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BY

PROFESSOR JAMES LONG.

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<table>
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<tr>
<th>Capacity</th>
<th>£</th>
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<td>15 galls. per hour</td>
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Modern Dairy-Farming:

A Manual for all who are engaged or about to embark in the production, manufacture, or sale of Dairy Produce.

BY

PROFESSOR JAMES LONG,


ILLUSTRATED.

LONDON:

"THE BAZAAR, EXCHANGE & MART" OFFICE,

WINDSOR HOUSE, BREAM'S BUILDINGS, E.C.
THE DAIRY AND CREAMERY JOURNAL.

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Established 1898.


Proprietor and Editor: J. Denyer Hand,
5, Whitefriars Street, Fleet Street, London, E.C.
PUBLISHERS' PREFACE.

It is scarcely too much to say that during the last decade Dairy-Farming in this country has received an immense impetus, and that in the near future it is likely to attract still greater attention. The War has made it abundantly clear that something ought to be done, and done quickly, to increase materially our National Herd, as well as to diminish our consumption of imported foodstuffs, by the better cultivation of grass and waste land and by the production of those rich forage crops which are so unaccountably neglected. None the less it is a question that needs to be pressed right home in the case of those who are about to embark on Dairy-Farming as a business. One way of doing this is by means of a cheap and an informative literature in which both the principles and the practice are carefully discussed. The publishers therefore trust that by issuing the present manual, for which Professor James Long is responsible, they will be helping not merely the student to obtain a better knowledge of his subject, but also the individual actually engaged in Dairy-Farming.
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Modern Dairy-Farming.

Chapter I.

INTRODUCTORY.

It may surprise many readers of this book to learn that Dairy-Farming as we know it to-day is an industry of less than forty years' growth. At so recent a date as 1876 it was impossible to obtain a tangible answer to questions relating to the production or manufacture of butter or cheese—if those questions involved any reference to scientific investigations. Butter was made by rule of thumb, and made very badly indeed. The best makes were not exempt from this practice, and therefore as a matter of course they were always liable to failure. It was well known that the work must be clean; hence the advice to beginners, apart from a recognition of the ordinary routine, almost began and ended with cleanliness of the most scrupulous character. As a rule butter failed to keep, and we venture to say that five samples out of six exposed in the then numerous country markets, or delivered to the grocer's shop in the nearest town, to be paid for in goods, were strong in flavour, of bad odour and equally bad colour, within two or three days,
although we are bound to except from this condemnation the butter made from the scalded cream of Devonshire, Cornwall, and Somerset.

The Butter Industry.

During the Franco-German War the makers of Normandy, unable to sell their produce in Paris and elsewhere in France as heretofore, commenced to export it to England, and from that date the brands of France have held a prominent place on our markets. The Normans do not send us their best, as they obtain a much better price in Paris—a price which we have known to reach in normal times 2s. 8d. a pound. We have, indeed, during excursions in France, made the acquaintance of a maker who obtained this price, and inspected his dairy and cattle. In spite of all the work of the past forty years, no butter is placed upon our market which equals that supplied to the Paris consumer. In London it is practically unknown, although there are usually numerous exhibits by private makers at the London Dairy Show which are quite equal to the best made in France and much superior to the finest brands sent over from Denmark. The best English butter is made for the tables of those who produce it, and it is usually obtained from the milk of the cattle of the Channel Islands.

With our increasing prosperity butter was found upon the tables of those who in earlier days were content with fats of a less costly character, such as dripping and lard, or with the fat bacon which was so largely produced by their own pigs. These sources of fat failed to meet the demand of the working classes, with the result that margarine—then known as butterine—was introduced as a preparation of the fat of the bullock; while Denmark, and in later years Canada and the Australian Colonies, commenced to export brands of butter which were lower in price than our own, and which, owing to their uniform character, soon made their way. Thus the English butter of a past generation has been almost entirely replaced by consignments from all parts of the world, including Russia and Argentina.
INTRODUCTORY.

For a long period margarine, which was gradually improved, was frequently sold as butter; but a change in the law—in obtaining which, by constant agitation, we were engaged with others who were equally interested—gradually destroyed a form of imposition and fraud, so that the imitation has made its way upon its own merits and now provides for an enormous population. The war with Germany and the consequent increase in the price of butter gave the margarine maker his opportunity, with the result that his produce replaced the most expensive fat on the tables of thousands of butter consumers who could not afford to pay the enhanced prices or who regarded it as their duty to economise. This increased demand was followed by an increase in the price of margarine, which was perhaps to some extent justified.

The quality and increased production per cow of modern manufactured butter are the result of a long and careful study of the subject by men in all countries. There was not one trained and skilled teacher of butter-making in this country when we first commenced our investigations, nor were there means whereby a teacher could be trained. In consequence of this great defect in our educational system we visited France, Switzerland, Denmark, and Sweden, in each of which countries it was evident that much had been done on both the scientific and practical sides of the subject. We found trained teachers, and these were teaching others, while we had not commenced to recognise that there was anything to learn in the work of the dairy. On returning to this country we were invited to address numerous meetings in different counties, while later on we were enabled to induce the British Dairy Farmers' Association, then a young institution, to establish the first Dairy School, which in a few years was removed to Reading, where it is still doing a great work in connection with the University College. When eventually grants were made to County Councils for technical education butter-making took a prominent position as a subject, and from that date it has been taught to tens of thousands of students, although
it is to be feared without that result which appears in other countries than our own.

This brings us to another question. England is a small country with a large population, and the demand for fresh milk is consequently considerable. It has always been contended that we cannot produce our own butter if at the same time we produce all the milk we require. Facts have proved this contention to be true, for our cattle have never been sufficiently numerous. Yet, when the whole subject is carefully investigated, it is found that the limitation of our cattle population is owing to the imperfect cultivation of our grassland, or indeed to the fact that there are millions of acres which are not cultivated at all. We have ample room for twice the number of cows, and there is little doubt that this fact will be recognised at the conclusion of the war, inasmuch as what we have pointed out in season and out of season for years has been acknowledged to be true by a committee appointed by the Government. British dairy-farming can never become a great industry, so far as it relates to the manufacture of butter and cheese, until all the available land is under thorough cultivation and stocked with cattle as heavily as it will bear. Already we have seen on the farms of progressive men milking cattle on the hills, as they should be wherever grass can be grown, just as we have seen them in Switzerland since our first visit there forty years ago.

Let us now look at the extent of our butter industry as we can gauge it from our imports. In 1893 the value of imported butter was as follows—and we have placed beside it the value of the imports of 1913, the year before the war:

<table>
<thead>
<tr>
<th>Value of Butter Imported into the United Kingdom.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1893.</td>
</tr>
<tr>
<td>£12,753,593</td>
</tr>
</tbody>
</table>

In 1892 we estimated the value of the butter produced in this country at £10,729,000. Since that date our consumption has increased very largely, partly owing to
our increased population and partly because more butter is consumed *per capita*. The probability is, however, that our home-manufactured butter has not increased at all, but has declined. If we still assume that it reaches 10 millions in value, we arrive at an annual consumption valued at £34,000,000, in spite of the enormous consumption of margarine, for which in 1913 we paid £3,917,000 to foreign producers alone.

One of the objects of this book is to point out that a very large proportion of the butter we consume could be produced in this country, and, contrary to popular belief, with advantage to the farming community. It is assumed that owing to the market value of fresh milk, for which the demand is always increasing, butter does not pay to make. Yet it is obvious to all who go to the root of the matter that if it will pay the farmers of France, Denmark, and Sweden, all of whom have surmounted difficulties in relation to transport and markets, it ought to pay us. If it is argued that the conditions in their case are superior to those which control us, the reply is that those conditions must be changed to meet the circumstances of the case.

In the countries we have named the land is in the possession of smallholders, and in consequence of this fact the prosperity of the rural population is greater than with us. We do not desire to depreciate the importance of large farms in this country, but what we do emphasise is the fact that a very considerable proportion of our farmers occupy much more land than they are able to cultivate to the best advantage, partly owing to want of knowledge and partly because they possess insufficient capital. This land in the hands of four times the number of men would not only maintain many more people but provide a much larger quantity of food. This fact has never been so fully recognised, in spite of what has been so frequently pointed out by ourselves and others, as during the second year of the war, and by the committee appointed to advise on the question of our food-supply.

Under existing conditions the supreme object of the dairy-farmer, as distinct from the producer of milk for
sale fresh, should be to make the most perfect butter and cheese for the supply of the constantly increasing wealthy members of the community. The quantity of these goods available is never adequate to the demand. The consumer is willing to pay the best price, and in this point he never complains if he can get what he wants. It is, however, an unfortunate fact that a very large proportion of our butter and cheese is of second-class quality, and it is thus brought into competition with the imports from over the seas. The result is that the prices paid by the trade are so small that the returns of the maker are less than those obtained by the seller of milk and, as a natural consequence, he prefers to sell all he produces in its raw condition, abandoning the manufacturing industry.

If dairy-farmers would make the most of their opportunities by producing really fine butter and rearing stock with the separated milk the result would be even better than can be commanded in normal times by the seller of milk. The demand for fine dairy stock is always increasing, and the sale of heifers at their best will always prove remunerative. This has been frequently demonstrated by men who made the attempt. In a similar way, fine cheese, which factories and retailers cannot obtain in sufficient quantities to meet the demands of their customers, will pay better than the summer sale of milk, leaving the winter yield at their disposal at a time when prices are highest.

The Milk Trade.

For some years this has been in a flourishing condition, and fortunes have been made by both dealers and retailers; but since the establishment of dairy-farmers' organisations prices have risen. Farmers have determined that the low prices of the past shall never return, and dairymen have sometimes been severely tested not only to cover the cost of their working expenses but to obtain a sufficient quantity of milk to meet the demands of their customers. The demands of the public, in addition to those of the local authorities, require, both at the hands of the farmer and the retailer, that care and cleanliness in the production
and manipulation of milk which will ensure purity—in other words, freedom from dirt and those forms of germ-life which are dangerous to health. In this direction much has been done, but there is yet much to do. Milk is not properly cooled in warm weather; it is seldom properly strained, and unless it is drawn by the milking-machine it is almost invariably contaminated with dust from the air of the cow-house or with particles of dirt from the coats and udders of the cows. In the examinations of milk made by the authorities of the West Riding of Yorkshire and in Chester it was shown that a high percentage of the samples submitted contained particles of manure. As the dung of the cow is partially soluble, the quantities found represented much larger proportions of the original introduction, some of which was thus dissolved in the milk. It has been conclusively demonstrated that cotton-wool strainers are the best, but they are seldom employed. The result of the employment of imperfect strainers may be demonstrated by the following facts:—Inspecting the great dairy in Zurich, perhaps the best of the kind in the world, under the guidance of the Director, our late friend Dr. Nicholas Gerber, we were shown the cotton-wool pads which were fitted in the sample bottles of milk as they were taken daily into the laboratory as a test of the cleanliness of the milk of each farmer supplier. The filled bottles were inverted, with the result that the dirt in the milk was deposited on the pad, thus indicating its condition from this point of view. In almost every one of the large number of pads the stain was repulsive, suggesting as it did that the dirt consumed in a small sample bottle of milk is of a very tangible character, and this notwithstanding the fact that each sample is daily submitted to four tests for its purity, its healthy character, and its freedom from dirt.

Milk is still sold which contains less than 3 per cent. of fat, and there are many contentions that the law should be changed for the protection of farmers producing it. We are not among those who would move a finger for the purpose of reducing a standard which we fought very hard to establish. Milk containing only 3 per cent. of
fat is as abnormal as milk containing 5 per cent. in any sample but that produced by Channel Islands cattle, and it ought not to be sold at full market price. Chicory in coffee, maize starch in wheat flour, margarine in butter all diminish the market value of the superior article and are condemned accordingly, although in neither case does the consumer suffer from a diminished quantity of nourishment in his food. Milk which is short of a just quantity of fat is not only diminished in market value, but it produces less cheese, less butter, and provides the consumer with less food. When butter stands at 1s. 6d. per pound, 3 per cent. milk is worth less by three-farthings a quart than milk containing 3 ½ per cent. of fat, and it should never contain less. At a time when farmers are obtaining a substantial price for all their produce it is a duty incumbent upon them to provide a perfect article, rich in food, clean, and well cooled. So long as they are able to do this, without the least possible doubt they ought to do it, and by adopting this course all fear of prosecution and unjust punishment would vanish.

Condensed Milk.

In this we have a valuable addition to our food-supply. It has often been a cause of condemnation in the past, owing to the practice of some makers of removing a portion of the cream. Since the change in the law, however, which compels makers who adopt this practice to state the fact upon the tins, there has been little cause for complaint, although the practice is not entirely abandoned. The best course to pursue in buying this food is to choose a recognised brand, for we have reason to believe that the best makes are not only produced from rich milk but are unskimmed. As these brands are now more extensively made in this country, condensed milk forms an important item in our home dairy-farming, and so far comes within the scope of this work.

Cheese-Making.

There is yet much to be done in relation to the manufacture of cheese. Cheddar, Cheshire, and Stilton
have been brought to a high state of perfection by the best makers. These makers form a very small percentage of the whole, and we may safely assert our belief that 90 per cent. of all that is manufactured is second-class, and thus comes into competition with the imports. The British cheesemaker cannot compete with the Australian and the Canadian manufacturer, whose goods are of great value to the mass of our people. His rôle is the production of the finest quality for the wealthier consumers, as this cannot be obtained from our Colonies. There is, however, another difficulty which needs removing. Leicester, Derby, Gloucester, and Wensleydale cheese is practically all of second-class quality. The art of making the first-named is apparently lost, for there has not been a solitary sample of the soft mellow Leicester of the old type exhibited at the Dairy Show for many years. Efforts have been made to revive the Wensleydale cheese, but without any very good results. It is still made on a perfunctory or empirical system, badly shaped, badly finished, and badly bandaged. This variety, which shares with Stilton the first place among the blue-veined cheeses of the world, ought not only to be found in all English towns, to most of which it is an entire stranger, but with Stilton it ought to become the medium of a large export trade to our Colonies and foreign countries. While we are daily consuming in Gorgonzola a much inferior cheese we are ignoring these varieties and, in a word, assisting to build up an industry in Italy which we are neglecting at home.

**Farming Products Tabulated.**

According to the report in connection with the Census of Production Act published in 1912 the value of the dairy products sold by farmers in Great Britain was as follows:

<table>
<thead>
<tr>
<th>Product</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk (whole)</td>
<td>£24,820,000</td>
</tr>
<tr>
<td>Milk (skimmed)</td>
<td>143,000</td>
</tr>
<tr>
<td>Cream</td>
<td>590,000</td>
</tr>
<tr>
<td>Butter</td>
<td>2,940,000</td>
</tr>
<tr>
<td>Cheese</td>
<td>1,400,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>£29,893,000</strong></td>
</tr>
</tbody>
</table>
If we accept this total as applicable to the year in which we are writing, and add the value of the imports of butter, cheese, and condensed milk, we shall obtain some idea of our actual consumption. It must, however, be pointed out that Irish produce is not included, and further that the quantity of milk sold for consumption by farmers is only 70 per cent. of the whole of that produced. In regard to butter, the figures do not include that made in factories and creameries.

Estimate of the value of the milk, cream, butter, and cheese consumed in Great Britain:

From the produce above £20,893,000
Add 10 per cent. of the total production consumed by farmers in their households 3,545,000
Imports—Butter 24,083,000
Cheese 7,035,000
Condensed milk 2,185,000
Milk and cream 77,000

£66,818,000
Chapter II.

HOW TO ATTAIN SUCCESS.

In spite of all that has been done in the promotion of dairy-farming, much has been neglected. We know of no progressive country in which so little has been accomplished as with us. The land has been almost entirely neglected by the Government; no bold attempt has been made to improve the milking powers of our cattle, whether as regards the yield of milk or the quality of what our cows produce. There has been no increase in the number of cows to correspond either with the increase in our population or with the increase in our per capita consumption. Butter-making has been allowed to fall out of the ranks as a national industry without any attempt being made to revive it, while cheese-making, which is still confined to a few counties in England and Scotland, is practically unknown in Ireland and in Wales.

Milk is still sold with an artificial colour, and no effort is made to ensure its cleanly character beyond that practised by dairymen themselves. The result is that in warm weather it keeps sweet twelve or more hours less than milk which has been perfectly cooled or which has been drawn under the most hygienic conditions.

Conditions of Success.

Success on the part of the milk-selling farmer depends upon conditions to which we propose to direct the reader's attention.
1. The cows must produce a larger yield.
2. The milk should contain a minimum of 3.5 per cent. of fat.
3. The milk should be drawn by a milking-machine.
4. In summer the milk should be cooled to at least 50° F.
5. Forage crops should be grown on the farm to ensure abundance of food in dry weather, and in suitable counties maize silage for winter, this food being better than turnips.
6. If roots form the succulent portion of the ration in winter, the yield of mangels should not fall below 35 tons and swedes below 25 tons to the acre.


7. The pasture grass should be manured with phosphatic and nitrogenous fertilisers, and in some cases with potash, if this is demanded and is available, in order that the yield of grass may be increased to such an extent that more cows can be kept on the same area of land and sufficient allowed for October and November feeding in the milder parts of the country.

These points indicate that more and better milk should be produced on the farm with the assistance of improved cattle and more abundant and better crops.

The Yield of British Cows.

Various estimates have been made from time to time as to the average yield of British cows; but it is
assumed in the Report on the Census of Production, on the basis of the work of 1907-8, that the average yield of the cows of Great Britain is 550 gal., or of the total number of cows enumerated 437 gal. Neither figure is satisfactory when we know that there are cows in this country which yield anything from 1,000 to 1,400 gallons in a year, and in the United States very much more. The records of the competitions at the London Dairy Show, and those of Dr. Watney, show that it is possible to largely increase the yield of milk and butter per cow, and still more the yield of these materials per farm. In the United States, published records obtained by officials from the Agricultural Colleges show that while some cows have produced 2,000 gal. of milk, others have produced sufficient fat to yield 900 lb. of butter. In this country Dr. Herbert Watney has obtained an average yield of milk from his herd of Jerseys of 70 gal., from which an average of 415 lb. of butter was produced. The butter yield in this herd has reached an average of 463 lb., and has exceeded 400 lb. in nine out of the fourteen years of which we have records. Many of the cows, small as they
are, have produced 1,000 gal. of milk, or from 500 lb. to 540 lb. of butter. The best cows in the herd have made the following averages:

<table>
<thead>
<tr>
<th>Name</th>
<th>Pounds of milk</th>
<th>Pounds of butter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Maple II</td>
<td>---</td>
<td>530</td>
</tr>
<tr>
<td>Sharab</td>
<td>---</td>
<td>542</td>
</tr>
<tr>
<td>Lady Siphon</td>
<td>---</td>
<td>446</td>
</tr>
<tr>
<td>Guennon's Lady Teasel</td>
<td>---</td>
<td>448</td>
</tr>
<tr>
<td>Guennon's Lady Teasel</td>
<td>---</td>
<td>497</td>
</tr>
<tr>
<td>Sunbeam II</td>
<td>---</td>
<td>430</td>
</tr>
<tr>
<td>Red Maple II</td>
<td>---</td>
<td>471</td>
</tr>
</tbody>
</table>

These are marvellous figures, and they point to the fact that, if farmers accomplished what Dr. Watney has accomplished, the wealth of the dairy-farming community might be increased threefold. It may be suggested that in this and similarly important instances of success wealth came to the rescue, but in our judgment the practical farmer occupies a far more advantageous position than a mere man of science or wealth. He can attend markets and become acquainted with other practical men, and so acquire cattle with which the wealthy man can never come into contact, and for which even then he is compelled to pay a great deal more money.

