BAKHMUT, a town of Russia in the government of Ekaterinoslav, near the river from which it derives its name. It owed its origin in the latter half of the 17th century to the discovery of salt-springs, which ceased, however, to be utilised in 1782. Its present importance is chiefly due to the extensive coal-deposits in the vicinity. Population, 16,791

BAKING. The art of baking consists in heating anything in an oven or fire so as to harden it, and in this sense the term is used when applied to the manufacture of bread, porcelain, pottery, and bricks. It is also applied to certain modes of dressing or cooking animal food; thus we speak of baked meats, pies, &c. In the present article the baking of flour or meal for use as human food will alone be treated of.

The origin of baking, as of most arts of primary importance, precedes the period of history, and is involved in the obscurity of the early ages of the human race. Excavations conducted on the site of some of the numerous lake dwellings of Switzerland have resulted in the discovery of abundant evidence that the art of making bread was practised by our prehistoric ancestors as early as the Stone Period. Not only have stones for grinding meal and baking bread been discovered, but bread itself in large quantities has been disinterred, preserved by being carbonised in the fires which frequently destroyed the pile-dwellings of the primitive inhabitants of the world. At Robenhausen, Meisskomer discovered 8 lb of bread, a weight which would correspond with about 40 lb of newly-baked bread. At Wangen there has been discovered "actual baked bread or cake made of the crushed corn, precisely similar to that found about the same time by Mr Meisskomer at Robenhausen. Of course, it has been burned or charred, and thus these interesting specimens have been preserved to the present day. The form of these cakes is somewhat round, and about an inch to an inch and a half in diameter. The dough did not consist of meal, but of grains of corn more or less crushed. In some specimens the halves of grains of barley are plainly discernible. The under side of these cakes is sometimes flat, sometimes concave, and there appears no doubt that the mass of dough was baked by being laid on hot stones and covered over with glowing ashes."—(Keller's *Lake Dwellings*, Lee's Translation, p. 63.)

The very early mention of bread in written history further bears out the great antiquity of the art of baking. Bread is first specifically mentioned in Genesis xviii. 5, when Abraham, wishing to entertain the three angels on the plains of Mamre, offered to "fetch a morsel of bread;" and the operation of baking is immediately thereafter alluded to in the instructions to Sarah to "make ready quickly three measures of fine meal, knead it, and make cakes upon the hearth." At the same time, when, in the city of Sodom, Lot entertained two angels, "he made them a feast, and did bake unleavened bread, and they did eat" (Genesis xix. 3). It may be inferred from the mention of unleavened bread that, in those patriarchal times, the two great classes of bread were known and used. At a period little later the art of baking was carried to high perfection in Egypt, which then took the lead in the arts of civilised life. The Egyptians baked cakes and loaves of many varieties and shapes, in which they employed several kinds of flour, and they flavoured their bread with various aromatic ingredients. The chief baker of Pharaoh, who was in prison along with Joseph, doubtless pursued his craft in its essential features in the same way as bakers do at the present day.

From ancient Egypt excellence in the art of baking travelled with the march of civilisation into Greece, and the allusions to bread in the works of classic authors are very numerous. In *The Deipnosophists* of Athenæus mention is made of no less than sixty-two varieties of bread as known among the ancient Greeks, and minute descriptions of many of them are given. We learn from Pliny (*Nat. Hist.*, xviii. 28) that professional bakers were first introduced into Rome at the close of the war with Perseus, king of Macedon. By the practical Romans the baking trade was formed into a kind of incorporation or guild, with special privileges and immunities attached to the calling. Public bakeries were distributed throughout the city, to which slaves were assigned for performing the heavier and more disagreeable tasks connected with the occupation. Grain was delivered into public granaries by enrolled *Saccarii*, and it was distributed to the bakers by a corporation called the *Catabolensee*. No separate mills for grinding corn then existed, the grain being pounded and sifted in the bakeries, and hence the Roman bakers were known as *Pistores*. A special magistrate was appointed to take cognisance of every matter connected with the management of public bakeries.

The calling of the baker during the Middle Ages was considered to be one so closely affecting the interests of the public that it was put under strict regulation and supervision, and these special restrictions continued to affect the trade down to very recent times. In England, an Act of Parliament was passed in 1266 for regulating the price of bread by a public assize, and that system continued in operation till 1822 in the case of the city of London, and till 1836 for the rest of the country. The price of bread was determined by adding a certain sum to the price of every quarter of flour, in name of the baker's expenses and profit; and for the sum so arrived at tradesmen were required to bake and sell eighty quartern loaves, or a like proportion of other sizes, which it was reckoned each quarter of flour ought to yield. The following table exhibits the assize price of bread in London in 1814:—

