeal of the malt tax. In consequence of these disappointed hopes they have from time to time engineered agitations against the brewers with the object of placing a limitation on the "free" mash tun. Beer, according to them, should be brewed from malt and hops only, with the exception of 3 per cent. of sugar for priming, and beers containing sugar and malt substitutes should be labelled as such. The question of "pure beer" was submitted to a parliamentary inquiry, and the Beer Materials Committee reported in 1899 that they were unable to find any grounds why Parliament should alter the existing law. The only way in which it seems possible to mend matters, from the farmers' point of view, would be to place a heavy import duty on imported malting barley and prohibit substitutes. This, were it within the range of practical politics, would mean a complete upheaval of the brewing trade. To put the matter quite plainly, can the country afford to cripple seriously an industry which provides so great a portion of the Exchequer receipts? The brewers are quite aware that many of the customs of their trade are open to improvement from the point of view of the public good, and from year to year beneficial changes are taking place.

The official police returns completely refute the statement so frequently put forward by the teetotal party, that the number of licensed houses a town has exerts an appreciable influence on the amount of liquor a man drinks. If this surmise were true, the towns and districts possessing the greatest number of licensed premises should have the greatest amount of drunkenness.

The following table, taken from a Parliamentary Return for 1895, shows the six boroughs with a population of more than 100,000 having the highest, and the six having the lowest number of police court proceedings taken for drunkenness, with their number of licensed houses per 100,000 inhabitants:—

Borough.	Arrests for drunkenness.	Licensed houses.
Newcastle-on-Tyne .	2,841 ...	373
Liverpool . . .	1,532 ...	419
Manchester . .	1,254 ...	600
Salford . . .	1,132 ...	518
Cardiff . . .	880 ...	261
Sunderland . .	767 ...	434

Borough.	Arrests for drunkenness.		Licensed houses.
Norwich . . .	87	...	611
Bradford . .	159	...	428
Brighton . . .	232	...	608
Portsmouth . .	244	...	654
Bolton . . .	304	...	440
Sheffield . . .	306	...	558

These figures conclusively show the inaccuracy of the teetotal contention.

The temperance problem is one of great importance for the future welfare of our country and our race. At the present time a strenuous struggle is taking place between the prohibitionist or teetotaler and the trade. But it is doubtful whether the result of the conflict will to any extent directly touch the root of the matter. What we want is a thorough and exhaustive investigation of the drink problem on economical and scientific lines. This was done some years ago in Switzerland, and it seems regrettable that we cannot follow in these footsteps.

From the evidence submitted, the Swiss Commissioners were of opinion that the highest degree of inebriety and alcoholism prevailed in localities which had the smallest number of drinking-places, the drink generally consumed being ardent spirits. In confirmation of this the greatest sobriety prevailed in places where the drinking facilities were greatest; the beverages consumed being fermented liquors. Under the operation of laws designed to restrict the entire traffic, fermented beverages were driven out by distilled spirits. The main conclusion arrived at was that a reduction of drinking-places for purposes of diminishing drunkenness was absolutely inessential, but that the nature of drinks offered for sale was of the utmost importance.

The amount of beer consumed *per capita* in the different countries varies considerably. A Parliamentary Return relating to alcoholic beverages gives the following figures for 1899:—

Country.	Beer. Gallons per head.
France	6·2
Switzerland	15·4
Belgium	46·9
Italy	0·13
Denmark	22·0
Austria	15·8
German Empire	27·5
Bavaria	54·6
Wurtemburg	42·2
Baden	38·1
United Kingdom	31·7
United States	13·3

Germany is now the largest beer-producing country, the United Kingdom follows, whilst the United States comes third. In 1902 the beer-production of the world was 160,420,500 barrels. The increase over 1901 was 1,573,610 barrels.

So far as the United Kingdom is concerned, beer is still the national beverage, and there appears every likelihood of its continuing to remain so. The increased consumption of spirits is an unfavourable sign, and it is to be hoped that the public authorities will invoke the aid of the Food and Drugs Act and prevent the large amounts of raw spirit being sold as the matured article.

No doubt the economic influences of the day, which attract large populations into limited areas, account for the increasing demand for stimulants in the form of ardent spirits. It is unfair to class beer, wine, and spirits together, for their relative effects are very different on the human race. Beer and unfortified wines, containing as they do but small quantities of alcohol, can be freely drunk without injury to the individual; spirits, on the other hand, unless used very moderately, rapidly affect the vital powers.

Alcohol, in some form or other, appears to be a necessity for mankind, and beer is certainly the most popular of the alcoholic beverages. This fact is not lost sight of by brewers, and every effort is made by them towards producing the beer which the public demand. If any support of this statement is necessary, one need only refer to the recent introduction of lager beer, brewed in this country on German lines. This beer is rapidly becoming popular amongst certain classes of society, but the amount brewed is infinitesimal compared with "mild ale," which is still the favourite beer of the working classes, and it should always be remembered that they form the main body of beer-drinkers in this country.

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