This point may be illustrated from practical experience. On two occasions we called upon a dealer in a distant county famous for its Dairy Shorthorns and asked him to collect a number of cows of prime milking quality from which eight could be selected. This task he undertook, and on each occasion we went to his farm, examined the cows, saw them milked, and were afforded the opportunity of testing the milk. On the first occasion the milk produced by the cows, which were purchased, was employed in the manufacture of butter, with the result that the yield reached 5 per cent. of the milk. The price paid for the cows was, in round figures, a pound per head more than the price in the market for cattle of similar type. By adopting this practice a buyer can ensure milk of high quality, and, as far as human knowledge can
HOW TO ATTAIN SUCCESS.

command it, a large yield. On the other hand, neither qualification can be ensured by the usual system of buying.

We quote an instance relating to the purchase of a single cow, and this a very simple one. Discussing this question of yield with a neighbouring landlord, who was to some extent a practical man, we remarked that it was an economical plan to pay an extra five pounds for a cow which was known to be a really deep milker—i.e., a cow yielding 800 to 1,000 gallons of milk. His reply was immediate. He had possessed such a cow, and had sold it to a neighbouring farmer. This farmer was called upon, and he was willing to sell—at a price. His figure was named; it was perfectly fair, and the purchase was made. Had this gentleman recorded the yield of the cows in his herd he would have probably asked a different figure; but apparently knowing no more than the fact that the cow was an excellent milker he was perfectly satisfied, although her first record exceeded 1,300 gal.

**Building up a Herd.**

In order to build up a herd of deep-milking cows close study should be made of the system adopted by others, and here the work of the late Mr. George Taylor will provide a liberal help. Much depends on the bull. If he is of an old milking family the way will be easier; but it is obvious that the cows should not only be heavy milkers of rich milk, but that they should belong to good milking families on both sides.

Milk which is rich in fat should be regarded as an essential to success, without the least recognition for what others have done. A standard of 4 per cent. should be set, and set higher when it is reached, for the mixed milk of the herd. With rich milking stock the breeder possesses material advantages—thus:

1. He need never apprehend the possibility of prosecution.
2. He will never find the slightest difficulty in selling his milk at the best price.
3. His surplus stock will realise higher prices if it is shown in his catalogue what percentage of fat each cow has given.

4. In an emergency the milk can be retained at the farm for making butter, which will be of the best type, assuming that it is well made, because rich milk naturally produces better butter than poor milk.

5. If cheese is produced it will be richer in quality than cheese made from poor milk—and realise a better price.

The Milking-Machine.

We now arrive at the third point in our argument: that milking should be performed by a milking-machine. The time is coming when much greater demands will be made upon farmers to produce clean milk. It is almost unthinkable that milk should be sold which, however it looks to the eye, contains a solution of the manure of the cows, whether it be in infinitesimally small or in tangible quantities. Yet this is precisely what it does contain. Milkers still dip their fingers in the pail to enable them to draw the milk more easily with their hands. The atmosphere of the cow-house reeks more or less with dust, partially faecal, and bacteria, the extent of which may be revealed by a ray of the sun. The coats of the cows, unbrushed as they are, cast particles of dirt and germ life into the milk pail as they are rubbed by the men in the act of milking. The udders are not often washed, or if washed the process is perfunctory, and the milk is contaminated. No process of hand-milking can prevent this contamination, although with daily care and constant supervision it may be minimised. Nor does the straining remove the difficulty, for however perfectly cotton-wool removes tangible matter from the milk, it does not alter the fact that it leaves the intangible or soluble matter behind.

The milking-machine is the only source of perfect cleanliness, because, while covering the teats only, and therefore a very limited source of contamination, these are not handled, and the milk is drawn out of contact
with the air, and does not come into contact with it again until it is poured out of the pail. We have seen herds of various sizes milked, or partially milked, and on no occasion has master or man had anything but praise to award to the machine, which they regarded as a labour-saving boon of great value to themselves and one in which they believe their cattle rejoice, so much easier and less abusive is its work in comparison to that of mankind. We are aware that there are farmers who ask for a machine which is no trouble at all, which will act without the control and assistance of man, even to the extent of cleaning itself when milking has ended. And it is perfectly true that the milking-machine has been condemned because it required cleaning. It was not intended for this class of farmer, nor were the cows that he milks with the hand.

We are acquainted with one instance in which a herd of 100 cows is milked by three men with the assistance of three machines, and of another in which some forty-seven cows are milked by two men, who between them maintain the engine in perfect order, with a dynamo which illuminates the cow-house—a new and splendidly constructed yet
simple building—with electric light. It is needless to say that the combination adds to the comfort of the cows and the satisfaction of the men. In a third instance a farmer has personally constructed an appliance which enables him to work the machine and to milk the cows in the field. In this case the cows come up to him to be milked without being fetched, and thus add their dumb testimony to the valuable character of the work.

Cooling the Milk.

Our fourth point deals with the cooling of the milk. On two occasions we have had the opportunity afforded us of witnessing the system adopted at the home farm of Mr. Robert Mond, near Sevenoaks. This gentleman has long conducted a scientific investigation of the question of tuberculosis and its possible cure by the employment of tuberculin, and one of his herds, consisting of cured cows, was milked in a separate building. Mr. Mond has also been engaged in demonstrating the possibility of milking cows without contaminating the milk with the germs of disease. Next to the milking-machine the system adopted claims our attention. Two old cow-houses have been remodelled within. The cows live in a covered yard adjoining the building, in which they are free. The house is kept perfectly clean, flushed before each milking from top to bottom with a hose, and the cows are then driven in and chained in their stalls. They are subjected to similar treatment by spraying with water, so that all dust is at rest. The milkers next wash the udders and their own hands, which are rinsed after each cow has been milked, after clothing themselves with a white overall and cap. After milking, the cows are driven back into the covered yard, where they remain until the next milking, when the same method is followed.

Near at hand is a small refrigerating plant, which enables the foreman to cool and keep his milk to any degree he requires as long as he likes. The milk is sent to London, to the Children’s Hospital, which we have also had the advantage of inspecting, and from the records examined both there and at the farm we ascertained
that it remains sweet many hours longer than fresh milk obtained at the best dairy in the neighborhood.

Milk cannot be cooled sufficiently low in summer with water which seldom falls below 60° F. For this

Hall's Refrigerating Machine.
reason artificial cooling is almost invariably necessary if good work is to be done, and this of necessity involves co-operation among farmers. In those districts where milk-selling farmers are sufficiently numerous the best plan is to combine, construct a shed near the station, install a refrigerating plant, and arrange for the milk from each farm to be cooled by the men as it arrives. The expense divided among ten or twelve farmers would amount to a very small sum as compared with the importance of the work. The building could be adapted to the storage of the milk when prices are low, for sale when the market is better. This question will have to be faced, for under existing conditions it is impossible to sell a valuable article of produce because of its perishable character without serious loss, when by its preservation it can be sold at will. Wholesale dealers in milk and the largest retailers are compelled to adopt this method of preservation, without which they would be subject to continual losses.

Farmers who have refrained from spending their capital in those forms of equipment which are essential to success in their business are fighting against themselves. If we carefully examine the matter we shall find that similar objections were raised at the time of the introduction of cotton cake as a food, nitrate of soda as a manure, the self binder, the threshing machine, the cream separator, the selection, preservation, and special packing of fruit, and at the present moment of the milking-machine and the motor plough. We are acquainted with many of the ablest farmers in the kingdom, and have found no instance in which there has been marked success where the most modern improvements have not been employed.

It may lastly be pointed out, in dealing with the question of cooling or refrigeration, that milk is spoiled by the action of millions of bacteria which have been produced by the increase in the number of those which find their way into it from the atmosphere when it is drawn from the udder. This increase, however, is possible only when the conditions are normal. Thus, by cooling the milk to 50° F. or heating it to a temperature which
would make it impossible to deal with it as a commercial product there is a check to the growth of this form of germ life, and the milk remains sweet. With a rise in the temperature after cooling there is corresponding activity in the life of the bacteria, and an increase which reaches its greatest point as it approaches 80° to 90° F., with the result that the milk becomes sour, and while in this condition it is useless for selling and is unfit for the production of saleable butter or cheese.
An Abundant Food-Supply Necessary.

Success on the dairy farm, if not ensured, is substantially promoted by the abundant provision of food. In this country, however, it seldom happens that a summer passes without sufficient very dry weather to check the growth of grass in the pastures, and therefore to diminish the yield of milk. So common is this occurrence, and sometimes so severe, that many farmers have learnt to regard it as inevitable, and in consequence they take no pains to prevent it, to their serious loss. There is no cause for this attitude. There are forage crops which can be grown with more marked success during great heat than during more temperate weather, while to a large extent all the leguminous plants common to England—sainfoin, lucerne, clover, trefoil, and vetch—will respond when grass herbage on the pasture land is refusing to grow owing to want of moisture within reach of its much shorter roots.

To rely solely upon grazing on permanent grass is to court disaster in a hot summer, unless the plants of which it is composed have been specially grown for the purpose of resisting drought or of furnishing a good bite or a good cut of hay. There are two plants which can be grown successfully for the supply of succulent food in hot weather which are the very foundation of the crops intended for milch cows in the United States, Argentina, and on a large portion of the Continent of Europe. We refer to maize and lucerne (or alfalfa), which we have grown for years in succession, and are fully convinced that between them the farmers of a large portion of this country can be furnished with more food for their cows during the months of July, August, and September than they have been able to produce under any other conditions. With the assistance of these plants, and of others that have been mentioned, together with liberal manuring, more cows can be kept, more young cattle grown, and more food secured for the winter. Both lucerne and maize are of great value when preserved in the silo on the American plan, providing an agreeable, succulent food which is much superior to roots and much cheaper to grow.
Messrs. Jewson and Sons' Model Silo.
There is, however, another aspect of this question of cropping which secures an additional advantage to the farmer. The leguminous plants—lucerne, sainfoin, clover, and vetch—to which the American farmer adds a large variety of cow pea, are nitrogen gatherers, producing such large quantities of albuminoids that there is less necessity for the purchase of cakes and pulse rich in these materials. In a word, where abundance of nitrogenous food is grown on the farm, as it should be, the artificial food bill is automatically reduced. To ensure the best results in this direction, and therefore to minimise the cost of nitrogenous manures in the same way, it is essential to use phosphatic manures with judicious liberality.

Roots as Milk-producing Food.

We may now discuss the question of roots as a milk-producing food. The turnip is not only a poor food, however agreeable to the cows, but a poor cropper; although we attribute the poverty of our British yield to the very many cases of poor farming. So long as our average is less than 13 tons to the acre, and in some counties occasionally 7 to 10 tons, so long will the crop be costly to grow and ill-adapted as an economical food for milk production. Apart, however, from the cost of cultivation and lifting, there is the cost of clamping, carting, cleaning, and pulping. By the time the food is in the manger the nutritious matter of the turnip (and swedes are included under this term) becomes one of the most costly which is used upon the farm. There is, nevertheless, always hope, inasmuch as skilled growers are able to obtain 25 to 40 tons of swedes to the acre, with the result that they are not only able to feed more cattle at the farm but to produce milk at a smaller cost per gallon.

Here, indeed, lies one of the chief elements of success in Dairy-Farming. Efforts have been made in Scotland, in Yorkshire, and in Kent to ascertain from the practice of farmers what is the actual cost of producing a gallon of milk; but conclusions have been drawn from the results in which the factor of yield has been ignored. It is perfectly
obvious that a farmer who produces 2 tons of meadow hay, 30 tons of turnips, and 50 tons of mangels to the acre is able to produce milk at a much cheaper rate than a farmer who obtains no more than the average yield of the country—e.g., 25 cwt. of hay, 12½ tons of turnips, and 19 tons of mangels. From this point of view the figures which have been officially published, and which are intended to show what the cost of production has been on various farms, are erroneous, and therefore misleading, and cannot be justified.

The results obtained in the county of Kent, for example, were based on the fixed price of the various foods grown upon the farm. Mangels, swedes, and cabbage are thus valued at 10s. a ton, white turnips at 8s., chat potatoes at 20s., meadow hay at 60s., oat, pea, and bean straw at 40s., and barley and wheat straw at 25s. These are empirical figures, and in all probability do not apply to any two farms. The cost of a ton of food grown upon the farm depends not only upon the money spent in its production, but upon its weight. Thus, if a crop of 12 tons of swedes has cost £8 to grow, each ton has cost 13s. 4d. If, however, the crop reaches 30 tons to the acre, and has cost £10 to grow, each ton has cost only 6s. 8d., or precisely one half.

In Kent the lowest cost of producing a gallon of milk in the winter (42 weeks) of 1912-13 was 4·3d., in 1913-14 it was 4·2d., and in 1914-15 4·64d. On the other hand, the highest cost in each of these seasons was 7·46d., 7·08d., and 8·18d. Taking the average cost on the farms, the milk of the combined herds, which during the three winters produced an average per cow of 2·17 gallons per day, was 5·76d. per gallon in 1912-13, 5·4d. in 1913-14, and 5·72d. in 1914-15; and it should be observed that in the last two years war prices prevailed.

Finally, we hold the opinion that on farms where swedes do not produce 25 tons to the acre and mangels 35 tons root-feeding stands in the way of success, and had better give place to some other crop. The swede is apt to spoil the flavour of milk unless its crown is removed, while neither mangels, which are much better than turnips, of
whatever variety, nor swedes are adapted to the production of butter. We may go farther than this and add that fine butter cannot be made from milk produced by their aid. Turnips are an item of great importance on a farm, a large portion of which is manured with the assistance of sheep, which consume them in the fold, but on a dairy farm they are not in their place, and we may safely conclude that as thousands of farmers do not grow 12 tons to the acre they are a source of serious loss.

The pastures and meadows of England do not produce one half the grass of which they are capable, and considerations of national pride must not blind us to the fact. If we may judge by the hay crop we have still a great deal to learn. The average yield in England, 1904-13, on our permanent meadowland was 23·9cwt., in Wales 20·29cwt., in Scotland, on a very small area, 29·63cwt., in Great Britain 23·73cwt., and in Ireland 45·07cwt. The humid climate and the soil of a large part of Ireland immensely assist her result; but while there are plenty of farms in this country which obtain equal or still better results, the fact remains that the vast majority fall below the average, many of these growing no more than 15cwt. to 20cwt. per acre.

We have travelled through numerous counties during the past few winters and springs, and especially remarked upon the brown tint of the herbage which covers most of the country not under the plough; whereas on every well-managed farm the pastures were green. There are whole districts in Warwickshire, Worcestershire, Gloucestershire, Wilts, Hampshire, Sussex, Surrey, Herts, Cambridgeshire, and East Anglia, to mention a few, in which the grassland needs what it apparently never receives: large dressings of mineral manures, and that care and attention which alone will command a successful result.

Good herbage is so important to the producer of milk, butter, or cheese that we may briefly refer to the chief means of effecting its improvement. First comes the fact that while dung is invaluable on arable land, its results on permanent grass are inferior to and more costly than those obtained with the assistance of artificial manure.
Not only is the influence of mineral fertilisers more permanent, but they absolutely prevent that increase in the growth of weeds which dung promotes. Phosphates and potash develop the clovers and trefoils, which is a fact of enormous importance inasmuch as these species collect nitrogen from the atmosphere and with it enrich the soil without cost to the grower. Thus, as these plants are consumed by stock grazing upon them they indirectly feed the grasses which do not possess the same faculty of helping themselves. In a word, the dung made from the clover which the cattle consume contains the nitrogen which they have absorbed; the cultivation of grass-land is therefore trebly important. We have had the advantage of visiting farms in various counties in which the grass has not only been improved but reclaimed, and these facts have convinced us that in all probability 75 per cent. of the pastures of many English counties are practically uncultivated, although capable of doubling their crops.

During various visits to Switzerland we have studied the practice of the small farmers in some of the Cantons in which heavy grass crops are grown, these sometimes yielding 5 tons of hay to the acre in several cuts. One or two hints derived from this source may therefore be given. The cows are stalled during the whole of the year, apart from the fact that one or two are daily employed in hauling the grass to the farm in the summer and returning with solid or liquid manure—the latter being almost daily distributed after mowing in summer. The best grassland is of a temporary character, the seeds including clover, lucerne, sainfoin, rye grass, cocksfoot, timothy, and rib grass. The herbage is mown for the cows as fast as it grows, and the manure assists in the production of the following cut. In this country the growth of the grasses could be checked in dry summers by the heat of the sun in spite of the manure; but the Swiss plant the land with fruit—standard apples, chiefly employed in the manufacture of cider, and pears—and by thus shading the grass prevent any possible failure.

Again, we have found milking cows on the Alps at all altitudes up to 5,000 ft.; and this fact suggests that cows
might be grazed on the Downs in this country with equal success. Among the farms to which we have referred there are some which are partially downland, and these have in some instances been so much improved that the old value of 5s. to 10s. an acre has been increased to 30s. and 40s. by the system elsewhere suggested.

More Herbage by Sowing Long-rooted Plants.

Another suggestion may be made for the assistance of those who are in a position to improve their poor grassland, although it is of a more drastic character. On poor, light land, or on hill-sides which have never produced good herbage within the memory of man, much has been done by ploughing it up, taking a turnip crop, and sowing a mixture of the seeds of plants possessing long roots, in a barley crop which is manured withartificials. The object is simple. The old herbage, consisting solely of plants with short roots, has never been able to reach the food in the subsoil, which is usually rich in the essential minerals, or to travel deep enough to find sufficient water to enable it to grow. The new herbage, which includes wild clover, cocksfoot, tall fescue, tall oat grass, chicory, burnet, rib grass, and, on light soils, kidney vetch, consists entirely of long-rooted plants, which are not only able to find water below but to feed on the minerals awaiting the development of man. These they bring up to the surface soil, which is enriched by their roots to such an extent that when ploughed up heavy corn, root, and potato crops can be grown in succession to the improved grass crops which the new plants have provided.

The principle underlying this practice is one of the most important of all those which are applied to the farm. What the subsoil is the surface soil was, and if by its application the dairy-farmer can utilise the mineral matter below, and simultaneously the nitrogen of the atmosphere above, he may be able, and will be able in most cases, to ensure fertility, which costs nothing but the labour so long as he lives on his farm, and therefore to increase his crops beyond all expectation. If he prefers
to continue to scratch the top 4in. of arable soil, to use manure which has lost the small value it ever possessed by exposure and careless management, and finally to neglect his grass-land altogether, as the majority do, he is likely to remain unsuccessful and unsatisfied.

More Grass in Dry Summers and Early Winter.

Apart from the practice to which we have just referred, pasture grass may be improved to such an extent that the loss owing to drought may be much diminished, while herbage may be provided for grazing day and night during the last three months of the year, except on the few severe days when the cows are kept in the stall. This is a point of importance, for the more extensively the pastures provide for the stock the larger the area of arable land which will be available for corn and other saleable crops. It has been remarked that plants with long roots, by piercing deeper into the subsoil than most of the grasses are able, supply themselves with water even in very dry weather. This is peculiarly the characteristic of lucerne, sainfoin, kidney vetch, and chicory, but in a minor degree it also applies to the clovers. Obviously, too, the deep-feeding plants are also in a position to utilise the latent manures of the subsoil, to produce more herbage by their aid, and to store them in their roots, thus enriching the surface soil when these roots decay.