Price of Flour in Shillings.	Price of Quartern Loaf.	Price of 8-lb Loaf.	Price of 4-lb Loaf.	Price of 2-lb Loaf.	Price of 1-lb Loaf.
	s. d.	s. d.	s. d.	s. d.	s. d.
30	0 6½	1 0	0 6	0 3	0 1½
35	0 7½	1 1½	0 6½	0 3½	0 1¾
40	0 8	1 2½	0 7½	0 3¾	0 1¾
45	0 8¾	1 4	0 8	0 4	0 2
50	0 9½	1 5½	0 8¾	0 4½	0 2¼
60	0 11	1 8½	0 10½	0 5	0 2½
70	1 0½	1 11	0 11½	0 5¾	0 3
80	1 2	2 1¾	1 1	0 6½	0 3¼
90	1 3½	2 4½	1 2½	0 7½	0 3¾
100	1 5	2 7½	1 3½	0 7¾	0 4

The art of making bread made its way northwards very slowly; and even at present, in the northern countries of Europe and Asia, loaves of bread are seldom used except by the higher classes of inhabitants. In Sweden, for example, rolls are frequently seen in the towns, but loaves rarely. Towards the end of 1812 the captain of an English packet ordered a Gothenburg baker to bake for him a quantity of bread, to the value of £1 sterling. The baker was confounded at so large an order, and refused to comply till the captain gave him security that he would carry off and pay for the loaves, declaring that he could never dispose of so great a quantity of bread in Gothenburg if it were left upon his hands. In the country part of Sweden no bread is made but rye-cakes, nearly as hard as flint, which are only baked twice a year. About a century ago loaf-bread was almost as rare in the rural districts of Scotland, *barley bannocks* and *oaten cakes* then constituting the universal substitutes among almost all ranks. In many parts of England it is the custom for private families to bake their own bread. This is particularly the case in

Kent, and in some parts of Lancashire. In the year 1804 the town of Manchester, with a population of 90,000 persons, did not contain a single public baker. Bakers in Great Britain are now placed under the provisions of "The Bakehouses' Regulation Act, 1863" (26 and 27 Vict. cap. 40), a statute passed after a searching inquiry into the condition of bakehouses in London and of the persons employed in them. By this Act no young person under the age of 18 is permitted to work in a bakehouse between the hours of 9 P.M. and 5 A.M., and special enactments provide for securing the cleanliness and ventilation of bakehouses, and for the regulation of sleeping apartments connected with them.

As compared with wheat-flour all other materials used for making bread are of comparative insignificance. Oat cakes still form a staple article of food in many rural districts of Scotland, and are occasionally used in other countries. They are made by mixing up oatmeal, warm water, and salt, sometimes with the addition of butter or fat, into a very stiff paste, and kneading this out into a thin cake, which is first fired on a hot plate or "girdle," and finished in front of an open fire. Scones of barley-flour, sweet and tough, were formerly largely used in Scotland, but have now given place to a similar preparation of wheaten flour. Rye bread, both fermented and unfermented, is largely consumed by the inhabitants of the northern parts of Europe in the poor and backward districts. Cakes of maize meal, baked like oat cakes, are consumed in some parts of the United States. The meal of various species of millet is used in Southern Europe to form bread; and in India and China, durra (*Sorghum vulgare*) and other cereal grains are baked for food. Of non-cereal flours, the principal used for bread-making is buckwheat. *Fagopyrum esculentum*, extensively employed in Russia and Holland. The flour of pease, beans, and other leguminous seeds, are also baked into cakes; and cassava cakes are made from the meal of the tapioca plant, *Jatropha Manihot*, in South America. Excepting rye, none of these substances is used for making vesiculated or fermented bread.

The grain of wheat consists of an outer husk or covering, an embryo or germ, and a central mass of farinaceous material. The outer husk is composed of several distinct layers of ligneous tissue, closely adhering to the seed, and very hard in texture. In grinding, this is detached in scales, and constitutes the chief proportion of the bran. The inner portion of the envelope is softer, and contains an active nitrogenous principle, termed cerealin, and is besides rich in fat and salts. This portion goes with the pollard or parings in the dressing of wheat flour. Towards the centre of the grain the substance becomes whiter in colour and more friable in texture, so that, in grinding, the finest flour in consistence is always the whitest in appearance. By agriculturists several hundred varieties of wheat and a number of distinct species are recognised; but in commerce the grain is distinguished as white and red, or as hard and soft wheats. There is a considerable range of difference in the proportions of their proximate constituents, hard wheats as a rule being much more nitrogenous than the soft varieties; and similarly, wheats grown in hot climates are also usually richest in nitrogen. The following analyses of two typical varieties of wheat are taken from Payen's tables, water being neglected:—

	Hard Wheat. Taganrog.	Soft Wheat. Touzelle.
Nitrogenous matter	20·00	12·65
Starch	63·80	74·51
Dextrin	8·00	6·05
Cellulose	3·10	2·80
Fatty matter	2·25	1·87
Mineral matter	2·85	2.12

When wheat is ground it is sifted or dressed into a series of mill products, ranging from fine flour to bran, according to the size of the ground particles. The divisions vary in different mills and localities; but the accompanying table—the result of an elaborate series of experiments by Messrs Lawes and Gilbert—may be regarded as a standard of the relative proportions of mill products:—

Mean Yield of Flour, Bran, &c., in 100 parts Meal.