When lucerne, sainfoin, vetch, and clover are growing and feeding in this way they are also appropriating the nitrogen of the air, and so further enriching the soil in a way which is impossible by the action of fertilisers, essential as these are under other conditions. Thus it will appear that where pasture land is rich in clover it will resist drought better than where there are practically no clovers at all. In either case artificial fertilisers may be used with great advantage, for if there are no clovers phosphates will induce them to grow; whereas if there is a good plant, that plant can be stimulated by the suitable food they provide to extend their root system still deeper, and thus to obtain almost all they require.
Although winter grass is not highly approved by owners of stock it is better than roots, and will maintain the herd up to Christmas in many counties without cake or meal, but with the assistance of hay, if it is encouraged to grow in the manner suggested.
Chapter III.

MANAGEMENT OF THE HERD.

When a cow calves the milk in her udder, which is abnormally rich in casein and minerals and poor in fat, is known as beestings; the correct term, however, is colostrum. Fitted by nature for the benefit of the calf, this milk is often consumed in the farmhouse, especially when the calf is weaned at its birth. The milk of a newly calved cow is not fit for sale until she has calved four or five days, the latter period being frequently fixed in milk buyers' agreements.

Feeding the Calves.

Unless calves are reared upon cows which are kept for the purpose, in which case one average cow will rear five in a season, consisting of two pairs and a single, it is better to wean them at birth, teaching them to drink from the pail. In this way it is much easier to regulate the supply, and subsequently to mix separated milk with the whole milk preparatory to weaning from milk altogether. In the ordinary way a calf may obtain whole milk for a month, at the expiration of which it may be reduced to one half the quantity, which should be made up with the separated milk, until in two or three weeks the whole milk may be abandoned altogether in favour of an increased quantity of sweet separated milk. This plan will prove quite successful if the calf has been taught to feed upon the best and sweetest hay at the earliest possible day, and subsequently upon a little linseed cake meal or
crushed oats. As the young animal grows the hay and oats may form its sole food, until it is able to eat chaff and pulped mangels, both of which may be employed to increase the weight of its ration.

Where a calf is intended to take her place in the dairy herd she should be fed with liberality from her birth. A male calf should not only be fed in this way, but having developed plenty of flesh should be put upon a finishing ration, to fit him for slaughter at as near two years old as possible. This finishing process is not necessary for heifers, but they should be kept in good condition for calving, the vitality of the calves and their future value as milkers depending so much upon it.

It is, too, highly important that heifers should not be allowed to suckle their calves, nor should cows; the practice is bad for the milking propensity. It is necessary to add that hard udders, stoppage of a teat, pustules, and garget seldom trouble the cow which is suckling. This fact should induce dairy-farmers to recognise that these complaints are chiefly owing to carelessness on the part of the milkers.

**Milking-Time.**

Cows should be milked as nearly as possible every twelve hours. There is no advantage to be gained by milking three times a day. If the evening milking follows nine hours after the morning milking, the milk produced will be less and the fat percentage higher; but the nearer the second milking approximates to twelve hours after that of the first the larger will be the evening yield and the more regular the fat percentage. Thus one cause of risk, and sometimes of prosecution, for selling milk below the standard (3 per cent. fat) is found in milking too soon after the morning milking, with the result that the milk produced in the morning, while showing a large increase in volume over that of the evening, is correspondingly low in its fat percentage.

All cows should be stripped after milking. The first milk drawn contains very little fat, but it increases in richness until the last drop, the strippings being the richest
portion of any. As a rule the richest milkers yield less milk than producers of poor milk, yet modern breeders have succeeded in evolving cows of the Dairy Shorthorn, Jersey, Guernsey, Devon, and Dutch varieties which yield very large quantities of abnormally rich milk. It is therefore possible to obtain a Dairy Shorthorn cow producing 6 gal. a day at her best, the milk containing 4 to 5 per cent. of fat. Cows in this country have already given 1,400 gal. in a year, while in the United States there are many records of 1,500 gal. to 2,000 gal., and a yield of butter fat equivalent to from 800 lb. to 900 lb. of commercial butter.

**How to Milk.**

While we are convinced of the value of the milking-machine, it is important to note how a cow should be milked by the hand. The time will come when, owing almost entirely to the dirty habits of the majority of milkers, who practically forbid the sale of absolutely clean milk, hand milking will be officially abolished. Until that period arrives the udder of the cow should be washed and dried, the hands washed, and rinsed after every cow has been milked, when the two hands should grasp two of the teats. Each hand alternately loosens its grasp, presses the udder with the thumb and forefinger, quickly grasps the teats again, and passes down the milk. The teats should never be wet to assist this action, as wet milking is the most fertile cause of dirty or contaminated milk, while to maintain it the fingers are dipped into the pail, and thus become quickly plastered with filth. When a pail is placed under the cow it receives countless numbers of bacteria and particles of dirt during the whole time it is exposed; nor can this be prevented without the milking-machine or milking in the open air, although the latter plan is but an amelioration of the trouble.

**Mechanical v. Hand Milking.**

We have not only had numerous opportunities of seeing cows milked by mechanical means since the machine was
first introduced, but of witnessing the complete system of manufacture of the several machines with which we are acquainted. The pail is completely enclosed, while above it is a pulsator which regulates the inflation and collapse of the rubber cups which fit over the teats. In various instances known to us, either owing to visits to farms or from letters of farmers describing their practice, large herds are now milked by very small numbers of persons. In one case three men milk and manage a herd of 100 cows, in another three girls milk seventy-six cows, while in a third 1,000 gal. a week are drawn by one double

![The Lister Milking-Machine at work.](image)

and four single Lister machines. The points in favour of mechanical milking are:—

- Perfectly clean milk.
- Large reduction in labour.
- No bad udders.
- Rapidity of milking.
- The milk keeps longer.

The power necessary for running the machine can be employed for electrically lighting the cow-house. Fresh cows introduced into a herd take to machine milking without trouble, and the men rapidly learn to manage both engine and machine. The work should be even, the parts requiring lubrication should be always well
oiled, and the machine cleaned and left in cold water when milking is completed. There is no evidence of cows falling off in their yield; on the other hand, cows are now milking which were being milked twelve months ago, and have never been dried.

Two features related to the new system of milking may be mentioned, both having come under our notice. There is perhaps no point in relation to the housing of cows which reflects so much on the cleanness of milk as the absence of light during milking in winter. Cows are still milked with the assistance of candles and paraffin lamps. On one farm known to us the installation of the machine was accompanied by the addition of a dynamo and electric lamps sufficient in number to illuminate the entire collection of cows, not only with the result that the work is all clean, but that both milkers and cows are provided with that form of comfort which light alone gives.

**Straining the Milk.**

When milk has been drawn, whether for sale or the manufacture of butter or cheese, it is essential to remove the dirt which it contains. At the present time it is passed through a hair or metal sieve or a piece of cheese cloth, neither of which retains the minor particles, which
through the sieve or the cloth still provides a sediment, whereas that passed through the cotton-wool is practically free. It must here be remarked that in both cases the soluble portion of the dirt remains, thus indicating that milk can be clean only when it is drawn out of contact with the air.

Refrigerating or Cooling.

This question has already been discussed in a previous chapter, but it is important to mention that the two forms of refrigerator have equally valid claims in practice.

The vertical cooler is so arranged that as the cold water passes through the inside of the tubes from the bottom to the top the milk passes over the outside from the top to the bottom, as it leaves the receiving pan into which it is poured. Thus the milk, already partially cooled, passes over the bottom tubes in which the water is at its coldest. Although it is properly claimed that by this process of cooling the thin layer of milk is submitted to aeration as it flows, it must not be forgotten that it takes a heavy
toll of bacteria and particles of dust from the air at the same time. For this reason milk thus cooled should be cooled in the open air. The other form of cooler is of lenticular form, the milk passing over the circular reservoirs in a similar way, while the water passes through them, built as they are one upon the other. There can, however, be no perfect cooling without water much colder than

Milk Churn with Model Lid and Fastener, Splash, Dust, and Rain Proof.

that obtained on nineteen farms out of twenty. On a large dairy farm the milk ought to be cooled by a real refrigerator, and to such a degree that it can always be dispatched at 40° F. in hot weather. With the assistance of a refrigerating plant it could be retained when prices are low and sold when, owing to drought
or great scarcity, prices are high. Milk cooled in this way will keep twelve to twenty-four hours longer than is possible in the ordinary practice of the farm.

Railway Milk Churns.

Milk is sent to London in cans, improperly called churns, which are tall, and much larger in diameter at the bottom than at the top. Both top and bottom are fortified with stout rims, the lid being usually fixed inside the top rim, and sometimes also provided with a rim. The rim of the churn does not prevent rain passing into the milk; but this may be prevented by a lid which completely covers the mouth of the churn. Farmers largely ignore these details, and are wise to look for strength and economy in the vessels they buy. The milk churn is gauged inside, and usually holds 17 gal.—the obsolete and illegal barn of 16 gal. and sixteen half pints, it having been the custom to require the producer to give one half pint to every gallon to make up for the loss in retailing. This loss, of course, never occurs, for skilful distributors are quite able to serve their customers and still to return with some milk, or sell it and put the money into their pockets, as so many have done.

Buying a Cow.

No man can expect to succeed as a dairy-farmer unless he is able to select his own stock. Large sums may be lost in buying cows which have no value for milk. Age, infirmity, a blind teat, a diseased udder, imperfect type, or the propensity to milk well for a few weeks and then to fall off—all these faults must be guarded against.

A good cow should be in her prime, having produced two to five calves. She should possess fine horns which are never too long, a long head with a broad muzzle, and dew on her nose, full eyes, a fine neck and forequarter, getting broader towards the hips, which should be wide apart, and without those bunches of beef which are common on the rump of so many pedigree cows of beef-making type. The belly should be large, the udder broad, built well forward, full between the thighs, and globular, but
never pendent, provided with four medium-sized teats placed well apart, all of which should give milk without trouble. A good cow should breathe freely and without effort; she should chew the cud when at ease, her ears should be warm, her coat soft, and her skin mellow and loose on the body. A cow which is short and thick in build, with a short head and neck, and a rump which is heavily fleshed, is seldom a milker, and should be strictly avoided; she should be docile, sleek, standing square on the legs, and looking a picture of health and contentment.

A cow has no incisor teeth in the upper jaw, but eight in the lower jaw, and thirty-two teeth in all. Although a young cow may be recognised by her teeth, for she has not a full mouth until she is three and a half years old, it is more difficult to determine even approximately the age of an old cow, and then alone by the condition of her teeth. The central incisors appear in a heifer at the age of about twenty-two months, the second pair at two and a half years, the third pair at three years, and at three and a half years her outside incisors. Cows kept in a stall and fed on soft food may not push their teeth through so quickly, whereas in those which consume coarse foods the teeth may appear earlier.

Although it is customary to ask for a warranty with a horse, it is not the practice to do so with a cow, for in any case it is worthless. The purchaser of a cow which is said to be in calf must satisfy himself, for no honourable man can give him a guarantee, unless the calf can be felt, as it can be about five months after service, and when felt it will respond by its movement. Nor can a seller justly warrant a cow to supply milk of either a given quality or quantity. No figures should be accepted in this matter, unless the yield is recorded systematically in a book kept for the purpose, as the result of regular weighing, not measuring.

A cow which calves in the spring produces most of her milk in May, June, and July, usually falling off as the summer grass dries and as the grass fails. With a diminution of the yield there is an increase in the fat percentage, and this increase may continue until the
animal is dried off, nine, ten, or eleven months after calving, although some cows continue to milk after a year has expired.

**Drying the Cow.**

Under all circumstances six weeks should elapse between drying and calving. The cow should be maintained in good but not fat condition, and as far as possible she should earn her own living by grazing on a not too rich or luxuriant pasture. She needs the exercise which may prevent an attack of milk fever, from which so many cows die. On the other hand, a cow which is soon due to calve, if tied in a stall or left in a loose box and fed liberally, may put on flesh and incur the not very unusual penalty. A fleshy cow should receive a drench of 8oz. of Epsom salts dissolved in two quarts of cold water two or three times within the last four days before calving.

It should be remembered in relation to drying that when a cow falls off in her yield of milk and gives no more than two quarts it is better to dry her at once and to deduct the meal from her ration. So small a yield is not worth the cost of feeding and labour, while continuous milking may do harm to the calf, which now makes a great demand on the cow.

**Importance of Grooming.**

All cows should be groomed. The skin receives a healthy tone from the friction, while the coat is soon loaded with dirt and bacteria, which find their way into the milk. The maintenance of the health of a herd largely depends upon cleanliness, which is one of the first rules of life in the domestic animal as well as in man. Cleanliness is promoted by the provision of movable tubs for the mixed food or mangers fixed in the floor. This gives more room for the cow and prevents her lying on manure, which during winter plasters the haunches and soils the udder and teats.

**Calving.**

Although it is the custom in this country to calve the large majority of cows in the spring, it is obvious that the
increased value of milk in the winter necessitates autumn calving as well. Many farmers prefer to produce most of their milk in the summer, owing to the diminished cost of feeding on grass and to the fact that in cheese-making districts it is essential to obtain all they possibly can between April and October. It should be remembered, however, that in most years the yield falls with the hot weather of July and August, unless provision is made by the production of forage which is not likely to fail. On a milk-selling farm it is quite as important to calve cows in September and October as in March, and this is especially the case where care is taken to preserve grass in sufficient abundance to feed them, except upon occasional very cold days, right up to the end of December. For many years past milk has been so scarce in mid-winter that prices have been exceptionally high, and farmers who do not bind themselves by contracting have done exceedingly well.

The average time which elapses between service and calving is 284 days. Some cows calve earlier, while others are delayed. The calf may be felt by gently pressing the inside of the thumb and the forefinger on the right side of the abdomen, between the fifth and sixth month; and from this time forward it usually responds. Approaching parturition is recognised chiefly by the expansion of the udder and the enlargement of the genital organ. In summer the cow about to calve may still be left on a pasture, but not kept with or near to the herd, with the result that she will usually calve without any help. In cold or severe weather she had better be put in a loose box provided with very clean straw. When calving commences the fore feet of the calf first make their appearance, and with each throe the body comes forward, being usually expelled without any assistance. If difficulty arises and it appears to be certain that assistance is required, a fine tough rope should be obtained, and a noose passed round the fore feet. A couple of men should then take hold of the other end and pull well, yet gently, when the farmer gives the word, which he will with each throe, this action ceasing at its expiration. It usually
happens that with patience and great care all will go well. Should there be any other form of presentation than the fore feet a skilled vet. should be placed in charge of the job, which may be of a highly dangerous character to the cow and calf.

All experienced stock-breeders are aware that the placenta or after-birth follows the calf, although its appearance may be delayed. Should it, however, after abnormal delay not be expelled, or after partial expulsion remain attached to the cow, no attempt should be made by a non-professional man to remove it by force. As its adherence means danger to the health of the cow, the first course to pursue is to syringe the passage through which it has passed with a mixture of 1 part of carbolic acid to 50 parts of water twice in each day. Although there are methods of removing the placenta, it is the wisest course to place the cow in charge of a veterinary surgeon at once.

After calving the cow may be left with her calf with tepid water beside her to drink and a warm bran mash, which may be followed at a normal interval with a second mash mixed with boiled or steamed roots and some extra good hay. Under ordinary conditions she will soon be fit to turn out with the herd, but care must be taken in cold, windy, or rainy weather to prevent a chill by exposure, and to help her to recover her strength. If it is exceptionally cold she may be protected with a rug.

A newly-born calf is soon on its legs, when it is not long before finding its way to the udder; and it should be encouraged to drink, the first milk or colostrum being exceptionally good for it. We have already discussed the question of rearing the calf.

It will now be convenient to refer to the subject of Abortion in the cow, which is usually caused by a micro-organism communicated by an affected animal. The trouble, and it is a very serious one, is therefore contagious, and no care should be regarded as too great to prevent its introduction into a herd by a newly-purchased cow. A cow usually casts her calf from this cause during the fifth month, and if she is with the herd the chances are
that others will be attacked by the disease. The first thing is to remove and isolate the cow, and to bury the calf and all that has fallen with it, well covering the whole matter with lime. The spot on which the abortion took place, if in the field, should be well disinfected, and the herd removed elsewhere. The next course is to provide the following solution:—3 oz. of alcohol (specific gravity 36), with glycerine, and 2½ dr. of perchloride of mercury (a poison) in 20 pints of pure water, and with this to wash the tails and organs of every cow daily for some days, fortifying them at the same time with good food and keeping them out in the air as much as possible. If a cow is due to calve within four months she is not likely to be affected with the calf she carries. No cow which has aborted should be served again until the expiration of the nine months she ought to have gone, and then only if she is "clean" and in robust health. Nor should a bull be used which has been in contact with a cow which has aborted, unless this condition is fulfilled.
Chapter IV.

HOUSING.

The subject of housing and the equipment of the cow-stalls might easily occupy a volume, so varied are the materials which are employed in construction and so numerous the methods of arranging the stalls, the mangers, and the various other fixtures which are required for a herd of cows. In this country cows are usually stalled in pairs with partitions between. In old buildings which are cramped and badly adapted to the work the cubic space per cow is usually much too small, the ventilation bad, and the drainage worse, the floors being frequently soaked with the accumulated manure of years. In new buildings, which are larger, lighter, and more perfectly ventilated, the stalls are ranged in rows, either tail to tail with a wide passage between, and the heads of the cows facing the walls, or head to head with a similar passage dividing and narrower passages behind them. In the former case the food is taken from the barrows behind the cows to the mangers and racks, while in the latter it is drawn down the central passage and the mangers filled on either side at one operation. This is much the better plan, saving time and labour, while it is more cleanly at all times. Where, however, a building is so narrow that three passages are impossible the tail to tail system is the most convenient, but it is much the less economical, whether as regards the time expended, the food provided, or the health of the cows.
A Model Cow-house.

A cow-house should be wide, high, well ventilated from above, and well lit. Apart from light passing through the windows, which should be open in summer for ventilation, it is well to provide light in the roof by the removal of slates and tiles and the insertion of glass. In winter, when the building is dark from four in the afternoon until eight on the following morning, during which hours almost the whole of the work is performed, artificial light is essential, and there is none of such value as that provided by electricity. Candles are insufficient and costly, while paraffin lamps are dangerous, disagreeable in use, soiling the hands, occupying much time in preparation and cleaning, and never providing sufficient light. Where power is employed by a fixed engine used for chaffing, pulping, and grinding, or, in a more modern sense, for working the mechanical milker, the additional cost of a dynamo and electric lamps is quickly paid for in the greater comfort of the cows and the happiness and convenience of the men, for the building can be made almost as light as at midday.
The floors of the passages should be well constructed of concrete, but the kerbs of the gutters are better made of black grooved fire-brick. The floors of the stalls, however, open up another question. The best we have ever seen in practice are made of beaten earth laid upon a chalk foundation and well levelled. If chalk is kept upon the premises the holes made by the hind feet of the cows are easily mended. If the floor runs right up to the front partition which separates the stall from the central passage so much the better; it will give the cows more room and materially help in preventing them soiling themselves with manure, although it may be remarked that many practical men prefer exceptionally short stalls, which compel the cows to drop their dung in the gutter behind, this gutter being made shallow and wide with a longer drop from the stall than from the passage opposite. A long stall may be provided where there is no manger, and after an examination of almost every system which has been devised—and we have seen them in various countries—we arrive at the conclusion that there is no simpler, less costly, or more economical and handy system than that of providing the cows with rations in well-made wooden tubs which have been painted inside and out, and this is the practice in some parts of Yorkshire. Each tub is removed after the cows are fed, conveyed to the food preparation floor, filled, and returned at the next meal. The additional space provided for the cows affords them greater ease and convenience and keeps them cleaner. If a manger is regarded as essential it should be made of semicircular fireclay, and built so that it can be flushed with water from a tap fixed at one end and carried off at the other. It has long been the custom to provide racks over the manger for the reception of hay; but where the tub system is employed no racks are needed, for the hay can be placed upon the dry floor in moderate quantities at a time, and if it is of good quality it will not be wasted. A rack is an additional expense in construction and maintenance and has no economical value.

The partitions between each pair of cows, usually made of wood and built short, are now frequently
constructed of tubular iron, galvanised or painted (see illustration, p. 45), while a bar of the same material passes in front of the cows in the place of a partition between the stall and the central passage. This system is clean, simple, substantial, and much to be commended. The less material employed, however, in equipment the better. In some cases water is laid on to the manger—a small receptacle in the centre of each pair of cows being filled automatically. Although this appears to be ideal it is not a success in practice, the water being frequently tainted with food dropped into it, while the mechanism gets out of order. Further, it is only needed during the winter season. The walls of the building should be smooth, preferably finished in Parian cement and limewashed, this washing being conducted at least
twice a year, as well for the sake of purity and cleanliness as appearance. The cow-house should be ceiled in some way; buildings which are only covered with tiles or slates are frequently the abode of cobwebs and other accumulations, with the result that the atmosphere is contaminated, together with the cows, the food they consume, and the milk which is drawn into the pails. To this end room should be made for a loft overhead, in which hay, cake, and other foods can be stored, the ceiling being covered with matchboard, stained and varnished.

The most common practice of tying up cows is with the use of the chain, one end of which passes round the neck, while the other is fastened by a ring to a vertical rod, upon which it slides in order to give the cow more freedom. Some farmers have introduced the American system of looping the cow to the manger. A metal loop of tubular iron is fixed between the travis of the manger and a narrow beam above. This loop opens and revolves at will as the cow moves her head, but it is unsightly and costly, while it provides no advantage which is not supplied by the chain. The cow should be provided with a bed of wheat-straw or peat-moss, although sawdust and even shavings are sometimes employed instead.

The Food-Store.

Although there are many methods of communication between the food-store, the cooling-house, and the cow-house, it is essential that it should be convenient and time-saving. The food should be as near the cattle as possible, and prepared upon a clean, smooth, hard concrete floor. It is therefore requisite that each material used in its composition should be stored near at hand. Thus the hay may be kept overhead, being packed in trusses as it comes from the rick from time to time. If a chaff-cutter is in the same apartment, communicating with the engine by a belt, the chaff can be cut in the loft and passed through a trap-door on to the floor below it. Similarly, cake can be broken on the floor itself, and roots pulped, these being passed by the feeder from a store close at hand direct into the hopper of the machine ready
cleaned. We believe there is no more economical or convenient system, as part of the feeding process, than the provision of a grist-mill, by means of which a farmer is able to provide much better food than if he buys crushed oats, maize-meal, middlings, bran, and barley-meal from a merchant, inasmuch as, having purchased or grown the corn from which it is produced, he knows precisely what he is using. Where brewers' grains are used as part of a
winter ration—and it applies equally to summer—a pit should be provided outside the food-store, for the simple reason that where they are kept for any length of time grains decompose and emit a disagreeable odour, which is somewhat neutralised when they are mixed with other food. The pit should be covered with a roof to prevent the entrance of rain. The best method of conveying food to the mangers is by the assistance of a large galvanised food-barrow. The manure dropped by the cattle should be removed twice daily, and either shot upon a dung-heap outside—this heap also being under cover—or directly into a cart, and taken daily into the fields, for in this way nothing is lost. Where the manure is shot into the yard in the open it is washed
by rain and partially destroyed, or it is allowed to ferment, with the result that in a few months it loses one-half of its weight and almost one-half of its fertilising matter. Although liquid manure is of greater value per cow than the solid manure, it is almost invariably wholly or partially lost. If drained into a tank it ferments and parts with its ammonia, which is volatile, or it is diluted with rain-water to such an extent that it is never carried away until it is next to worthless. This liquid should be taken to the fields at least every second day if loss is to be prevented.

The Cooling-House.

Where milk is sold it is necessary to cool it, and each pail is emptied by the milker into a receiving pan above the refrigerator as fast as it is drawn. It should, however, be passed through a strainer in the process. The cooling-house should be constructed at a convenient spot, for if it is at one end of the building the milkers have to walk a considerable distance in doing their work. The cooling-house should be free from the contamination of the cow-house, and should therefore not communicate directly with it. It should be well ventilated, floored with concrete, kept well limed, and provided with abundance of water. The milking-pails, railway churns, and other implements employed in the work should be cleaned in another apartment where a copper is provided, and always put out of doors under a shed to dry in the open air.

Value of Recording-Sheets.

One of the most important features in the cattle-house is the series of recording-sheets, which should hang upon a board behind each cow, her name being at the top, together with her age, the date when she calved, and when she is due to calve again. On this sheet the weight of milk produced morning and night should be recorded, and each sheet handed to the employer by the foreman once a week. A glance at this sheet will easily tell in a moment whether anything is wrong with the cow, inasmuch as under given conditions she immediately drops off in her yield of milk. The recording system involves the practice of weighing the milk of each cow as it is drawn.
Chapter V.

DAIRY CATTLE.

Although well acquainted with the cattle of the European Continent, we know of no variety—with one exception, the Norman—which can approach the best breeds of this country for the production of milk, butter, and cheese. The first of British dairy cows is undoubtedly the Dairy Shorthorn, which must not be confounded with the Pedigree Shorthorn. Among cows of this type there are many that produce milk at some time in their career which contains less than 3 per cent. of fat, this being the Government standard. On the other hand, public competitions have shown that there is a still larger number producing milk which is as rich as that of the Jersey. Apparently, therefore, it is comparatively easy to form a herd of Dairy Shorthorns quite equal in this direction to a herd of Jerseys. The Dairy Shorthorn is found at her best in Cumberland and Westmorland, Lancashire, parts of Yorkshire, Cheshire, Buckinghamshire, and contiguous parts of neighbouring counties. She is a big-framed, gentle beast, with a mellow skin, and colour which varies from red or white to red-and-white and roan, or roan-and-white. She weighs about 1350 lb., is easily fattened for the butcher when her milking days are over, and produces from 600 to 1200 gallons of milk in a year—in some few cases slightly more. This cow is a good butter and cheese maker and producer of milk for sale. She is broad across the hips and wide between the buttocks, giving ample room for the udder, which is large and
broad and provided with large teats set wide apart. No cow possesses so large a milk mirror, or escutcheon, as the Dairy Shorthorn.

The Devon cow is smaller than the Shorthorn, weighing from 1150lb. to 1200lb., and producing from 550 to 1000 gallons of milk, which on the average is slightly superior in quality. She is a deep rich red in colour, and of a broader type and less meaty build than the Devon of the show-yard, which provides such excellent beef. The milking Devon common to the south of the county must not be confused with the North Devon or Somerset breed. She is responsible for a large proportion of the clotted cream and the rich butter made in Devonshire—butter which realises a much better average price than that made in any other part of the kingdom, if we except that of the Channel Islands.

The Red Poll dairy cow is again of a different type from that of the Red Poll which is kept for beef-production, both strains being bred in East Anglia, although herds are occasionally met with in other parts of the country. She is a lighter red than the Devon, and weighs slightly less, while her milk-yield is approximately similar. The milk of the Devon, however, is rather richer than that of the Red Poll, and there are more cows of the Eastern Counties breed yielding poor milk. The Red Poll is docile, well formed, handsome, and fairly fleshy. Her udder is not so large as that of the Shorthorn, nor, like the Devon, is it so well formed as it might be.

The Ayrshire cow is the native Dairy breed of Scotland, and is chiefly bred in Ayrshire and Wigtownshire, where large herds are kept for the manufacture of cheese. This variety is hardy, but small, weighing about 1,000lb., and although it is said that the Ayrshire will live and thrive on poor pastures, it is well known that, like other varieties of cattle, it responds to good feeding and is capable of yielding a very large quantity of milk, and milk of rich quality. Ayrshire breeders by the adoption of the recording system have considerably improved the milking character of their stock by rejecting poor milkers and breeding from rich ones. The data published in the transactions of the
Highland Society are most instructive and conclusive on this point. The Ayrshire may be red, brown, yellow, or black-and-white, white usually predominating, some cows being almost entirely white with small spots or splashes on the coat. The form of the horn is peculiar to this breed, growing to some length upwards and outwards and forwards. The fore part of the body of the Ayrshire is slender, expanding towards the hips, which are wide apart. The udder is wide, long, and flat, falling no lower than the base of the abdomen, while the teats are small, and for this reason women are chiefly employed as milkers in the dairies of Scotland.

The Jersey is the richest milker of our native breeds, her milk sometimes producing 7 per cent. of fat, while no cow but the Guernsey produces milk or butter of such rich colour. The Jersey is the best butter-producer in the world, if we regard her claims to quantity, quality, and colour. She has small horns, which are fine and black at the points, almost yellow at the base in choice specimens, and curved inwards, the tips almost meeting. The coat has black points, while the colour varies—from silver-grey, mulberry, fawn, and golden to golden-fawn. The yellow and oily nature of skin is shown within the ears, on the tail, beneath the thighs, and sometimes upon the udder. The form of the body is fawn-like, being extremely slender, the face slightly dished, and the tail lying between the two pin bones. The skin is soft, thin, and loose, and the cow, while in the picture of health, is so thin that her coat is apparently stretched across her body structure. The Jersey weighs from 900 lb. to 950 lb.—British-bred cows being the largest—while the milk may contain from 4 to 7 per cent. of fat, its quantity reaching from 450 gal. in a poor specimen to 1200 gal. in an exceptional one.

The Guernsey cow is, as a rule, slightly larger and somewhat coarser in build than the Jersey, but very fine specimens, which are rare—indeed, much rarer than in the case of the Jersey—are of similar form and almost equally fawn-like. The udder, too, is exceptionally good, if not quite so globular. These cows are good milkers,
and in the island of Guernsey produce milk and butter of the very finest quality. The colour of the Guernsey is orange or orange-and-white, the shades prevailing being a light rather than a dark orange. The Guernsey weighs nearly 1000 lb.; she produces milk of rich colour, and in quantities varying from 500 to 1300 gallons—some specimens, however, have produced still greater weights than the maximum of these quantities and taken their places amongst the finest milkers known to the dairy industry. The Guernsey is not cultivated in this country as it deserves. It has long been separately classified at exhibitions, but for some reason it has not taken hold of the public taste so much as the Jersey, although exceptional specimens are perhaps more profitable animals. A good Guernsey stands 50 in. at the hips and measures in girth round the middle 90 in., these figures being typical of prize animals which we have examined at public exhibitions.

The Kerry is usually black, with sometimes a small splash of white on the body or, as is more usual, on the udder. Although a very small variety on its native mountains, where specimens are poor in the extreme, it improves in both size and form as well as in condition when transferred to English pastures. The improved Kerry as we know it in this country is an excellent milker, producing some 50 per cent. more milk than the Kerry from the county which gives it its name. Some idea may be gained of the local value of this beast when at Kenmare Fair, where we have seen some two or three thousand beasts collected, the highest price of the day, so far as could be ascertained, was £5. A good Kerry weighs from 700 lb. to 800 lb., and stands 45 in. high at the hips. Her length reaches 78 in., while her girth is a similar figure—these measurements being also taken from prize stock. The milk of the Kerry is much richer than an average sample sold to the consumer, containing as it does some 3.8 per cent. of fat. The breed is therefore exceptionally useful to small occupiers of land or small cow-keepers, who prefer to supply their own families with dairy produce. It makes good butter and excellent cheese. The Dexter
Kerry is a still smaller but more compact animal, its build resembling that of a diminutive Shorthorn, whereas the modern Kerry is very symmetrical, for in form it somewhat resembles the more delicate Bretonne of France. The Dexter is an excellent dairy cow, and, making allowance for its size, it also is worthy of recommendation.

The Dutch, or British Holstein, cow, to give it the name which has been provided by the British Holstein Society, is an old-established breed in Holland, and one which centuries ago is believed to have influenced our early strains of Shorthorn. This is a cow weighing some 1300 lb., and producing very large quantities of milk. In the most important competition known in agricultural history—that at St. Louis—it was a Dutch cow which took the first prize after a test of 120 days’ duration. During this period the cow—Shadybrook Gerben—produced 810 lb. of milk, or 800 gal., containing 3 per cent. of fat and producing by calculation 330 lb. of butter, or a fraction more than the second-prize Jersey cow in the same competition. The Holstein cow is but one of several native breeds of Holland, all of which are black or black-and-white, and in many ways identical, although they are really maintained as separate families. The head is large, long, and somewhat ill-formed, the horns of medium size and varying in shape; while the body in the best specimens is compact, level at the top, provided with well-sprung ribs, a large abdomen, narrow forequarters, broad hips, and strong buttocks, with a good milk-vein and an exceptionally large udder, which well fills up the space between the legs. As this cow is a deep milker, although the milk is exceptionally poor, it is acquiring favour, and will probably be much improved within the next few years owing to the recent introduction by the Holstein Society of a considerable number of first-class cattle from Holland.
Chapter VI.

FEEDING.

The food supplied to the cow must be sufficient to provide for her maintenance, i.e., for the production of heat, energy, and repair, and for the manufacture of milk. Science and practice combined have enabled us to learn with some precision the approximate quantity of food to supply to a cow of given weight when she is giving milk and when she is dry. We learn, too, from the same sources what form that food should take, and in what proportion we should provide the protein, so essential for the repair of the muscular system of the body and the production of the casein of the milk, the carbohydrates, the main source of heat and energy, and the fat, which plays a similar rôle. So far no place has been assigned to the mineral matter in the compilation of rations, for the possible reason that as a heavy consumer of coarse vegetable matter the cow obtains from this source all that she requires. We may, then, justly assume that the dairy cow is fed with much greater care than her owner, and that in consequence her productive powers and her life are prolonged.

Selecting the Food.

A knowledge of the requirements of the cow and of the composition of foods materially assists the dairy-farmer in making his selections on the market, as in growing his
crops, and therefore in feeding her cheaply. In practice those foods which are rich in carbohydrates—roots, straw, hay, and oats—are grown upon the farm, while those which are rich in protein and oil, the pulses and cakes in particular, are purchased, farmers regarding it as more economical to sell their own grain and pulse and to purchase brewers' grains with cakes and cereal offals which have been imported. It would be still more economical to grow forage crops rich in protein—lucerne, clover, sainfoin, and vetches—together with maize, for winter consumption, either as silage or hay, and to buy less concentrated food, although for some occult reason this most sensible plan is seldom adopted.

The ration which is prepared for a cow during winter for consumption as she stands in the stall is probably richer in nutrient matter, where the feeding is good, than the grass she obtains from the pastures in summer. While, however, grass is an ideal food, and more easily assimilated than dry foods, it is better adapted to the production of milk and for maintaining a cow in good health.

A Well-balanced Dietary Essential.

In order that a cow may receive food which is well balanced, as are good pasture grass and hay, and therefore able to provide for her varied requirements, it is necessary to understand what is meant by the term. A good sample of grass contains 2.5 per cent. of digestible albuminoids (protein), 10 per cent. of carbohydrates, and .5 per cent. of oil, while a good sample of hay contains 9.2 per cent. of albuminoids, 42.5 per cent. of carbohydrates, and 1.5 per cent. of oil, giving a ratio of albuminoids to carbohydrates and fat of 1 to 5.1, and in the case of the grass 1 to 4.4. Thus for every pound of digestible albuminoids 4.4 lb. of carbohydrates and fat (or oil) are required, the fat being estimated at 2.3 times the value of the carbohydrates and added to their weight.

We have next to consider what quantity of these constituents of food are necessary for a cow of given weight, both dry and in milk. In the various investigations which have been made to determine this point the
Rations supplied to cows have been based upon a weight of 1000lb. Thus the total weight of a ration as well as that of each of the food constituents is increased or diminished in accordance with the weight of the cow—i.e., whether she weighs more or less than 1000lb.

It will now be convenient to give a brief description of these constituents.

**Food-Constituents.**

Protein is a term applied to those constituents of food which contain nitrogen. In this country the constituents that possess nutritive value are usually described as albuminoids, which form the chief proteid group. Examples of albuminoids or digestible and nutritious protein are found in the gluten of cereals, the legumen of pulse, the casein of milk, and the albumen of egg. In some continental countries all the albuminoids of food are known as albumen, or as digestible protein, while crude foods such as pulse, in which they are found in abundance, are termed nitrogenous foods. As protein is essential in the production of the casein of milk as well as for the repair of the nitrogenous parts of the animal body, it must be supplied, hence the great demand for rich cakes and meals. The quantity needed, however, is less than is generally supposed, and if that quantity is given in excess money is wasted, while extra pressure is put upon the digestion of the cow. It is true that the excess may appear in the dung and urine; but fertility so obtained is costly in the extreme. As protein contains carbon, it can be and is utilised in the animal system for the development of energy and heat and the production of fat. The cost of protein prohibits its economical use in the presence of the much cheaper carbohydrates, which dairy-farmers so liberally produce for themselves.

The carbohydrates of food include those nutritive materials which are the most abundant of all in vegetable life, for they are not found in animal foods, with the exception of milk. The most important is starch, which is the chief constituent of grain and which forms the bulk of all forms of cereal flour. Sugar, gum, and cellulose,
the material of which the cells of plants are constructed, are also carbohydrates. Although protein, fat, and the minerals present in foods are all indispensable, starch plays the greatest part in the feeding of stock, and for this reason it is largely produced on the farm, protein and oil being much more commonly purchased.

The rôle of fat and oil in food is not yet fully defined, but while they are capable of producing 2.29 times as much heat as starch and sugar, they are relatively more expensive to buy. While fat will produce fat in the animal consuming it, and while it probably directly assists in the production of the fat in milk, it has been demonstrated that milk can be produced equally well upon food which has been wholly deprived of its fat. Fat or oil is not therefore directly essential to milk production, yet the experienced farmer is well aware of the value it confers upon cattle consuming it, as in linseed cake. It gives mellowness to the skin and brightness to the coat, and by its laxative action confers upon the system a condition which not only contributes to but is an indication of health.

Too little importance is bestowed upon the value of the mineral constituents of food. If the milk supplied to a calf were first deprived of the mineral matter it contains the young animal would not be provided with bones, which are chiefly constructed of phosphate of lime.

In the last analysis the health and, finally, the life of the animal depend as much upon the mineral constituents of food as upon the larger constituents. Fortunately, and unlike man, who deprives so much of his food—e.g., the cereals by milling and vegetables by boiling—of so large a portion of these natural minerals, and is constantly suffering in consequence, the animal is fed upon raw foods in which lime, iron, potash, phosphorus, and other minerals are present, and so its health is preserved.

The Ration Required.

The quantity and composition of the food required by a healthy cow to enable her to maintain her weight and condition depend upon that weight, upon the milk that
she gives, the character of the food, its cost, where it is bought, and to some extent on the season. In cold weather a larger quantity of food is required to maintain the heat of the body than in warm weather. When a cow is turned out to graze she requires more food than when she is resting in the stall, because her expenditure of energy is greater. A large cow requires more food than a small cow, and a cow giving 5gal. of milk demands more food for its production than a cow giving 3gal. Some foods, too, are more popular than others equally good, and therefore it is that a farmer acquainted with the composition of foods can select them in accordance with their price in the market.

The chief nitrogenous foods are peas, beans, almost all cakcs, clover, fucrme, sainfoin, and vetches, while the carbonaceous foods—i.e., those rich in carbohydrates and relatively poor in nitrogen—are the cereals, roots, cabbage, hay, and straw. It is now generally assumed that a cow weighing 1000lb. requires 15½lb. of digestible dry matter as a purely maintenance ration. If she weighs more the food is increased in proportion. For each gallon of milk she produces she requires an extra pound of this digestible dry matter, which may be described as the digestible portion of the dry matter of foods which remains when the water of combination has been entirely driven off.