	Wheat of 1846. 7 Cases.	Wheat of 1847. 19 Cases.	Wheat of 1848. 2 Cases.	Mean of the 28 Cases.
1. Wire 1	44·0	35·7	47·4	41·1
2. Wire 2	17·9	16·4	23·9	18·6
3. Wire 3	8·7	13·3	2·0	9·2
Amounts of 1, 2, and 3 together	69·3	70·2	73·3	70·2
4. Tails	4·9	5·8	2·1	5·3
5. Fine Sharps or Middlings	10·2	8·7	4·5	8·8
6. Coarse Sharps	3·5	3·3	3·6	3·4
7. Fine Pollard	3·9	1·8	2·6	2·4
8. Coarse Pollard	4·4	7·2	7·9	6·5
9. Long Bran	3·5	2·5	5·9	3·0

The tails and fine sharps are generally passed through the mill a second time, bringing up the yield of flour to about 80 per cent. of the entire grain. As an example of mill products in practice, the following table is copied from the actual mill receipts of a Scotch miller. The quantity dealt with represents 16 quarters of wheat, weighing 63¾ lb per bushel, in all 578 st. 11 lb. The yield was—

	St.	lb
Fine Flour	414	0
Odd and Second Flour	23	13
Parings (Sharps and Pollards)	36	12
Bran and Shellings	92	0
Waste	11	0

The composition of flour and bran given in the understated table is the mean result of a series of fourteen analyses by Peligot:—

	Flour.	Bran.
Water	14·0	10·30
Fatty matters	1·2	2·82
Nitrogenous substances insoluble in water (gluten)	12·8	10·84
" " soluble " (albumen)	1·8	1·64
Non-nitrogenous soluble substances—dextrin, sugar,	7·2	5·80
Starch	59·7	22·62
Cellulose	1·7	43·93
Salts	1·6	2·52

It is a disputed point whether dextrin or sugar exists in flour of the best quality; but the action of heat and moisture in the baking process quickly transforms a portion of the starch into the soluble condition. In flour of inferior quality a large percentage of dextrin is usually found—a circumstance very detrimental to its bread-making qualities. A table of the percentage of gluten, obtained by Messrs Lawes and Gilbert from a large number of flours, shows a variation from 8·9 to 14·9 per cent. This gluten itself (the insoluble nitrogenous substance in flour) is a compound body, composed of three or four distinct substances; but its physical conditions of elasticity, tenacity, and colour are of much greater importance to the baker than either its chemical constitution or its amount.

The varieties of wheaten bread are divisible into two great classes—*Unvesiculated* and *Vesiculated* Bread. Under the first head are included such products of the art as are fired or baked without first being raised or rendered spongy by the development of carbonic acid gas within the mass, either by fermentation or otherwise. Vesiculated bread is produced when carbonic acid is either developed in or introduced into the dough, so as to permeate the mass with an infinite number of minute cavities, which render the product light and spongiform.

Unvesiculated Bread.—The simplest form of bread, and the rudest baking, are seen in the Australian "Damper," a cake made from dough composed of flour, salt, and water, baked in the dying embers of a wood fire. The dough is laid on a flat stone, covered with a tin plate, and the hot ashes heaped around and over it, care being taken not to expose it to a heat of more than 212° Fahr. Pass-over cakes, scones, and "bannocks" are prepared from a similar dough, and fired on hot plates or in ovens, and form an agreeable and nutritious food. When such dough is exposed to a high heat, so that the resulting cake is hard, dry, and resonant, biscuits (*bis cuit*, twice baked) are formed.

Biscuit Manufacture.—Biscuit making is a branch of trade distinct from ordinary baking, conducted under different conditions, and requiring machinery and processes peculiar to itself. Biscuits are made by a rapid and continuous process; they can be preserved a long time, and in proportion to their price they occupy little space, so that it is practicable to sell them in markets remote from the place of manufacture. The manufacture of biscuits is now conducted on a very large scale, ingenious and complicated machinery is employed in the various processes, and a large export trade in biscuits has grown up. The firm of Messrs Carr & Co., of Carlisle, was the first to originate the manufacture, and that firm still possesses one of the largest and best-appointed establishments. To the partners of this firm we are indebted for much information as to the processes employed in this modern industry.