Thus a cow weighing 1000lb. and giving 4gal. of milk should receive food which will provide her with 19½lb. of digestible dry matter. The next point to consider is how this ration should be composed. Practice has confirmed the results of scientific investigation in this matter and shown that the ration of a cow should contain one part of digestible albuminoids to five and a half parts of carbohydrates and fat, estimated as a carbohydrate by multiplying by 2·29. Thus a sample of hay containing 9·2 per cent. of digestible protein, 42·8 per cent. of digestible carbohydrates, and 1·5 per cent. of fat possesses a ratio of 1 to 5·0; 42·8 + (1·5 × 2·29) = 46·2 ÷ 9·2 = 5·0. If, therefore, the ration was composed entirely of hay of this quality it would be a little too rich in protein. But
the error is easily rectified by the addition of a food rich in carbohydrates or poor in protein—cereal meal on the one hand or roots or straw on the other.

**Food in its Relation to Milk Quality.**

There is, however, another side to the question of feeding which must not be overlooked. So far we have discussed the question of food for the production of milk without regard to the character of that milk. Where it is employed in the manufacture of butter or cheese some foods must be avoided, or they will either communicate an undesirable flavour to or spoil the consistency of the produce. Brewers' grains, turnips, cow cabbage, mangels in quantities, inferior hay, linseed cake, peas, and beans are all undesirable foods in a butter or cream dairy, in which the closest attention must be paid to the feeding.

It should be pointed out, too, that no food is stable in its composition—analyses are therefore always approximate, sometimes wide. The value of hay depends first upon the composition of the herbage and next upon how it was saved. Hay which has been badly weathered loses both protein and carbohydrates. One variety of mangels contains more sugar than another; one variety of oats may contain 7 to 8 per cent. more waste than another which is more popular. One pasture may be rich in clovers and trefoils, and therefore in protein, while in a field over the hedge there may be no clover at all. These facts have all to be estimated by the dairy-farmer in feeding his stock. Young grass is richer than old grass, and it makes much better hay. Grass, indeed, which has been left in order to obtain a larger yield of hay may be no better than straw owing to the shedding of its seed. Again, grass which has been well manured with phosphate of lime is richer than grass which is not manured at all; and this fact, combined with the larger yield which the manure provides, is one of the most important of all the facts which will lead to the increased prosperity of the farm. Mangels of medium size and grown close together are richer in food than very large mangels, while all mangels are richer after long keeping than when they are lifted and stored.
Food is improved in value by some forms of preparation. Thus hay and straw chaffed and packed tightly in a barn have a better and more appetising flavour than the raw material; vetches and all forms of green fodder are richer and more digestible when they have lain twelve hours in the sun; hay improves in the rick; while a mixture of foods—prepared roots, chaff, and meals—are warmer and more agreeable to the cows after heating or slight fermentation than when the several materials are supplied raw. On the other hand, all forms of dry food deteriorate if kept in a damp store, and especially grain, meal, and cakes. Brewers' grains, although pitted for winter consumption, not only become partially putrid, emitting a strong odour and acquiring a sour flavour, but they lose a large portion of their nutritive value.

Cooking is not only an extravagant practice, but it diminishes the nutritive value of food, unless the water in which it is boiled is consumed. For all that, when food is given hot, with the water used in its preparation, something is saved. A smaller quantity of the carbohydrates and fat in the ration are employed in maintaining the heat of the body, and when cows are regularly drinking very cold water this fact cannot be dismissed.
Chapter VII.

MILK.

Milk is an opaque fluid containing the solid materials fat, sugar, casein, with numerous minerals, all of which are either dissolved or suspended in water, the quantity of water in an average sample reaching 87½ per cent.

Composition.

The fat of milk, which forms 88 per cent. of a good sample of butter, exists in the form of globules which are suspended in the milk and give it its colour. When the fat has been removed from milk in the form of cream the fluid remaining is known as skimmed or separated milk, the term depending upon whether the cream is removed by hand or by mechanical separation. Skim milk is white, and this is due to the presence of the casein, part of which is suspended and part dissolved. When both the fat and the casein have been removed—and this is the case in the manufacture of cheese—the fluid remaining is of a greenish-yellow colour, owing to the presence of the sugar and the minerals. This fluid is known as whey. Milk varies in composition, that represented by the figures of the table on page 68 being examples of the milk of a poor milker and of a rich milker respectively, together with an average sample as taken from a mixed herd of cows.
MODERN DAIRY-FARMING.

Composition of Milk.

<table>
<thead>
<tr>
<th></th>
<th>Average quality.</th>
<th>Low quality.</th>
<th>High quality.</th>
</tr>
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<tbody>
<tr>
<td>Fat</td>
<td>3.55</td>
<td>2.61</td>
<td>5.29</td>
</tr>
<tr>
<td>Casein</td>
<td>8.45</td>
<td>8.39</td>
<td>9.25</td>
</tr>
<tr>
<td>Sugar</td>
<td>5.83</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mineral matter</td>
<td>7.72</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>87.45</td>
<td>89.00</td>
<td>85.46</td>
</tr>
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100.00  100.00  100.00

The examples showing high quality and low quality respectively are taken from two cows which competed in the milking trials at the London Dairy Show in 1912.

Quality.

The quality of milk varies with the age of the cow, with the time which has elapsed since she calved, with the hour of milking, and with the breed. Thus, a mature cow produces richer milk than a heifer or a young cow. When a cow has calved several months, and has therefore advanced in her period of lactation, she has fallen off in her yield, and her milk is richer in proportion; and so as lactation proceeds there is a gradual increase in the fat percentage. Again, when cows are milked at unequal periods in the day the milk is poorer in the morning than in the evening. This is the case, for example, when the morning milking is at six o'clock and the evening milking at four o'clock. But when milking is conducted at equidistant periods—i.e., twelve hours apart—the quality is almost identical in each case. The first milk drawn from the udder, too, contains scarcely any fat, whereas the last is extremely rich, and may contain 10 per cent. This accounts for the importance of stripping the cows after milking. Cows of the Channel Islands and Devon breeds produce richer milk than other breeds employed by the dairy-farmer; but in all varieties of dairy cattle there are both rich and poor milkers, and it is not difficult, if the trouble is taken, to select a herd composed entirely of rich milkers. Most herds, however, consist of cows which produce between 3 and 4 per cent. of fat. If we may suppose the existence of a herd of twenty-one cows
Milk.

of average type, the milk of each of which is tested when it is normal, and the figures placed in the form of a table in order of precedence—the best milker standing at the top—we shall usually find that the eleventh cow in the column will represent the average quality of the milk of the herd. This fact equally applies to the quantity of milk supplied by each cow; and so it is that in each herd, whether it be large or small, the cows which stand below the middle cow are usually unprofitable servants, inasmuch as they not only yield poorer milk than the average, but often less than average quantity. This is one of the secrets of the importance of the recording system, although so far few farmers have cared either to try it or, having tried it, to abide by its natural teaching—that is, the early disposal of the offending unprofitable cows. Where this practice is rigidly followed there is not the slightest difficulty in gradually levelling up the character of the herd, for where an improvement is effected both in the quality and quantity of the milk produced the returns are increased accordingly.

Food Influences.

It is generally supposed that the food consumed by the cow influences the quality of her milk. It certainly does influence the colour, and this may be observed by the richer tint of butter produced when cows are feeding upon grass. But by no process of feeding can we increase the fat percentage; that is an inherent property which can only be improved by breeding. If a cow is properly fed, or, in other words, if she is receiving all she can assimilate, no addition to her food can improve the quality of her milk. On the same principle the employment of special foods has sometimes been condemned, although with no just cause. A cow, for example, has been supplied with all the food she can utilise. To this food has been added a particular cake or meal; but no result has been observed. Nor can it be, for the reason which has already been advanced. The following facts will afford us some idea of what a cow is able to perform.

In the great American contest between Shorthorn, Jersey, Dutch, and Swiss cattle at St. Louis, in the conduct
of which £49,000 was expended, partly by the American Government, the winning cow of the Dutch breed produced milk containing 3·5 per cent. of fat, and in the course of ninety days gave a total yield of 232 lb. of crude fat, equal to 330 lb. of butter. It was calculated that this cow secreted 136,000,000 fat globules per second, and that her production of milk was equal to 2\(2\frac{1}{3}\) lb. per hour day and night throughout the whole period. During the competition this cow produced 903 lb. of milk solids, or at the rate of 7\(\frac{1}{2}\) lb. per twenty-four hours. This feat, too, was accompanied by a gain in weight of 54 lb. The produce of the second prize cow—a Jersey—was almost equal to that to which reference has been made.

The health and condition of a cow practically governs her powers of production, but it may be observed that disposition or temperament plays an important part. A contented, placid, docile cow is invariably the best milker. On the other hand, where the cow is frightened by any occurrence, or where she stands in fear of the man who milks her, she is liable to fall off in her milk yield, and not to return to her condition as a milker until the trouble is removed.

Test for Purity.

The purity of milk is usually tested in the first place by its specific gravity or density. As distilled water at a temperature of 60 degrees, the barometer standing at 30, weighs 10 lb. to the gallon, so milk under similar conditions weighs, to give the two extremes, from 10·27 lb. to 10·34 lb. per gallon. Employing these figures in another way, the specific gravity of milk is therefore placed at from 1·027 to 1·034. Milk of average quality, however, almost invariably has a specific gravity of 1·023 to 1·032. The variation of these figures is owing to a variation in the composition of the milk. Thus, where a sample is rich in fat, the other constituents remaining similar to those of average milk, the specific gravity is lighter, because fat is lighter than water. If, therefore, the fat is extracted from milk the specific gravity is increased, because we have removed from it its lightest constituent. Where milk
possesses a specific gravity of less than 1.029 or where it is more than 1.032 it may be suspected. Some persons combine the specific gravity test with the cream test. In adopting the latter method milk is poured into a narrow tube without regard to temperature, and the depth of the cream is noted by the gauge upon the glass. If the cream is apparently deep, forming perhaps 15 to 20 per cent. of the whole, it is regarded as satisfactory. Milk cannot be tested in this way, nor is the cream tester reliable under any conditions. It is, however, approximately reliable when, instead of a tube, a burette is employed, this standing on a foot and reaching a height of 10 in, and being 2 in. in diameter. If any practitioner will test this question for himself he will sometimes find that a cow which is known to be a rich milker will produce milk which throws up a poor volume of cream, whereas a cow which is a poor milker produces a milk which throws up a large volume of cream. The apparent inconsistency is found in the fact that in one case the cream is extremely thick and in the other it contains a large proportion of water. The best method of testing milk is referred to in a later chapter. It is important in all cases in ascertaining the specific gravity or density of milk to see that the temperature is at 60 degrees before the lactometer, or specific gravity instrument, is used. The reason is that milk expands or contracts in accordance with the temperature, and therefore its density varies.

Cause of Souring.

The fermentation, or souring, of milk is caused by the presence of bacteria, which are more active in warm milk and in warm weather than in cool milk or in cool weather. Although milk has been drawn from the udder in a sterile condition, and so kept for a long period, it is undoubtedly true that under normal conditions the milk which is drawn is contaminated by the bacteria which exist in the passage of the teat of the cow. Some milkers are instructed to draw the first milk upon the floor of the cow-house—an improper proceeding—with the object of maintaining the
purity of the fluid, but bacteria are still found in the sample afterwards drawn. The bacteria common to milk cannot be excluded, nor is it desirable that they should be. They are practically essential in the manufacture of butter and cheese. The danger lies in the entrance of disease-producing, or pathogenic, bacteria into milk, hence the enormous importance of maintaining perfect conditions of cleanliness. The first thing is to provide for a healthy environment, and the second is to perfectly cool the milk. In some cases the milk contains a very small number of bacteria; in others the number is so prodigious that it becomes practically unfit for sale and rapidly ferments and spoils. There are no conditions so perfect as those provided by the milking-machine, which enables the farmer to draw milk from the cows entirely out of contact with the air in which bacteria float with myriads of particles of dust and dirt. Apart from this excellent contrivance, the best method is to milk the cows in the field, taking care to maintain their coats and udders in a high condition of cleanliness. As already shown, the milking-machine is now actually working in the fields in the summer season, so that a double effort is made to maintain the purity of the milk. Where, however, the cow-house is small, the ventilation bad, the stalls unclean, and the cows never groomed it is practically impossible to prevent the milk drawn in open pails from becoming highly contaminated. Clean milk which has been cooled down to 40° F. will keep twenty-four hours longer than the average milk produced upon the farm and cooled only to 60° F.—a figure which presents with a high degree of accuracy the temperature of the water which is employed in the process of refrigeration.

When milk is pasteurised at 170° F. the bacteria it contains—and this refers to all species—are destroyed, but the spores remain unharmed. It has been assumed that when milk is boiled to 212° F. it is sterilised; but this is not the case. Simply boiling has practically no more effect than pasteurisation, for it fails to destroy the spores. When milk is placed in bottles with the stoppers open and heated to 212° F. for half an hour,
the stoppers being fixed in their places by a gloved hand in the live steam, the milk will keep for a considerable time, but it is not sterile. If, however, this process is followed on three occasions, with intervals between, the spores will be destroyed as they develop, and then sterilisation is complete. Much greater care is now taken by farmers and dairymen in the manipulation of milk than was the case a few years ago, when outbreaks of disease were somewhat frequent, owing to the contamination of the milk by milkers and others who had been suffering from some contagious disease or who had been in contact with such a sufferer. It was shown in these cases that a large number of persons were attacked with dangerous diseases owing to this practice. The importance of this question warrants our referring to it in these remarks, for under no conditions should a member of a household in which there is any person suffering from a contagious disease be allowed to milk the cows, to groom them, or to cleanse the vessels in which the milk is drawn or transported. Such a person should, indeed, be kept entirely off the farm until the danger has passed.

When milk, as in hot weather, is suspected, or is in danger of developing acidity, it should not be "preserved" with boracic acid, carbonate of soda, or any other drug. Not only is the practice in opposition to the law, but it is one of danger to the pocket of the dairymen and to the health of the consumer. The first essential in the keeping character of the milk is, as already observed, milking with the milking-machine, or in the open air, and cooling to a temperature which should not be higher than 45° F. Where milk is employed in factories it is a common practice to pasteurise it, and then if it is required for distribution suddenly to cool it. This method will enable it to keep for a considerably longer time than is possible under any conditions short of actual sterilisation.

**Fat Globules.**

The fat of milk is present in globules which are so minute that in rich milk they average about $\frac{1}{100}$ of an inch in diameter. They can be easily recognised by the use of a
moderately powerful microscope—one magnifying 180 diameters. These globules are suspended in the milk, and they vary in size, those produced by cows of the Channel Islands being larger than those produced by cows of other varieties; but while these breeds stand easily ahead in this matter, individual cows of any breed may produce globules of fat which are larger or smaller than the average produce of that breed. The globules in the milk first drawn from the cow are smaller as well as less numerous than those found in the last drawn milk when the udder is emptied. The globule consists of several fats, the chief being olein, a fluid, which is present in much larger quantity than the stearin or the palmitin, two solid fats, and which constitute so large a proportion, with the olein, of the vegetable oils and fats of animals. These are all known as insoluble fats. Milk fat contains soluble or volatile fats, which include butyrin, caproin, and caprylin, although the latter are present in insignificant quantities. The fat which gives the consistence to butter is the olein. This, however, varies in quantity in the milk of different animals, as well as in accordance with the season. Thus, it is more abundant in summer than in winter, whereas the solid fats, stearin and palmitin, are more abundant in the winter season than in the summer. Although olein is tasteless, colourless, and without odour, it becomes disagreeable when exposed to the air, owing to the absorption of oxygen, and at the same time it becomes yellow. The fat of milk when exposed to air and light and when it comes into contact with water gradually decomposes until it becomes rancid.

Casein.

The casein of milk, which is its only albuminous constituent, so far as is known, is therefore the only material which contains nitrogen. In this material there are small proportions of sulphur and phosphorus. Casein is coagulated by rennet and certain acids, among which lactic acid is the most prominent. It is for this reason that milk in the process of decomposition and the consequent production of lactic acid so easily coagulates. The casein
of milk should not find its way into butter, which it assists in the process of decomposition, but should be carefully washed out in the churn. It is, however, one of the two food constituents of cheese, of which it forms about one-third, fat being the other.

**Lactose.**

The sugar of milk (lactose) is less sweet than the sugar employed in the household. It has a specific gravity of 1.52, and although it is not present in butter or cheese, finding its way into the whey, it exerts considerable influence in the manufacture of both, owing to the fact that in the process of decomposition it is converted into lactic acid, and it is lactic acid which plays so important a part in the production of the flavour of both these foods.

**Mineral Constituents.**

The minerals of milk are of the highest importance to young animals, for which they are naturally produced. Thus, if these materials were extracted from milk the young animal, like the young child, could produce no bones or teeth, while the blood and the muscular system would be deficient in one of its most important constituents. The minerals of milk are therefore vital to the life of the animal or child consuming it. They chiefly consist of phosphate of lime, iron, and potash, these materials being supplemented by magnesia, soda, and chlorine. Although the minerals of milk vary slightly in quantity, 7 per cent. constitutes the average of a large number of samples. Where milk is sold from the farm the fertility of the soil is to some extent removed, or, in other words, the soil is impoverished owing to the large quantities of phosphate of lime and potash which are removed by a herd. Thus, a cow producing 750gal. of milk in the year provides about 15lb. each of phosphoric acid and potash. If we multiply this figure by the number of head in the herd of cows it will be seen what a large quantity of mineral fertilising matter is represented, and that a considerable sum would be required to replace it in the form of artificial fertilisers. Farmers, however, are in the habit of providing
their cows with cake and corn of various kinds, thereby replacing the minerals which the milk has removed. If a cow consumes 1500 lb. of cotton cake in the course of a year she will practically return to the soil as much mineral matter as her owner has removed from the farm in selling his milk. This matter, however, can be provided in the form of potash salts, or an equivalent in the form of wood ashes, and by using superphosphate, bone manure, or basic slag, so long as it contains the requisite amount of phosphate of lime. It is important to recognise that milk-selling does impoverish the land if it is not accompanied by high feeding or by the employment of mineral fertilisers. In the manufacture of butter there is no mineral matter removed from the milk; it remains in the skimmed or separated milk, and if this is consumed upon the farm there is practically no loss of fertility. On the other hand, if cheese is made and sold there is a marked quantity of phosphate of lime removed. Thus it is that cheese-makers in counties like Cheshire are wise enough to employ large quantities of bone manure.

**Tainting Milk—How to Avoid.**

Milk should not be touched by the hand, nor should it be placed in any position or apartment which is contiguous to a bad smell, which it readily absorbs. It is for this reason that milk sold by general shopkeepers in the poorer districts of large cities is so frequently tainted—the shop containing perhaps candles, firewood, and many other articles which possess an odour of their own. Milk takes up the blend, and this fact, combined with its change of colour when exposed to the light, should induce sellers of milk to take particular care as to the spot in which their milk is to be kept. For a similar reason neither milk nor butter should be placed in a larder or a pantry or in any other apartment where it is near to foods, so many of which emit odours; and yet this is quite a common practice on many farms where there is no milk-room or dairy. It follows that if milk is so susceptible to contamination the floors of milk-rooms should be of impermeable concrete or stone, not laid in earth, but
MILK.

grouted in the floor with cement. Brick is not exempt from the trouble which is so common to wood. The shelves on which milk vessels are placed should not be of wood, however frequently it is scrubbed, but of slate, concrete, or stone, the first named being the best. If wood is employed it should be painted, and if the work is well done the wood will not absorb the milk spilt upon it.

How to Treat.

When milk is intended for separation it should be taken direct to the machine after straining. If it is to be used for setting in a shallow pan for skimming later on it should be poured into the vessel while still warm from the cow. Again, if it is intended for cheese-making it should be strained directly into the cheese vat or tub. A word with regard to the reason why milk used for the manufacture of butter should be set warm will be useful. The quantity of butter produced depends upon the perfect rising of the cream. Skimming is at the best an imperfect system, but if the whole of the cream does not rise it cannot be removed. Rising, however, depends upon temperature. Thus, if milk is set cold the cream will rise very slowly and never perfectly. If it is set at 90° F., or thereabouts, in a dairy which should be as near 60° F. as possible in spring, summer, and autumn, it will have to fall through 30 degrees before it reaches the temperature of the apartment. The fat of milk—i.e., the milk globules—has a lower specific gravity, or weight, than the fluid in which it is suspended. If the milk is cold the margin between the density of the fat and of this fluid is narrowed until they become almost alike in weight. If, on the other hand, the milk is warm and the apartment cooled so that there is a sudden serious change of temperature, the margin between the density of the two materials is widened, with the result that the fat globules rise more quickly as cream. The reason is that the fat feels the change of temperature much less quickly than the milk, inasmuch as it is a non-conductor of heat, while by comparison the milk fluid is
a conductor of heat, and therefore feels the change of temperature in the dairy immediately.

Cream.

This varies considerably in both quantity and consistence. It may be almost as thin as rich milk, or it may be nearly solid, like the clotted cream of Devonshire and Cornwall. If cream is raised upon the system of cold-setting, which is now obsolete, it is invariably thin, and larger in volume. If it is raised at 60° F. it should be rich and thick, whereas if it is removed from the milk by the mechanical separator it may be made thin or thick at will. A rich-milking cow does not of necessity produce thick cream, while a poor-milking cow may, and frequently does, produce thick cream. Milk is placed in a burette, or test-tube, in order to ascertain its richness in cream—a desire which is never satisfied because the system is
inaccurate. It is quite possible for the milk of a poor-milking cow to throw up a small volume of thick cream and for the milk of a cow yielding rich milk to throw up a large volume of thin cream. The volume of cream varies with the cow and with the season. It should be sufficient to say that the object of the dairy-farmer in making butter should be to obtain all the fat from the milk, whether he skims the cream from a shallow pan or removes it with the separator. When cream is left in contact with the air at a temperature of above 65° F. it rapidly changes, decomposes, and becomes acid and thick in consistence, the thickness being due to the influence of the acid upon the casein, which it coagulates. The specific gravity of cream varies between 1·000 and 1·016. It is therefore lighter than milk and usually heavier than water. From what we have said it will be understood that the quality of cream varies considerably. It may in fact contain only 25 per cent. of fat, or it may contain 60 per cent. Hence, in buying a sample of sweet cream the consumer should beware of the consistence.

Skimmed Milk.

This is not precisely identical with separated milk. The latter should be absolutely sweet, and taken immediately after milking. It also contains less fat than skimmed milk, for however perfectly the cream may have risen to the surface it cannot all be removed by hand. Skimmed milk, too, is usually more or less acid, and on that account less fit for human consumption. The artificial process to which cream is subjected after separation in order to produce ripeness or acidity is not equal to the natural ripeness which follows the rising of the cream in a shallow pan. In this case the cream rises in a thin layer, and is all exposed to the air, and therefore becomes thoroughly oxidised, this fact accounting for the perfect flavour of the butter which is produced from it. On the other hand, when cream is removed by separation the milk is usually kept in volume, the surface of which alone comes in contact with the air, however much it is stirred. In spite of the addition of a "starter," which assists in the cultivation
of bacteria, we have never found the same results in the butter produced by this method as in that produced by a first-class system of shallow setting. Skimmed milk contains about 10 per cent. of solid matter, consisting of sugar, casein, and minerals. It is an excellent food, and worth more money than is usually paid for it; but the milk which is the residue left in the churn after the removal of the butter is strongly acid, sometimes sour, while it contains 9 per cent. of solid matter. Contrary to common belief, it is in consequence inferior as a food to skimmed milk.

Whey.

Whey is the liquid remaining after the removal of the curd in the process of cheese-making. It contains almost the whole of the sugar of the milk and a large proportion of the minerals, together with some fat and traces of casein which the cheese-maker has failed to remove. Practically speaking, the only value of the whey is in the sugar and the minerals, for it is the custom of the cheese-maker to set the whey for skimming, removing such fat as remains when it has risen to the surface, and with this he makes butter.

Testing.

Adulteration is much less rampant than it used to be when water was unblushingly added by large numbers of dairymen. The punishment to which the offenders are now subjected by legal tribunals and the certainty with which adulteration can be detected have long since purified the vocation of the milk retailer. In the early days of the change in legislation sweet separated milk was added to new milk as an adulterant instead of water. This practice, too, has considerably diminished, and the necessity for testing milk is much less than it was. Before the invention of the Gerber and Babcock testing machine milk was examined by various methods. It was set in test-tubes, with no tangible result, and its specific gravity was obtained by the aid of the lactometer, which was only a partial guide, while other instruments were employed
with but uncertain results. There are now two systems which can be described as accurate, or approximately accurate and satisfactory. One of these can be used upon the farm with considerable ease and at little cost—we refer to the centrifugal machine on the Gerber system—while the other is the chemical test made by the analyst in his laboratory. The Gerber system is now very frequently employed, and can be easily learnt from instructions which are supplied by the manufacturers of dairy implements. Small quantities of milk are measured and poured into test-bottles and subjected to centrifugal force, when, with the assistance of a solution which is added to the milk, the fat is driven into the neck of the bottle and its proportion read off by the scale at the side. When milk is to be sampled in this way it should be taken from a churn or churns representing the milk of the whole herd, which has been well stirred. If, for example, a sample is taken from a dairyman's delivery can in the street, a perfect sample is impossible if it is taken from the top or the bottom. In spite of the shaking to which the milk has been subjected, some of the fat will rise to the top, therefore the quality at this point will be richer than that at the bottom, where the milk is frequently drawn from a tap.
Chapter VIII.

BUTTER AND ITS MANUFACTURE.

Butter, the most popular of all edible fats, contains approximately $87\frac{1}{4}$ per cent. of the fat of milk, 12 per cent. of water, and small but varying quantities of sugar, casein, and mineral matter, chiefly salt, where salt is added in the process of manufacture.

Constituents.

Imperfectly made butter may contain more water, and consequently less fat, or it may contain more casein and sugar, and where butter is salted for keeping the proportion of mineral matter is correspondingly increased. A good sample of butter should be a rich primrose in colour, so tough that when a roll is bent it will not break in halves, but fracture, and thus show a grain which resembles that of cast steel. If, however, the butter has been overworked in the effort to remove the superfluous water the grain may be partially destroyed, and with it the texture of the sample. Butter may contain a larger proportion of water than the average, but owing to the fineness of its division it may not be seen so well as a sample of butter containing a smaller proportion of water, which is present in drops or droplets. Thus, when a sample of butter is cut or broken these droplets may be revealed, and suggest that the water present is excessive. The object in removing the water from butter during manufacture is to enable it to keep better and to produce a higher quality, for highly-watered
butter means a diminution in the proportion of fat, as well as inferior flavour, and sometimes of colour also. If butter is washed in a churn too freely water may be imparted to it, and in addition its colour may be reduced. Washing to be effective should take place only when the grains of butter have been brought to the right size.

**Colour.**

The colour of butter depends chiefly upon the breed of the cattle which have produced it. Thus, the milk, the cream, and the butter of the Jersey and the Guernsey are of richer colour than those of almost every other known variety, not excepting the Devon, which probably takes the third place. The colour of milk is in the fat, for when this is removed the skimmed milk of Channel Islands cattle resembles that produced by cows of other varieties. Colour, however, is improved or diminished by the food consumed, hence butter from cows fed upon grass in summer is superior to that produced by the same cattle fed in the stalls in winter upon hay, roots, and concentrated foods. In some instances butter produced in winter upon these rations is almost as pale as lard, and in consequence manufacturers have long since adopted the practice of colouring it with annatto, a harmless material, although it is one which gives butter a value which it does not otherwise possess, for pale or white butter is not so fine in flavour as butter which is naturally rich in colour.

**Flavour.**

The flavour of butter depends partially upon the breed and partially upon the food. That food exerts an influence is demonstrated by the fact that where cows are fed upon turnips or swedes, especially when the crown of the bulb is not removed, an ill-flavour is imparted to it. Cow-cabbage, brewers' grains, distillers' grains, barley-meal, maize-meal, inferior hay, or turnips and mangels when given in large quantities, should be avoided as food for cows kept in a butter dairy. The best foods are fine fragrant hay, crushed oats, a very small quantity of decorticated cotton-cake, the white hearts of savoy cabbage, with
carrots and parsnips in small quantities, and of course grass. Linseed-cake, common cotton-cake, beans, peas, and large quantities of green leguminous forage crops influence the flavour and texture of butter. This is especially marked where cows receive a good deal of linseed-cake, in which case the butter is usually oilier and consequently of bad texture. The immediate cause of fine flavour in butter, assuming that no deleterious foods have been supplied and that the milk is absolutely clean and kept in an apartment in which the atmosphere is pure, is in the perfect oxidation of the cream. This also influences the aroma of butter, which many dealers accept as a guide to its quality. Imported butter is frequently coloured to a uniform shade, and, produced as it is in factories or creameries, its flavour and aroma are the result of ripening with the assistance of an artificial “starter.” In other words, the cream is pasteurised by heat to from 150° to 170° F., thus causing the destruction of the bacteria, and subsequently inoculated with a pure culture, which is the direct cause of the ripening process that follows, and therefore of the flavour which results.

When butter is newly made it is comparatively insipid, for its flavour has not developed. If a sample made in the ring at the London Dairy Show by the competitors for prizes in churning is compared with the first prize sample in one of the butter classes, a lesson will be conveyed which would be impossible under any conditions of a different character. The prize samples which we have examined for very many years in succession are invariably firm, of beautiful texture, perfect in colour, and deliciously nutty in flavour; so good are they as a rule that it would be impossible to obtain a sample of a similar quality from any merchant in London, or to excel it in any part of the world. This butter is immensely superior to the samples made in the show-yard, partly owing to the conditions of manufacture, which are most imperfect, and partly to its age. If, however, a fine sample of butter of this type is examined on the last evening of the show, when it is four days older than when it was judged, it will be found that on the outside the colour has changed,
while the flavour of the same part of the sample has been destroyed, for the butter has absorbed the various odours in which it is environed. This fact teaches us that for the production of both colour and flavour butter should be kept out of sunlight as well as out of the reach of smells.

**Keeping Properties.**

These depend very largely upon the removal of the casein, the sugar, and all other impurities which are liable to set up fermentation and rancidity. Much, however, depends upon the temperature of the atmosphere, for fermentation is more rapid in warm than in cold weather. Impurities may be introduced into butter in salt, hence the importance of using salt which is of the purest type and which has been baked in an oven to perfect dryness after it has been ground as finely as possible. Butter should never be treated with coarse salt; a sample thus salted when cut will reveal a mottled appearance, which is caused by the attraction and absorption of water by the salt. Salt should be almost as fine as flour, and it should be distributed with a fine dredger. It is employed partly to retard decomposition and partly to satisfy the demand of consumers, so many of whom curiously prefer a slight salt flavour to the delicious nuttiness of a good sample of butter, which is not revealed, as they suppose, by the salt, but partially hidden or neutralised.

**Quantity Produced.**

The quantity of butter which can be produced from a given quantity of milk depends upon the quality of that milk. If it contains 4 per cent. of fat, and allowance is made for the loss of fat in the process of skimming or separating, and finally of churning, 100lb. of 4 per cent. milk should make about 4 1/2 lb. of butter, the increase being due to the incorporation of water.

**Butter-making Systems Considered.**

In past days butter was frequently made directly from milk which was churned in large barrels and frequently by horse power. It was customary to allow the milk to
"lapper"—in other words, the milk was ripened until it was so acid that it coagulated when it was ready for churning. Milk too was then set in shallow leads, round shallow pans, and deep oval or circular tins. Deep setting resulted in the production of a large volume of thin cream, for the cans were immersed in very cold water. That process is practically dead, although it reigns in a modified form in Normandy and Brittany, where the best butter is equal to the finest in the world. During our last visit to these provinces the separator had still failed to take the place of the prevailing system. The milk is set in conical earthenware vessels about 15in. deep and 14in. to 15in. in diameter at the top. These pans are placed in a broad gutter through which cold water is flowing at the foot, around the walls of the dairy, and on the floor. The cream having risen to the surface, hot air is turned into the dairy, the milk and cream coagulate, and the cream is then skimmed for churning, the separated milk being taken in the pans just as it is to the calves, which are fattened upon it for the Paris market, getting no other food. The butter made in this way obtains a higher price than any made in Europe or America. We have seen it sold in the wholesale Paris markets at 2s. 1d. per pound to dealers, and we are acquainted with one farmer who has realised 2s. 8d. The second and third qualities of butter thus made are purchased by the owners of large blending-houses for dispatch to this country. We have inspected some of these factories, and have been the means of introducing to two of them, those of Le Petit and Bretel, the whole conference party of the British Dairy Farmers' Association during its visit to France.

No butter can be obtained which excels that produced either by this Norman system or by our own old system of shallow setting in round pans, which on the whole is perhaps the best known when it is properly conducted. The reason is this: the flavour of cream depends upon its perfect oxidation, but this is impossible unless the conditions are perfect. When the milk drawn from suitable, properly-fed cows is clean and pure it is brought to the dairy and strained into the pans at once. Its temperature
should then be 90° F., while that of the dairy should be 60° F. It will be observed that before the milk reaches the temperature of the dairy it must fall through 30 degrees of heat. The result, as we have explained in a previous chapter, is that the rising of the cream is accelerated. In the process of rising the fat globules which form the cream, and which are spread in a thin layer over a large surface of milk, come into contact with the air, and if this is pure they are perfectly oxidised in consequence. Where milk is set in a deep vessel, or where the cream after mechanical separation is placed in a large volume, oxidation is impossible, however well the cream may be stirred. Where the dairy is kept at varying temperatures—cold in winter and too warm in summer—where the milk is retained before it is placed in the pans, or where the temperature of the dairy varies between morning and night to any marked extent, perfect rising of the cream is impossible, and therefore perfect oxidation. This, too, is impaired where the dairy is unclean, where articles of food or strong-smelling materials are placed near at hand, or odours reach it from the farmyard. It is the want of management in these directions which has given the separator its high position, for while it increases the yield of butter it diminishes the labour involved in its production.

Milk-setting pans may be either of metal, such as tinned iron, earthenware, or glass, but it is obvious where these vessels are used and the cream is removed by hand skimming there must be a loss, for by no process can all the cream be taken off the milk. When cream is skimmed by hand and the conditions are approximately exact it should be mellow, thick, rich in colour, and very slightly acid, so that it will be fit for churning in twelve to twenty-four hours. It is customary, however, to place it after skimming into a cream pan, and to add the cream of one, two, or even three days to this until churning day arrives. It is this practice which prevents fine butter being produced. Where cream consists of several lots of various ages its condition can never be perfect—in summer it may be over-ripe, and in winter under-ripe.
In Devonshire it is the custom to produce butter from scalded cream. The milk is placed in round pans about 7in. in depth, and when the cream has risen perfectly each pan is taken to a stove constructed for the purpose, and the whole volume is brought to a temperature of about 170° F., care being taken to prevent it boiling. It is then returned to the dairy and allowed to stand until it has cooled, when it will be covered with a skin which is the result of the oxidation of the casein. It is then skimmed, and ready for conversion into butter. This form of cream is sweet, like the milk from which it is removed. Formerly this cream was worked into butter with the hand, but the practice is an improper one, and it is now churned in the usual way.

**Pasteurising Milk.**

In dealing with milk intended for butter-making on a large scale, it may be pasteurised at 145° F. for half an hour, or at 165° to 175° F. for a very short time. At 170° F., for example, the milk may be passed through the pasteuriser as fast as it will flow. Here it is kept in motion, and on passing out of the machine it is quickly cooled down to as near 40° F. as possible. Milk is not sterilised in this way, for the spores of the bacteria remain, ready to emerge into active life immediately the conditions permit. Milk, like cream, heated and then rapidly cooled in this way is ready for skimming for inoculating with a pure culture of bacteria, without which good butter could not be made. No process of this kind has so far enabled the manufacturer to produce as fine a sample as can be made in the private dairy. Where milk is set for cream to rise upon it it should never be cold, nor indeed should it ever lose its heat, for it must not be reheated. The more heat the milk loses the less cream will it throw up.

**Separation.**

Milk is deprived of its cream by mechanical separation. We were the first from England to observe this process conducted in competition in Denmark in 1883, when the
Laval machine achieved such great distinction. When the milk passes into the separator, which revolves at high speed, the fat, which is its lightest constituent, is thrown to the centre of the bowl by the centrifugal force exerted. The skimmed milk, on the other hand, is thrown to the wall or periphery. Suitable apertures being made in the bowl, the cream and the milk respectively are forced out by the continued inflow of fresh milk. Separation is accelerated by heat and by the employment of discs which, placed horizontally in the centre of the bowl, divide the milk into layers. In this process all dirt is removed from the milk, which adheres to the walls of the bowl, and is therefore easily extracted. By this means almost all the fat is removed from the milk, while the cream can be made thin or thick at will. The separated milk is sweet enough for immediate sale and consumption, which is seldom the case with skimmed milk; and where a full plant is employed the milk can be pasteurised as it passes into or out of the machine, and immediately cooled,
as is the case with the separated milk. Thus a completely economical result follows. An improvement has been made, too, in another point by the use of a Regenerative Heater, which employs the already heated milk which is ready for cooling in heating the cold milk.

Churning.

When cream has been ripened it is ready for churning. Churns not only vary in size, but in form and construction. There are fixed churns with internal beaters, and there are revolving churns, both with and without beaters.

The former type is exemplified in the Holstein churn of Denmark and the latter by the English end-over-end barrel and the ordinary barrel churn with fixed and movable beaters. The size of a churn influences the speed at which butter is brought as well as the quantity of butter produced. If a churn is too small in size, or is filled too full of cream, churning will be protracted, while the butter obtained will be too small in quantity. It is therefore much better to use a large churn for a small quantity of cream than a small churn for a large quantity. When the cream is ripe it should be passed into the churn
through a strainer, but it should be of a temperature varying from 56° to 63° F., in accordance with the season of the year. Thus, in hot summer it should not exceed 56° F., and in the depth of winter, when the temperature is very low, not less than 63° F. Cream which is churned in a sweet condition, while producing very finely-flavoured butter, will yield less, while sour cream produces butter of a fuller flavour and a larger quantity. If cream is over-ripe or practically sour, rather than agreeably acid, it will give an ill-flavoured butter. Perfect work, however, is done only when the condition of the cream is good, when its temperature is exact, and when the churn itself and the apartment in which the work takes place are all maintained at the same degree. If cream at 63° F. is put into a cold churn its temperature will fall, and the result will be loss. If it becomes essential to warm the cream for churning, this should be done by placing it in an apartment at the required temperature, or approximately at that temperature, for several hours before it is required. Hot water must not be added to it to raise its heat, nor is it a wise plan to stand a jar of cream in hot water unless it is immediately and continually stirred.