The general arrangements of a ship-biscuit factory are shown in the sectional view, fig. 1. The flour stored on the

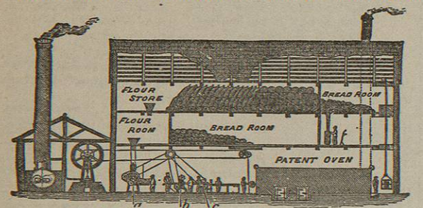

Fig. 1.—Sectional view of Ship-Biscuit Factory.

upper floor is passed down through a shoot to the flour-room, where it is sifted to free it from knots or lumps. In the making of plain water or ship biscuits, the flour is shot directly down into the mixer *a*, on the ground floor, in quantities usually of one bag at a time, to which the requisite quantity of water, regulated by a gauge-glass, is added. The mixer is a cylindrical vessel of cast-iron, in which a series of knives or arms is kept revolving on a central axis. The revolution of these knives is sufficient to incorporate the flour and water thoroughly into a very stiff dough in about seven minutes. From the mixer the dough is delivered on a table in large amorphous masses, and it is next carried forward to the brake machine *b*. The brake consists of two heavy iron rollers, having generally a reciprocating motion, between which the dough is passed backwards and forwards several times till it is rolled out into a plate or sheet of uniform thickness and consistency. The sheet of prepared dough is next carried forward to the cutting and panning machine *c*, a highly complex and ingenious apparatus, the principle of which is shown in fig. 2. In this machine the dough is first passed between a pair of gauge rollers *a*, graduated to secure a sheet of any desired uniform thickness, from which it is received on an endless sheet of felt *b*. On this web the sheet of dough is carried forward by intermittent motion to a punching apparatus *c*, in which moulds or cutting edges of the

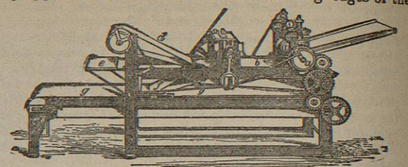

Fig. 2.—Cutting and Panning Machine.

size and form of biscuit desired are arranged. Here the biscuits are cut out, the scrap being caught on a web *d*, and carried upward till it falls over in a box or trough on the table *e*, from which it is returned to the brake machine. The biscuits are carried down the web *f*, and fall into tin trays, which are fed in at *g* by a boy, and move forward at the same rate the biscuit web travels, so that they are ready for being immediately placed on the travelling stage of the patent oven. The processes are so arranged that the oven carries forward the biscuits as quickly as they are delivered by the cutting machine, and in some cases the ovens are fed direct from the cutting and panning apparatus by automatic machinery. The patent travelling ovens are constructed from 30 to 44 feet long, and fitted with endless webs either of plates or chains. The chain webs are used for baking small and fancy biscuits, such as are placed in trays, and the plates are used for large and plain water biscuits, which are placed by hand on the travelling plates. The rates at which biscuits of different sizes and degrees of richness must traverse the whole length of the oven varies from about five to forty minutes, and the temperature of the oven has also to be modified to suit the various qualities. Both the heat and rate of motion are under easy and adequate control in the patent ovens.

There is an endless variety in the form and composition of plain and fancy biscuits. In the trade list of Messrs Vicars, of Liverpool, the chief manufacturers of biscuit machinery, the names of 128 varieties of cutters are mentioned. In the making of fancy biscuits, milk, eggs, sugar, butter or lard, and flavouring essences are extensively used, and in these cases the proportions of the various ingredients are roughly mingled before being sent down the shoot into the mixer. The richest class of biscuits, the dough for which is necessarily soft, are cut out by hand labour, and fired on trays in common ovens. The dough for rout biscuits is placed in a strong metal box or chamber in which a piston is tightly fitted. The piston is moved forward by a screw, and it pushes the dough through a series of holes or dies. The dough is received on a sliding board, and is cut into proper lengths by a knife. Cracknels are made without either milk or water being used to mix the dough, eggs alone being employed for this purpose. Certain proportions of butter, sugar, and sesquicarbonate of ammonia are added to the mixture of flour and eggs, and the dough is baked in the usual way. The cracknels, when cut out, are thrown into a boiler of boiling water, and in about two minutes they float to the top. They are then fished out and thrown into cold water, and then drained on cloths, panned, and fired in an ordinary oven at a high heat. In the firing, the ammonic carbonate, being very volatile, is driven off, and the cracknel thus assumes its spongy structure. Many other varieties of biscuits are rendered light and spongiform by the use of the sesquicarbonate of ammonia, or of carbonate of soda, in conjunction with sour milk. In the firing of biscuits, not only the moisture of the dough is driven off, but a certain proportion of the water held by the flour in its apparently dry state, so that from 10 lb of flour only about 9 lb of water biscuits are obtained. The composition of plain biscuit is given by Dr Parkes as follows:—

Water	8 to 12	Sugar	1·9
Nitrogenous substances	15	Fat	1·3
Dextrin	3·8	Starch	72 to 75

Vesiculated Bread.—Under this head is included such bread as is rendered spongiform in structure by the action of carbonic acid within the dough, and which is not baked hard and dry as in the case of biscuits. It includes ordinary loaf bread, pan loaves, French or Paris loaves, cottage loaves, bricks, rolls, buns, and many varieties of fancy bread distinguished by local names and minor differences of form and composition. Vesiculated bread is made in three different ways:—

1*st*, By the development of carbonic acid within the dough through fermentation of the flour. This is the ordinary and principal method of bread-making.

2*d*, By mixing the dough with water previously aerated with carbonic acid. The aerated bread made under the patent of the late Dr Dauglish is thus manufactured.

3*d*, By the disengagement of carbonic acid from chemical agents introduced into the dough. Dodson's patent unfermented bread comes under this head, and the "baking powders" and "yeast powders" extensively sold consist generally of carbonate of soda or ammonia and citric or tartaric acid, which evolve carbonic acid in presence of water.

Fermented Bread.—The manufacture of fermented or leavened bread is, as has already been hinted, of very great antiquity, and it is still by the fermentation process that bread is chiefly made. In ancient times leaven was employed to induce fermentation in dough ("a little leaven leaveneth the whole lump," Gal. v. 9), and to this day Parisian bakers, who excel all others in the quality of the bread they produce, chiefly use the same ferment. Leaven is simply a portion of dough, put aside from a previous baking, in which the fermentative action has reached an advanced stage of activity. Yeast, however, has been used as a ferment from an early period, and it appears that it was first so employed in France. Pliny says (*Nat. Hist.*, xviii. 12), "Galliæ et Hispaniæ frumento in potum resoluto, spuma ita concreta pro fermento utuntur; qua de causa levior illis quam cæteris panis est." The use of yeast appears to have died out in France, but was revived again towards the end of the 17th century, when its reintroduction was violently opposed by the Faculty of medicine of Paris. Yeast is now used by Parisian bakers for fancy bread and pastry only.

The baking of fermented bread involves three distinct operations, which are technically denominated "setting the sponge," making the dough or kneading, and baking or firing. It will be convenient first to describe these processes as they are conducted in a London bakehouse. The first duty of the baker is to mix a ferment, which consists of a mixture of potatoes, yeast, and flour. The potatoes, in the proportion of 6 lb to a sack of flour, are boiled and mashed in a tub, and water is stirred in till the mixture is reduced to a temperature of from 70° to 90° Fahr. About 2½ pints of yeast and 12 lb of flour scalded in boiling water are then added, and the whole forming a thin uniform paste is set aside for several hours, during which it undergoes an active fermentation. Setting the sponge consists in mixing the ferment in a large trough with flour and water sufficient to make the whole into a rather stiff paste. The flour used at this stage, when "full sponge" is made, should be about one-half the entire quantity intended to be used in the "batch," and the ingredients have to be thoroughly incorporated by the workman stirring them laboriously together with his arms. The operation occupies from twenty minutes to half an hour, and when ready the sponge is covered over and allowed to rest for several hours according to the temperature at which it is maintained. Generally in from four to five hours the sponge "rises;" fermentation has been going on, and carbonic acid steadily accumulating within the tenacious mass till it has assumed a puffed out appearance. By degrees the sponge gives off the gas in puffs, and the mass begins to collapse, till what was a swollen convex surface assumes a somewhat concave form, the centre being depressed while the sides adhere to the edges of the trough. The workman judges by the amount of collapse the time the sponge is ready to be taken in hand for kneading or making the dough. This process is thus described by an eye-witness:—"The batch consisted of a sack and a half of flour, nearly one-half of which had been used in making the sponge. Two men commenced breaking the sponge at 1.4 P.M. Having poured the water into it, they plunged their arms in and stirred it about until it became of the consistency of thin batter. At 1.10 they began to mix the dry flour with it, immediately upon doing which they were enveloped in a cloud of flour dust, their heads being bent down to within a few inches of the mass they were handling. Flour and pieces of dough were splashed over the trough upon the floor. At 1.12 a third man was added. Their hair, caps, and face powdered thickly with the dust, a thick cloud of which was thrown up with every movement, especially when large masses of dough, as it became a little solid, were taken up in their arms and thrown upon the rest, fresh flour being first strewn between. At 1.15 one of the men became very red and heated. The other two were very pale, and did not show any perspiration. At 1.16 the cutting off of large masses began, as much as two men could lift to place over the adjoining mass. At 1.23 the men began to pound the mass with their fists. At 1.26 one of the pale men, who was also very thin, began to look red and hot. At 1.29, after smoothing the mass down, they began again to pound it with their fists. At 1.30 it was again smoothed over, the sides of the trough scraped, and a little dry flour thrown over it. It was then considered finished."[1] After this laborious process the finished dough is covered over for some time, varying from half an hour to two hours according to the temperature, during which fermentation again begins, and the mass is "proofed." It is then "scaled off," *i.e.*, weighed on scales in pieces of 4 lb 4 oz., if 4-lb loaves are to be made, or half that amount for 2-lb loaves; and as rapidly as weighed it is "moulded" into the form of the loaf, when it is ready to put into the oven. Flour of good quality will take up about 17 gallons of water in course of the foregoing operations, and before putting into the oven the ingredients of a 4-lb loaf will be—