When butter is bad in flavour and odour after churning, and when this fault is constant, there is only one course to pursue, unless the trouble can be traced to any particular cause. The dairy must be emptied, the floors, benches, and walls scrubbed or washed, the ceiling limed or whitened afresh, and the churn, butter-worker, and all other utensils submitted to a process of cleansing with boiling water, with which neither soap nor soda should be used. Open windows and thorough ventilation will assist in the purification of the apartment. The next milk should be drawn from the cows in the cleanest possible manner, strained, and brought to the dairy, where it should be separated or poured into setting-pans, as already described. When the cream has been skimmed it should be inoculated with from a pint to a quart of butter-milk, which should be obtained from a dairy where very prime butter is made. It may be pointed out that the flavour of butter depends
almost entirely upon the presence of a suitable species of bacteria. This exists in abundance in perfect milk or cream, and therefore in the butter-milk obtained after churning. On the other hand, the bad flavour and odour of milk and cream, and therefore of butter, is usually caused by abnormal or unfriendly bacteria. Thus, if there is no opportunity for these germs to enter the milk—and there will not be if the conditions described are thoroughly carried out—the inoculation with butter-milk obtained under the best conditions will ensure more, if not absolutely, perfect work.

When cream is skimmed from day to day, and kept for churning, it is obvious that if some days elapse it will consist of a mixture of cream of various ages. This difficulty will not be overcome by simply stirring and mixing; but where it is impossible to avoid the practice the cream should be added and stirred for the admixture of air, and not churned until twelve hours have elapsed after the last cream was poured into the pan. It has been found that where sweet cream is mixed with acid or ripe cream of similar quality and then churned the result is not so satisfactory as where the whole cream was similarly ripe. It is always desirable to churn cream immediately it is mature; but where a volume of cream consists of several skimmings, that which was skimmed first will probably be too old, while that which was skimmed last will be immature in spite of the fact that the various lots have been mixed.

As cream must be brought to a given temperature for successful churning various expedients have been adopted in order to arrive at the proper degree as quickly as possible. Hot water must never be added to cause a rise of temperature, nor ice to cause a fall. Apart from the fact that both may introduce impurities, the mechanical condition of the cream is altered, and bad work is the result. The cream should be placed where it will gradually rise to the required temperature. There will as a rule be no difficulty in summer, except in very hot weather, when churning is best in the early morning or late in the evening—the coolest parts of the day. If sufficiently
cool water is unobtainable, ice must be employed in order to reduce the cream to the required degree, the ice being placed in a tub of cold water in which the cream pan may be stood. In the winter, when the temperature of the cream for churning should be from 62° to 63° F., the cream pan, covered with a lid or cloth, may be placed within reach of the heat of the kitchen fire, or in any apartment the temperature of which exceeds that which the cream is to reach. If, however, this is impossible the cream pan may be stood in a tub of warm water, which should not be higher than 70° to 80° F., but in this case it should be frequently stirred.

Before commencing to churn the cream into butter the churn should be brought to the required temperature, which may be one or two degrees above or below that of the cream. If possible, too, the dairy should be at the
same temperature as the churn. Thus, in winter, if the cream registers 63° F. on the thermometer, and the dairy stands at 50° F., with the churn at the same figure, the temperature of the cream will fall immediately it is poured into it, and churning may therefore be long and difficult. Again, if the churn is brought to the required degree, and the dairy is still cold, its temperature will fall before churning is completed, in spite of the fact that the wood of which the churn is made is a non-conductor of heat. Fine butter is only made when the conditions are perfect. When the temperatures are correct, therefore, the cream may be poured into the churn through a strainer, the lid closed, and the work commenced.

There are many types of churn, although the principles upon which they are constructed are few in number. It was estimated some years ago that there were at least 150 makes of churn, some of which revolve. Revolving churns sometimes have beaters or dashers, and sometimes they have neither. In other cases churns are worked by beaters revolving within them. A good churn should be made of seasoned, tough wood, such as oak; its construction should be perfect; it should work easily, for churning is frequently performed by girls. Further, a glass window should be provided so that the cream may be seen in the process of churning, a vent for the expulsion of air or gas, a tap or vent for passing out the butter-milk, and a lid which can be easily and quickly closed, and through which it will be impossible for the cream to pass as working proceeds. One of the most popular churns is the end-over-end barrel, which has no beaters, but which has long been provided with a lid of a most troublesome character. Where it is necessary to turn several screws to open a churn, and to screw them down again in order to proceed with the work, and when at the same time a large lid of this type permits of the escape of cream, fault is naturally found.

A mistake is often made in buying too small a churn. In practice it is assumed that a churn may be filled to two-thirds of its space, but this is not so. It should not be filled more than half full, otherwise there will at some
time be a serious loss. It is much better to buy a churn one or two sizes larger than is required, in spite of the extra expense which is involved, for the reason that, while it is most difficult to churn too much cream in a small churn, it is easy to churn a small quantity in a large churn. Therefore, as no trouble arises when a churn is too large for the cream, unless we go to extremes, it is safer and more economical to buy a large churn than a small one, which will always cause trouble if the cream to be churned is too large in volume. A new churn should have been well prepared by the maker before it is sold, otherwise it should be filled with very hot water and used on several occasions before cream is put into it. The one difficulty about ordinary barrel churns is that there is no room for the hands to enter, either for the removal of the butter or for cleaning. The most popular churn in the Scandinavian countries is the Holstein, which is a tub larger in diameter at the bottom than at the top. A beater revolves within it as it stands erect by turning a handle at the side of the frame in which the churn is fixed. This churn will tip both for cleaning and emptying, and is in all respects an excellent implement.

The time occupied in churning butter should not exceed forty minutes. Churns have been produced in which butter has been brought in from five to ten minutes by very rapid work, but we have yet to see the implement which produces fine butter under these conditions. Where the time of churning is protracted—and this is sometimes the case in winter, when the cream develops a disagreeable odour and flavour which passes into the butter as it comes—attention must be given to the question or loss will be emphasised. We have never known this trouble to occur in either spring, summer, or autumn. It is not owing to the practice of feeding the cows with roots or cakes, as some people suppose, for it is found where neither of these foods is employed. It is probably owing to the presence in the milk of an organism, and therefore this point must be fully considered. In the first place the churn should never be too full. When the trouble is suspected a small quantity of cream should be churned
at a time, for it usually becomes larger in volume and froths. The first thing to do is to adopt the plan which has already been described, by cleansing the dairy, taking care to ensure perfectly clean milk, and then inoculating the cream with butter-milk obtained elsewhere. Until this practice is carried out the milk should be set in pans, and when the cream has risen to the surface at the end of twenty-four hours scalded on a hotplate on the stove for the destruction of the germs within it, whatever their species. When cooled the cream may then be churned in the usual way, for, being clotted on the Devonshire principle, it will not need to be ripened, and may therefore be churned sweet.

Towards the end of the churning process, and just before the cream breaks, it will be found to adhere to the glass window in a different form. In the earlier part of the process the window will be clear, but when this change takes place it will be dotted with tiny grains of fat, and then in a few moments the dull thud of the cream as the churn revolves will be changed into a distinct splash, indicating that the thick cream has been replaced in part by thin butter-milk. When the grains of butter on the glass are more prominent the lid may be opened, and a quart or two of cold water, as the case may be, this depending upon the quantity of cream employed, poured into the churn, partly with the object of reducing the temperature and hardening the butter-grains. When the lid is closed again a few revolutions may be given at a low speed, until, indeed, the grains of butter are larger, as shown upon the glass.

When butter has fully come, and the grains are as large as buckwheat or small rice, and crisp as they should be, the churning may be stopped and the butter-milk drawn off through a sieve in order to catch any butter which may pass out of the churn. In summer cold water may be again needed, for in very hot weather the grains of butter are apt, by their extreme softness, to unite rather than to separate. In this case water is quickly blended with the butter, and is subsequently difficult to remove, while working may be impossible. In any case two or three
washings may be given in a similar way, the churn being rocked instead of turned. The object of this washing is to remove every trace of butter-milk, the solid matter of which consists of sugar and casein, which materially assists in turning butter rancid if it remains in it. Obviously, the butter can only be washed when it is in the grain. If it is brought in a few large lumps washing becomes impossible, for water will not enter into the solid fat. The last washing should be with brine, prepared by adding salt to the water, and when the water runs from the churn perfectly pure—i.e., with no indication of milkiness—the butter may be removed with the Scotch hands on to a butter-worker, or preferably on to a butter-trough, if the time permits, for it to remain and drain there for an hour or two.

Butter-workers.

There are two forms of butter-worker commonly used. One a long rectangular table, sometimes flat, sometimes slightly convex, upon which a roller revolves. This roller is fluted or ringed, so that as it passes over the butter it squeezes out the water without smearing or pressing it. The other form of butter-worker is circular, and is made in very large sizes for factory work and for butter-blending. On the larger machines there are two rollers, beneath which the butter passes, these being worked by machinery. When the butter is placed upon the table of the butter-worker, which may be either concave or convex when it is round, it is in the grain, but gradually it becomes homogeneous as it is pressed and the water is removed. Care must be taken never to overwork it or to smear it, by which the grain is spoilt. When butter is salted for keeping—for very fine butter intended for immediate use should never be salted—the salt employed should be at the rate of 3 oz. to 4 oz. to the pound. This salt must be the finest obtainable. It should be ground in a mill made for the purpose to almost as fine a consistency as flour, and then dried in the oven for the removal of its water. The salt should be distributed over the butter as it lies upon the table with a flour-dredger to ensure
even salting. Where the salt used is coarse it will be found that upon cutting a pound of butter in halves the grains have attracted moisture, and that it is mottled in consequence, showing two colours, and therefore spoiled for sale. The subsequent process of making up into rolls or pats can only be learnt by experience. It is important to observe that the butter-worker must be prepared before it is used, otherwise the butter will adhere to it. The usual practice is to scald it, to scrub it with salt, and then to cool it with cold water. When work is proceeding, the water which is squeezed out of the butter must be mopped up with a butter-cloth from time to time, or it may be reintroduced into the butter. In winter difficulty may be experienced in working the butter if it has become hard,
hence the importance of care in the employment of the cold water, which should not be at too low a temperature, while in summer the temperature of the atmosphere is such that it may sometimes be impossible to work the butter at all unless every feature to which we have referred has been observed. Although butter is sometimes coloured with annatto, the practice is a bad one, for the simple reason that it is not absolutely honest. If butter is so white that it needs artificial colouring to make it saleable it is not worth the price charged for it under these conditions.

Churning Milk.

Although milk is now very seldom churned, the practice must be referred to. In earlier days milk was churned in very large churns with the assistance of a horse, the labour being too considerable for men or women. There is no doubt that more butter is obtained by this practice than by churning cream. On the other hand, there are many objections to the practice. It entails enormous labour; churning must be conducted daily; the butter-milk cannot be sold like separated milk is now sold, for it must be lapped or soured before it can be churned, and the sourness is very emphatic. On some occasions milk sent to a dairy is returned because it is sour. Under these conditions it may be churned whole, for it cannot be properly skimmed. When milk is churned it is brought to a temperature of 66° F., except in the heat of summer. We have obtained 4½ per cent. of butter from milk churned in this way, and subsequently 5 per cent.; but when similar milk was churned in its sweet condition it returned only 3 per cent. of butter, while the work was much more laborious.

Preserving Butter.

In preserving butter without the employment of boracic acid the very best work must be carried out, for no butter will keep unless it is thoroughly cleaned by washing. As keeping butter is usually made in summer it should be churned at 56 to 57 degrees, drained in a
trough at a still lower temperature after washing, and then hardened in a hardening-box, for which purpose ice is employed if this is necessary when the weather is unusually warm. When upon the butter-worker the butter should be salted with \( \frac{3}{4} \) oz. of salt to the pound. After working it should be rolled out like paste and placed in layers in the tub or pan in which it is to be kept, each layer being pressed at the bottom and sides of the vessel with the hand to keep out the air. When the layers are sufficiently numerous to fill the pan, it should be smoothed over the top with a wooden butter-knife and covered with a thin layer of salt, upon which a piece of butter-muslin should be laid, with another layer of salt on the top of it. If a wooden vessel is employed for keeping the butter it should be lined with grease-proof paper. In all cases it should be remembered that the more perfectly it is sealed—if hermetically so much the better—the longer the butter will keep. Low temperature, but not less than 35° F., immensely assists in the preservation of butter.
Chapter IX.

THE PRINCIPLES AND PRACTICE OF CHEESE-MAKING.

The object of the cheese-maker is to obtain as much cheese of the finest quality as he can from the milk at his disposal. It was long assumed, and to some extent it is still assumed, that good cheese cannot be made from rich milk. There is no greater mistake—the better the milk the richer the cheese and the greater the weight produced. This being the case, the cheese-maker is well advised to make every effort to improve not only the quantity of milk supplied by his cows, but its quality. Where it is possible to make cheese from milk containing 4 per cent. of fat the return per cow is much greater than when the milk contains only 3 to 3.5 per cent. of fat. The reason is not only because of the increase of weight of cheese manufactured, but because of the improvement in its quality, always supposing that the maker is sufficiently expert to do the best work. Rule of thumb has no place in the manufacture of cheese, for cheese-making is really an art, in which science also plays a considerable part. Good cheese cannot be made from unclean milk.

Importance of Cleanliness.

Cleanliness is the first condition of success; then comes the practice of feeding, which exerts a marked influence both upon the weight and the quality of the cheese. One pasture may contain plants which another does not, and
which convey a bad flavour to the cheese. It is, however, now thoroughly understood by experts that there is no reason why fine cheese cannot be made in one county as well as in another. It was formerly supposed that Cheddar cheese could not be made out of Somerset, but this was dispelled by the farmers of Wigtownshire, in Scotland, and it has since been dispelled by many others. Stilton cheese can be made equally as well in the south or north of England as in Leicestershire, while the Brie and the Coulommiers of France have been made equally as well in our own dairy as in Normandy or the Department of the Seine.

When the cheese-maker is placed in the possession of rich clean milk produced from sound food he has only to look to his appliances and himself to ensure success. The cheese-making plant must be complete, simple, well designed, and well constructed. This will be referred to later on.

Varieties of Cheese.

The principal varieties of cheese known in this country, and indeed the best-known makes in the world, are Cheddar, Cheshire, Leicester, Gloucester, Derby, and Lancashire, among English pressed cheese; Stilton and Wensleydale, our two blue-veined varieties; Caerphilly, a small variety popular in a part of South Wales; and ordinary Curd or Cream cheese, which has neither name nor significance in this country. The popular cheeses of France are Gruyère, Roquefort, formerly made of sheep's milk; Géromé, Gex, Brie, Camembert, Coulommiers, Pont l'Éveque, Gournay, Livarot, a skimmed-milk cheese, and Port du Salut. All these French varieties, with the exception of Gruyère and Roquefort, can be made equally as well in England; but, in spite of many years of teaching at our dairy schools and of incitement to produce them, dairy-farmers in this country will have nothing to do with the varieties made elsewhere. They prefer the public to buy them from the importer, in spite of the fact that the profits realised are larger than those realised by the manufacture of British cheese.
Holland makes two popular varieties of cheese, the round Dutch, or Edam, and the flat Gouda. Italy makes two varieties, the blue-veined Gorgonzola, which is sold so largely in this country, where Stilton should take its place as a native variety, and the Parmesan, which is a partially skimmed-milk cheese. The one variety common to Switzerland is the Gruyère, which is identical with that made in France. There are practically no other important cheeses made in any other part of the world, for the Scandinavian countries, like Russia and Germany, adhere chiefly to butter. It is a curious fact that there is no national cheese made in either Ireland, Scotland, or Wales, although at one time a type of cheese known as the Dunlop was made north of the Tweed.

Milk to Use.

Cheese may be made of whole or new milk, or partly of new milk and partly of skimmed milk, but the richer the milk the more profitable the cheese—hence the employment of skimmed milk is never advisable.

Cheese in the Making.

In making cheese milk is coagulated with rennet, assisted by heat and acid, the last being developed with the assistance of heat, which incites the decomposition of the sugar. In making pressed cheese the milk is set near the temperature at which it comes into the dairy from the cows, but in actual practice the temperature at which the rennet is added varies from 65 degrees in making some varieties of soft cheese which are long in coagulating to 92 degrees in making certain hard or pressed cheeses. The time of coagulation may vary from sixty hours in the first case to a few minutes. Where a firm or tough curd is required the temperature is comparatively high, and the quantity of rennet larger than where the curd to be brought must be tender and less elastic. Cheese is pressed either heavily or lightly, or it is not pressed at all, as in the case of Stilton, Gorgonzola, and the soft cheeses of France. For making soft cheese, however, the curd may be either brisk, lively, or elastic, or it may be extremely tender.
The finer curd is cut after it has coagulated the quicker and more perfect the drainage, for there is a larger area exposed from which the whey may exude. Thus, in making Stilton the curd is removed from the vat in which it was formed in large slices into a draining-cloth, while in making Cheddar or Cheshire cheese it is cut into small cubes about the size of dice, and these, heated in the whey, quickly part with the fluid within them, and shrink. If some of the cubes are too large when the smaller ones have parted with all the whey that it is desirable to remove they will contain some fluid, which if not expelled later will pass into the cheese and cause the production of gas, and consequent damage. Soft curd will not bear much manipulation, but the firm curd, such as is cut as suggested, bears much manipulation, frequent and lengthy stirring following the cutting process. When the curd is too tender in making firm cheese, it can be improved later by a rise in the temperature of the whey. Too high a temperature, however, like too much rennet, makes the curd too firm, so that when it is cut it parts with the whey too rapidly, and the cheese becomes dry in consequence, and of much less value in the market. For this reason too much whey must not be expelled. These facts suggest the high importance of exactness in maintaining the temperature adopted and the quantity of rennet used, as well as in the time of cutting.

In practice in British dairies acid is developed in the evening's milk with the assistance of temperature, so that when it is mixed with the morning's milk twelve hours afterwards its maturity contributes to the success of the future cheese. The larger the quantity of milk used in bulk the less the loss of heat, and therefore the greater the exactness. The higher the temperature employed in setting the smaller the quantity of rennet required. As there is a loss of heat involved in the setting of small quantities of milk it is usual to increase the quantity of rennet used.

A standard rennet is that of which one volume coagulates 10,000 volumes of milk in forty minutes, when the milk stands at 95° F. As 1000 cubic centimetres of milk
are equal to one litre, it follows that one cubic centimetre of rennet should coagulate this milk in four minutes at the same temperature, for the quantity of rennet used is in an inverse ratio to the time occupied in coagulation. Rennet is the active principle of the mucous membrane lining the fourth stomach of the milk-fed calf. There is no other material known in practice or science which exerts the same influence on milk. It possesses no flavour, although it contributes so materially to the manufacture and flavour of cheese. Cheese-makers have been accustomed in the past to prepare their own rennet, but the practice is uncertain and unsatisfactory, resulting in unequal quality, and consequently in unequal work. Rennet can be obtained in liquid, tablet, and powdered form, and a brand once adopted and found satisfactory should never be changed. Rennet should be kept in a cool, dark place that its strength may remain constant, for loss of strength means probable spoliation of cheese. The influence of rennet is exerted only at given temperature. Thus, while it is most active at from 100° to 108° F., there is no normal coagulation below 50° F., and very little below 66° F. On the other hand, above 108° F. its influence diminishes, until at 150° F. it has ceased altogether. The activity of rennet is considerable between 85° and 95° F., which almost represent the extremes of temperature adopted in pressed-cheese making. Rennet should be mixed with at least four volumes of cold water before adding to milk, inasmuch as it is more easily mixed or spread through the volume of milk, but it should be measured with extreme care, either in a graduated tube or a measuring-glass. In making soft cheese so little rennet is used that it may be necessary to count it in drops. As milk varies in quality between richness and poverty the rennet must be varied too, each cheese-maker learning precisely what quantity of rennet is required to obtain coagulation in a given time.