	lb	oz.
Flour	3	2
Water	1	1½
Yeast	0	0½
Potatoes	0	1½
Salt	0	0½

A loaf ready for going into the oven has about half the bulk it attains during the process of firing. Batches of cottage and household loaves are packed close side by side on the sole of the oven, the sides of each loaf being rubbed with butter to prevent them from adhering to each other, and they are consequently crusted on the top and bottom only. Pan loaves are baked each in separate tinned pans of the form of the loaf, and Parisian loaves are baked end to end in long tinned pans. The firing of bread in the oven occupies from 1 to 1½ hours, the temperature at the

[1] Tremenheere's *Report on Journeymen Bakers*.

beginning of the process being from 550° to 600° Fahr. The baker can ascertain if the oven is at a proper temperature by throwing a little flour on the sole of the oven, which ought to turn to a light brown colour. Ovens in London are usually built of brick, with a sole only 2½ inches thick; in Scotland stone is used, the sole being from 10 to 12 inches thick, and the oven consequently retains heat much more effectually

In Scotland the system of using ferments is not generally practised as in London, some of the varieties of yeast or barm being mixed directly with the flour. In some localities the system of setting "quarter sponge" is adopted, in which the sponge originally prepared contains only one-fourth of the flour to be used. To this, after an interval of about twelve hours, more flour and water are added, which brings it up to half sponge, and about two hours thereafter the mass is ready for making the dough. In Paris, where bread-making is carried to the highest perfection, leaven, as has already been mentioned, is the fermenting agent employed. This consists of a portion of dough laid aside from a previous baking in a uniform temperature for seven or eight hours, during which it swells and acquires an alcoholic odour. This, termed "the chief leaven," is taken and worked up with flour and water to a firm paste double its original mass, when it becomes "the first leaven." After an interval of six hours the amount is again doubled, forming the second leaven. The "complete leaven" is formed by doubling the size of the second leaven, and the proportion the complete leaven bears to the finished dough is about one-third in summer and one-half in winter.

Sound flour yields from 90 to 94 4-lb loaves per bag of 280 lb, some "strong" flours giving even a greater quantity of bread. A table of experiments, conducted by Messrs Lawes and Gilbert, gives a mean result of 135·2 of bread from 100 of flour; and in the observations of a large number of English and French authorities quoted by them, the ratio of bread to 100 of flour varied from 127 to 150. The following table gives the mean of 25 analyses of the bread of London bakers by Dr Odling:—

Water	43·43
Organic matter	55·26
Mineral matter or ash	1·30
Percentage of ash in dry bread	2·30
,, nitrogen in new bread	1·26
,, ,, in dry bread	2·22

The bakers' standard of excellence of flour, apart from the question of colour, is the weight of bread it will produce of a proper dryness and texture. The "strength" of flour in this respect appears to depend much more on its condition than on the absolute percentage of its constituents.

Panary Fermentation.—It would be altogether out of place in this paper to refer to the conflicting theories as to the cause of fermentation in organic substances. The so-called panary fermentation in bread-making is a true alcoholic fermentation, and whether induced by yeast or leaven the result is precisely the same. The gluten of the flour is the fermenting agent, and it is stirred into activity by contact with a glutinous body already in an active condition, which may be either yeast or leaven. In this condition it exerts a fermentative influence over the sugar which may either have existed previously in flour, or which is at least immediately developed in it by the influence of moisture. The active gluten splits up each molecule of sugar into two of alcohol, two of carbonic acid, and one of water, and consequently an infinite number of minute air bubbles are developed throughout the fermenting mass. The reaction is shown in the following equation: $C_6H_{12}O_7 = 2C_2H_6O + 2CO_2 + H_2O$.

	Carb.	Hyd.	Oxy.	Carb.	Hyd.	Oxy.
1 molecule of Grape Sugar				6	14	7
2 molecules of Alcohol	4	12	2			
2 ,, Carbonic Acid	2	...	4			
1 ,, Water	...	2	1			
				6	14	7

As the evolution of carbonic acid and alcohol proceeds, the sponge gradually swells, the little bubbles coalesce and enlarge, rising through the tenacious mass till the surface is reached, and then the carbonic acid bursts out and the dough begins to fall. This process would go on a considerable time, but the alcoholic fermentation would soon pass into an acetous fermentation and the sponge would become sour. When acetous fermentation ensues, as not unfrequently happens in baking, it may be remedied to some extent by the addition of bicarbonate of soda to the sponge. The late master of the mint, Dr Thomas Graham, was the first to demonstrate the presence of alcohol in fermented dough, and he thus described his experiment:—"To avoid the use of yeast, which might introduce alcohol, a small quantity of flour was kneaded, and allowed to ferment in the usual way to serve as leaven. By means of the leaven a considerable quantity of flour was fermented, and when the fermentation had arrived at the proper point, formed into a loaf. The loaf was carefully enclosed in a distillatory apparatus, and subjected for a considerable time to the baking temperature. Upon examining the distilled liquid, the taste and smell of alcohol were quite perceptible, and by repeatedly rectifying it, a small quantity of alcohol was obtained, of strength sufficient to burn and to ignite gunpowder by its combustion. The experiment was frequently repeated, and in different bakings the amount of the spirit obtained of the above strength was found to vary from 0·3 to 1 per cent. of the flour employed." Although the temperature of the oven drives off that amount of the spirit, fermented bread is yet found to retain a proportion of alcohol, as much as from 0·221 to 0·401 per cent. having been found in different specimens of baked bread. Speaking in 1858, Dr Odling estimated the amount of alcohol thrown out into the atmosphere from the bread baked in London as equal to 300,000 gallons of spirits annually. Many years ago a patent was secured by a Mr Hicks for collecting and condensing the alcoholic fumes from bakers' ovens, and a company was formed for working the invention. After an expenditure of £20,000 the attempt had to be abandoned, not from any failure to obtain the spirit, but because the bread baked in the process was dry, unpalatable, and unsaleable

When what is termed "whole wheaten flour"—that is, the entire substance of the grain, excepting only the outer bran—is baked, it is known that the resulting loaf is of a dark brown colour, sweetish in taste, and liable to be somewhat heavy and sodden. The brown colour was at one time supposed to be due to the presence of bran particles in the flour, and in 1846 an American, Mr Bentz, invented a process for removing the outer cuticle of wheat before grinding, it being supposed that the flour so prepared would yield a loaf of white colour, while utilising a larger proportion of the substance of the grain than is commonly used. To the astonishment of experimenters, however, the bread made from such flour was found to have the colour and other characteristics of whole wheaten bread. The subject was investigated by an eminent French chemist, M. Mège Mouriès, who found that the peculiar action of whole wheaten flour was due to the presence in the outer part of the seed of a peculiar nitrogenous body, to which he gave the name cerealin, and which is closely allied in composition and action to the diastase of malt. Cerealin exerts a peculiarly energetic influence on starch, transforming it into a brown adhesive mixture of dextrin and sugar. He showed that when the fermentative action of gluten

proceeded, the result is the formation of the products desired by the baker—carbonic acid and alcohol; but when the influence of cerealin prevails, lactic fermentation ensues, and dextrin, sugar, and acid substances are formed, which it is the object of the baker to avoid. Several methods of avoiding this deteriorating influence of cerealin, and at the same time securing the use of the maximum of flour, have been put in operation by M. Mège Mouriès. The process now in use at the Boulangerie Centrale de l'Assistance Publique (the Scipion) in Paris, for the preparation of the flour and baking white bread with the whole of the mill products excepting the bran, he thus describes:—"The corn is moistened with from 2 to 5 per cent. of water saturated with sea-salt, and at the end of some hours the exterior coverings only become moist and tender. The grain is then thrown between nearly closed millstones, and 70 per cent. of flour is obtained without cerealin, plus 10 to 14 per cent. of meal. This is bruised between light stones, and separated by winnowing from the greater part of the husk remnants. To prepare the bread, all the leaven is made with flour at 70 per cent., and the meal is added to the soft dough last of all; as, in spite of the small amount of cerealin which it still contains, it will not produce brown bread, because at that time the length of incubation is not sufficient to change it into a leaven. Thus white bread is produced containing all the farinaceous part of the wheat."

It not unfrequently happens that flour of good colour, and unexceptionable chemical composition, fails to yield a dough which will rise by fermentation, and the loaf from which is sweet, solid, sodden, and adhesive. Wheat that has been badly harvested, or which in any way has been allowed to sprout, has part of the gluten changed into the form of diastase, which, like cerealin, changes starch into dextrin and sugar. The gluten of flour which has been dried at a too high temperature, and of flour which has been kept in a damp situation, is modified and acts in the same manner. If dough is made with an infusion of malt, it yields a result exactly the same as that above described. It is to guard the starch of inferior flour against this deteriorative influence that a proportion of alum is used by many bakers of second-class bread. Alum has the power of preserving starch to a large extent from the metamorphic action of altered gluten, diastase, or cerealin, and of producing from an inferior flour a loaf of good texture and colour. The use of alum is regarded as an adulteration, and heavy penalties have been imposed on its detection; but its estimation in bread is a process of the greatest difficulty, and authorities are by no means agreed as to its deleterious influence. Other mineral salts have a similar protective power on the starch of inferior wheat, and lime-water has been successfully employed in place of alum. To this also it is objected by some that the addition of lime renders the valuable phosphatic salts of flour insoluble by transforming them into phosphate of lime.

Aerated Bread.—When carbonic acid, instead of being generated by fermentation within dough, is separately prepared and incorporated with flour and water, aerated bread is produced. The system by which this is effected was invented by the late Dr Dauglish, and aerated bread has been manufactured under his patent since March 1859. The system is now in operation in all the principal towns in the United Kingdom, and it appears to be steadily gaining in public favour

The Dauglish apparatus (see fig. 3) consists of the following parts:—1st, a generator A, in which carbonic acid is evolved from chalk by sulphuric or hydrochloric acid; 2d, a gas-holder, in which the carbonic acid is stored for use after being purified in passing through water; 3d, an air-pump, for pumping carbonic acid from the gas-holder, and forcing it into the water vessel and mixer; 4th, another air-pump, for withdrawing atmospheric air from the mixer

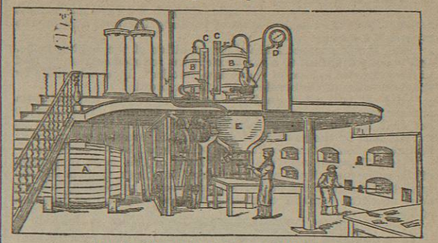

Fig. 3.—Dauglish Apparatus—double set.

before the aerated water is admitted; 5th, a water vessel B, a strong cylinder of copper capable of withstanding a pressure of 100 lb on the square inch, and of sufficient size to contain water for a full charge of the mixer; attached to this water vessel there are a gauge-glass C, and a pressure gauge D, for indicating the pressure of gas as it is pumped in; 6th, the mixer E, a globular vessel of cast-iron, capable of bearing high pressure, through the centre of which an axle runs, fitted with iron kneading-arms extending to the circumference of the vessel. The pumps and the revolving arms within the mixer are worked by steam power. In order to make a sack of flour into dough, a lid at the top of the mixer is opened, and the flour passed down into it through a spout from the floor above. The lid of the mixer is then fitted tightly on, and the air within it exhausted by the pump. The requisite quantity of water, about 17 gallons, is drawn into the water vessel, and carbonic acid is forced into it, till the pressure amounts to from 15 to 25 lb per square inch. The aerated water is then passed into the mixer, and the mixing arms are set in motion, by which, in about seven minutes, the flour and water are incorporated into a perfectly uniform paste. At the lower end of the mixer a cavity F is arranged, gauged to hold sufficient dough for a 2-lb loaf, and by a turn of a lever that quantity is dropped into a pan ready for at once depositing in the oven. The whole of these operations can be performed in less than half an hour. When 4-lb loaves are to be baked the lever has simply to be twice turned. At another part of the lower end of the mixer is placed a pipe G, with a stop-cock, by which dough intended to be fired as Paris bread, on the sole of the oven, is drawn off and weighed before being placed in the oven. The pressure of gas within the mixer is sufficient to force out the whole of the dough, which, immediately on being liberated, swells up by expansion of the gas confined within the tenacious mass. Currant loaves and various kinds of fancy bread are made by the aerated process by placing the necessary ingredients in the mixer along with the flour.

The advantages claimed for Dr Dauglish's process are:—

"(1.) It does away entirely with fermentation, and with all those chemical changes in the constituents of the flour which are consequent upon it.

"(2.) It avoids the loss consequent upon the decomposition of the portion of starch or glucose consumed in the process of fermentation, estimated at about from 3 to 6 per cent.

"(3.) It reduces the time requisite to prepare a batch of dough for the oven, from a period of from eight to twelve hours to less than thirty minutes.

"(4.) Its results are absolutely certain and uniform.

"(5.) It does away with the necessity for the use of alum with poor flour, and the temptation which bakers are under to use with all.