The time occupied in the coagulation of milk varies with the season, and therefore with the temperature of the air. If it were possible to control the temperature of the dairy this might not be the case. Again, where milk cools
before renneting, and it becomes necessary to reheat it, more rennet may be required, but the result is never so satisfactory. When the curd is perfect it is cut in order to assist in the drainage of the whey. If it is cut too soon, the curd being too tender, fat leaves the curd and passes into the whey, and it is not recovered in the process of cheese-making. The condition of curd for cutting may be tested with a glass thermometer, which, dipped into it diagonally and the bulb elevated through the curd, will fracture it. If the fracture is clean it is fit. If, on the other hand, it is so soft that there is no clean cut made by the instrument, it must be left until it is ready. Where curd when tested in this way is so firm that the fracture at once fills up with whey it is over-ripe, and the curd should be cut larger in consequence. In practice curd is now cut with a pair of knives with numerous blades, which in one case are vertical and in the other horizontal. Thus where a dairy is equipped, as it should be, with a jacketed rectangular vat standing upon wheels, the vertical-bladed knife, drawn very gently and very patiently from one end to the other through the curd, leaves strips of curd throughout which are square at the top, the knife having been drawn across the first cut. In other words, it is drawn first from end to end of the vat and then from side to side. The knife with the horizontal blades is now introduced, so that each strip or column of curds is cut into cubes.

In making pressed cheese acid is developed first in the evening's milk, which, poured into the vat as it comes from the cows, gradually falls to from 68° to 72° F. by the morning; by subsequent heating in the vat; by stirring; and later by the piling of the curd, as we shall see. More acid is required in handling rich milk than poor milk. The rôle of acid is to give mellowness, flavour, and texture to the cheese. In the manufacture of Stilton the slices of curd remain for some time in the whey which drains from them. In making soft cheese the curd is removed direct from the vat in which it has coagulated into metal moulds or cylinders, from which the whey gradually leaves it by gravitation, sufficient remaining to set up
fermentation, which assists in the production of flavour and quality. Some makers of pressed cheese add sour whey to the milk before coagulation commences, this inoculating the milk with bacteria of a desirable character when it is the by-product of good cheese made the day before. On the other hand, the addition of whey from imperfect milk may introduce noxious bacteria, and so destroy the cheese.

It may be useful to point out at this stage how in soft-cheese making raw curd is converted into the delicious food which is provided by such varieties as Camembert and Brie. When the curd in the cylinder has sufficiently parted with its whey to leave a firm residue the cylinder is removed, and the young cheese is placed upon a straw mat and occasionally turned. When sufficiently dry it is salted on its coat, and then in a day or two it is gradually covered with a white velvety fungus or mould, which is followed by a similar covering of blue mould, the same species as that which grows upon stale bread. This fungus is provided with mycelium, which we may perhaps not inappropriately compare to the roots of a flowering plant. As the cheese is at this stage acid, and in this condition imperfect, its characteristic is changed by the action of the fungus, the mycelium of which, gradually piercing the flesh of the cheese, neutralises the acid, and by partially liberating the nitrogen of the casein of the curd produces ammonia, and consequently an alkaline reaction follows. Thus it is essential that the curd should neither be too soft nor too dry. To this end it must have been set at the right temperature. If the dairy is too warm the whey will leave the curd in the cylinders too rapidly, and the cheese will be too dry, so dry that the fungus will not grow normally upon it. If, on the other hand, the dairy is too cool the whey will not leave the curd
rapidly enough; it will be impossible to handle it, and it will never make a cheese. The perfect drainage of whey from curd therefore depends upon temperature.

In making pressed cheese sour whey assists in the development of acid. Where sour whey is not employed in the process of manufacture acidity is more fully developed in the evening's milk. If this comes from the cows at 90° F., and is passed into the cheese vat through a strainer, the dairy being warm enough, it will have retained sufficient heat by the morning—i.e., 68° to 72° F.—to have developed sufficient acid for the perfect continuance of the process. This development is essentially important in cold weather, when the milk set in a cold dairy would fall within two or three degrees of the temperature of the dairy, while if it fell below 65° F. the process would have to be modified. Many expert makers test the milk in order to ascertain its percentage of acid, not only at this point or when the rennet is added, but when the whey is drained from the cheese vat.

The ripening of cheese may be described as the first stage in the process of putrefaction, which is the result of the action of the bacteria in milk. If these organisms were destroyed, as they can be by heat, cheese as we know it could not be made. Moulds or fungi also exert an influence upon the character of milk used for cheese-making, as we have seen in reference to the manufacture of soft cheese. The spores or seeds of these tiny plants are distributed in the air, and, falling into the milk, change it either for evil or for good. Their growth depends not only upon the air itself, but upon temperature and humidity. The growth of the blue mould in the veins of a Stilton, Gorgonzola, Roquefort, or Wensleydale cheese is facilitated by the process of manufacture. Thus they are unable to grow in the Cheddar or Cheshire, as in all pressed cheeses, because of the exclusion of air and moisture by the press. In the vein cheese, however, there is no pressure exerted; the curd, being put together in cylinders in a comparatively loose condition, leaves interstices which retain air, and thus enable the fungus to grow, as it will at a low temperature.
The weight of cheese depends chiefly upon two factors, the fat and the casein. It has been shown by repeated and extensive experiments that the casein in large volumes of average milk represents two-thirds of the fat of that milk, while, as lactation increases the proportion of both, the casein increases in larger proportion than the fat. Rich milk makes more cheese than poor milk, because of the extra fat and casein which it contains; but it is a curious fact that this weight is also influenced by the increase in the water which is incorporated with the cheese. Thus for every pound of fat present in milk there is a corresponding increase of 0.6 lb. of casein and 1 lb. of water. Another point of importance is that in making cheese from rich milk there is a smaller loss of solids which pass into the whey than when poor milk is used.

**Cheddar Cheese.**

The most important type of cheese made in this country is known as Cheddar, which practically represents the system of cheese manufacture in Canada and in our Australian Colonies. Cheddar is perhaps the most typical and popular cheese made in the world, but a fine sample is comparatively rare, and we have never seen one imported. The nutty flavour of this cheese is curiously characteristic of the very finest Gruyère and Gouda. In making Cheddar cheese the evening's milk is strained into the cheese vat as it comes from the cows, and is left there until the following morning. Care is taken to prevent the rising of the cream, but as some cream does rise this is skimmed in the morning, added to a portion of the milk, in which it is stirred and returned to the vat. The new milk of the morning is then added, and heat being raised, the warm jacket increases the temperature of the mixture to the required degree, which we may assume to be 85° F., perhaps the most commonly adopted in practice.

As we have seen, the evening's milk should be ripe in the morning—that is, it should contain acid. If it is not ripe enough the maker has the option of adding sour whey, or increasing the temperature for renneting, of scalding once or even twice later on, or of prolonged stirring to
give time for its development. When the required temperature has been reached, and is constant, the rennet is measured, mixed with water, distributed over and stirred into the milk. It is important that the quantity of milk should be gauged, measured, and recorded, together with the subsequent weight of the cheese and all details connected with its manufacture. Where the rectangular jacketed vat is used there will be no difficulty about heating or scalding, but as round tubs are still employed by many manufacturers it will be necessary to describe how the required temperature should be reached. The quantity of milk being ascertained, a portion is removed into a small vat and heated to such a temperature that when it is poured back into the tub the mixture will be the exact temperature required. The rule of procedure may be succinctly described in the following way: The number of gallons of milk in the tub are multiplied by the number of degrees through which they have to be raised or reduced, the figures obtained being divided by the number of gallons of milk in the small vat or warmer. The result of this calculation will give the number of degrees above or below the temperature to which the milk in the small vessel must be brought.

Supposing, for example, we have 45 gal. in the cheese tub and 15 gal. in the warmer at a temperature of 80° F., and it is necessary to heat the whole volume to 85° F., we have to raise the smaller volume of milk through 300 degrees of heat, i.e., 45 plus 15 multiplied by 5. If we divide the figure 300 by 15 we get 20 degrees as a result, and this added to the temperature 80 degrees brings us to 100° F., which represents the temperature to which the 15 gal. must be brought. This temperature, however, would be too high, and it is for this reason that we have adopted it; for it is not desirable to heat the milk much above 90° F., and therefore we have to make a fresh calculation, when we find that in order to bring the whole volume to 85° F. one half the milk must be heated to 90° F. In all these proceedings it is important to prevent heat being lost. Thus, when a small volume of milk is to be used for cheese-making it should be put into
a wooden tub, which is a non-conductor, and even then it should be covered with a blanket to prevent the escape of heat.

If sour whey is to be employed, as it sometimes is with the object of assisting in the formation of acid, it must be raised to the temperature of the milk in the vat, and in medium quantity. This whey should be the by-product of a previous making, and one which can be thoroughly relied upon. Although the exact quality of the cheese cannot be tested until it is ripe, a skilled maker is practically able to determine as the result of his day's work whether he has succeeded or not in making a first-class article. If the whey is obtained from an inferior day's work it may communicate its inferiority to the cheese which it assists in producing, and so from day to day, as the whey is carried forward for mixing with the next day's milk, that inferiority may be perpetuated.

Curd Knife.

Sour whey should never be added to milk which is extra acid in consequence of high temperature. If sour whey is not to be used in cheese-making, it is essential that the evening's milk should be ripe in the morning before it is added to the morning's milk, and that ripeness is only obtained by an increase in the temperature at which the milk has been kept. It should, in a word, be kept sufficiently warm to assure a temperature of from 62° to 68° F., and on no occasion less than 62° F.

A rise in the temperature is followed by an increase in the number of bacteria, and with this increased number there is increased decomposition of the sugar and a consequent production of lactic acid. If sour whey is used in the process of manufacture a temperature of 63° to 64° F. will be sufficient for the evening's milk when morning arrives. The production of acid is not only caused by
the temperature at which the evening’s milk is kept through the night and by the addition of sour whey, but also by the fact that the curd and whey are scalded, and sometimes scalded twice, in the subsequent process.

The curd forms and is fit to cut in forty to fifty minutes after the rennet has been added to the milk. In making Cheddar it is cut in cubes, as we have already described in the previous chapter, but care must be taken neither to drag it with the knives as they are drawn from one end to the other nor to bruise it, and so to cause a loss of fat in the whey. After cutting and resting the curd gradually falls, leaving the clear greenish whey above it. It may then be covered for a quarter of an hour, during which time whey will still further be expelled from the cubes, which have now shrivelled into small shapeless lumps.

This expulsion depends as much upon the acidity produced as upon the heat which has caused it. If too much whey is expelled in the process the work is quicker, but the cheese may suffer in consequence. It is essential that some whey should be left in the curd, inasmuch as it contains the sugar of the milk, and this is the material which, decomposing with the assistance of bacteria, produces the acid which plays so great a part in the subsequent character and flavour of the cheese.

When the curd has fallen to the bottom of the vat stirring and breaking commences, this being performed with a special implement. This process still further assists in the expulsion of the whey and in the reduction of the size of the pieces of curd. It must be gently done, and from time to time the workman should examine the curd in order to see whether the pieces vary in size and
whether they are progressing towards the perfect form which they should take before the process is complete. Stirring and breaking should now be continued until the highest temperature which is produced by the hot jacket of the vat has been reached. Some makers stir longer before heating commences, others stir while heating progresses, and others again after the curd has reached its highest point, in order that when touching the sides of the vat, which are the hottest, it may not be damaged. When stirring is complete the vat is covered with its lid, when the curd settles at the bottom.

In the process of scalding, which further develops the acid and improves the condition of the curd, the whole volume of curd and whey is heated to 87° F. up to 94° F., varying with the season and the practice of the maker. Some manufacturers scald a second time, the second scald being at a higher temperature than the first. In some cases the scald is restricted to a degree between 94° and 98° F., while in others it may reach 104° F. at the outside. The first process of scalding, like the second scald, depends upon the temperature at which the milk was kept through the night, upon the temperature of renneting, and the employment or non-employment of sour whey. Just as stirring must be continued after the first scald, so it must be followed after the second scald. This process completed, the curd falls to the bottom of the vat, and when the whey has been drained off, as it must be, it mats or coalesces, forming practically one solid block. It is important at this stage to ascertain the condition of the curd, whether or not it is sufficiently mature. Some makers test it by its smell and its taste, others employ the hot iron, ascertaining how long an elastic string can be drawn when a piece of curd is attached to the iron and gently pulled. These, like many other points in the process of making cheese, are better learnt in practice. One week over the cheese vat with an experienced maker on a farm or in a dairy school will do more than volumes written upon the subject.

Assuming that the curd is now fit for further treatment, it is cut into blocks of about 6in. square and piled upon
the rack at the bottom of the vat. The object is to develop acid, and this will follow the aeration of the curd while maintaining its warmth, which is not difficult, considering that the vat is still warm and that the curd after cutting is covered with one or more cloths to prevent the escape of heat. In a short time the cloths are removed, and the curd which has adhered is again cut into blocks and turned and placed in a new position that the inside pieces may become aerated as well as those which were outside. During this entire portion of the process the one object
is to obtain fine, mellow, silky curd before it is ground, salted, and placed within the press. When cutting and aeration have been sufficiently protracted the blocks are broken up with the hand, placed in cloths, tied up, and pressed upon the rack, the weight of the pressure depending upon the weight of the curd. It is important at this stage that the curd should have maintained a temperature of 90° F. After pressing the curd will have once more become a solid mass, when it is cut and turned again, and left sufficiently long to ripen for grinding.

The curd-mill should be a simple, well-constructed implement, designed to prevent squeezing or crushing the pieces, and so causing a loss of fat in the whey. It sometimes happens that a further development of acid may be necessary after grinding, but this is seldom the case if the work has been well performed throughout. We cannot, however, omit to impress upon the reader the importance of acid in the curd, as all depends upon its presence in sufficient quantity to produce a mellow cheese. The ground curd is now salted at the rate of 2 lb. of finely ground and dried salt per 112 lb. of curd. When an early ripening form of cheese is made, as it is in Cheshire, 2 lb. is sufficient, for it must be remembered that to some extent
salt prevents decomposition, without which there can be no perfect cheese. All salt should be dried, ground as finely as possible, and dried again until its weight is fairly constant. There is considerable difference in the influence of salt as between that prepared in this way and the raw material as it is purchased. There should therefore be no variation in the practice by using dried fine salt upon one day and coarse moist salt upon another. After grinding and salting, which must be carefully performed, the curd is ready for the round mould or vat which gives the cheese its shape and enables it to be pressed. The vat
is therefore lined with a cheese-cloth so arranged that it will cause no wrinkles or creases upon the crust of the cheese. The temperature of the curd should now be 70° F. If it is higher there is a danger of fat being pressed out of it in the whey when it is in the cheese-press.

In our early days the presses employed by cheese-makers were of a very primitive character. Now, however, the press is an implement which enables the maker to do perfect work with very little trouble. When the cheese is placed in the press, pressure should be put upon it until the whey commences to run, and then it must be increased gradually for an hour or two and left until the following morning. It is then removed from the press, taken out of the mould, enveloped in a clean cloth, turned, and pressed again. This practice is con-

Moulds for Cream Cheese. Dairy Supply Company.

tinued for three days; at the end of which the cheese is perfectly firm, when it is covered with incipient crust. It is then placed upon a stage or cheese-table and covered with a bandage which is marked or labelled with the date and weight. The whole of this portion of the process should be learnt in the dairy itself; it cannot be adequately described.

Cheddar cheese is not coloured artificially, as is the case with Cheshire and sometimes with Gloucester and Leicester, as well as with some Colonial cheese. No cheese is naturally yellow, the colour being conveyed solely by the annatto, to which reference has already been made. The newly bandaged cheese is removed to the ripening room, and placed either upon the floor or upon a wooden shelf, where it is examined and turned daily, and where it gradually acquires its crust or coat. The cheese-room
above all things should be dry, and maintained at a temperature which varies from 60° to 68° F. Where many cheeses are made the cheese-room is artificially heated with hot-water pipes, stoves and fires being partial in their power and leaving the room with an uneven temperature. The cheese-room must be well ventilated. If shelves are employed the cheeses should be changed from shelf to shelf day by day, those upon the top shelf being placed below and finally at the bottom, and *vice versa*.

The texture of a cheese, and consequently its solubility, depends largely upon the percentage of the fat of the milk from which it was made. The casein of milk is an insoluble substance, but in the process of ripening in a cheese it becomes perfectly soluble, its solubility being helped by the fat with which it is combined, and the greater the quantity of fat the more rapid and perfect the solubility. High-priced cheese is always mellow, soluble on the tongue, mild in flavour, and essentially nutty. One pound of Cheddar cheese is, on the average of the season, made from 10lb. of milk, but where rich milk is employed 1lb. may be made from 8lb. of milk, or, on the other hand, where the milk is poor in quality it may take more than 11lb. to make 1lb. of cheese. It is a striking and yet curious fact that while large cheeses are made from comparatively small quantities of milk, the solid matter in that cheese represents only half the solids which the milk contains. Thus the average weight of solid matter in the whey which has been drained from the

![Mould for Curd Cheese. Dairy Supply Company.](image-url)
cheese-vat is equal to the solid matter in the cheese which, as curd, was removed from it. In the cheese the solid matter consists almost entirely of casein and fat, while in whey it consists almost entirely of sugar and mineral matter. It is true that very small quantities of casein and fat find their way into the whey, while still smaller portions of minerals find their way into the cheese.

While the description of the process of the manufacture of Cheddar cheese is closely followed wherever that cheese is produced, it is an indication of the processes which are similarly followed in the manufacture of every other type of hard or pressed cheese, whether we refer to the Gruyère of France and Switzerland, the Parmesan of Italy, or the Dutch cheeses of Holland. If we were to describe the complete process of manufacture of either of these varieties, or of our own Cheshire, Derby, or Leicester, we should find that all were identical in one respect, inasmuch as the principles involved are precisely the same in each case. It is in the variation of the process not in the principles that we find the cause of difference of texture, of flavour, of form, and of size. Like Gruyère and the finest Gouda, Cheddar cheese stands higher than other varieties because of its flavour, a flavour which attaches to the two varieties just named, but which is not found in any other British cheese. The flavour of the filbert nut is almost unknown to any type of cheese but those to which we have referred. There is practically no flavour but a “cheesy” one present in any British cheese apart from the Cheddar variety, and it is for this

(Straw Mat. Dairy Supply Company.)
reason that they do not possess the character of the prime cheeses of the world. We may compare them to imported butter, which is as unlike a fine nutty brand of British-made private dairy butter of the first rank as it can possibly be. The public at large are unacquainted with this flavour, whether it be in butter or in cheese, and therefore they do not miss it; but it is precisely this flavour which, when combined with texture, ensures the highest price in the market, and if cheese manufacturers would insist on obtaining it they would realise much more for their product, as much indeed as the few who always ensure it. If we inspect the cheese at the London Dairy Show we find numbers of samples of the very best type, but much larger numbers which possess no such flavour, and seldom such texture. It is not so much a recognition of an empirical method of manufacture as in the principles involved, and it is therefore by a study of the influence of acid, of the exact proportion of acid present in the curd in the different stages of manufacture, and how to produce acid and to control it that the maker is helped to make the perfect cheese.

Veined Cheese.

Although space prevents our describing the method of producing Stilton, Wensleydale, or Gorgonzola cheese, it is important that a few words should be said about these blue or veined varieties, which owe their description to the presence of the fungus or mould which grows within them. A veined cheese is not a pressed cheese. In making Stilton the whey is removed from it by drainage or gravitation, and partially by evaporation as it is ripening. The curd is removed from the tub into cloths placed within a sink or draining-table; the whey immediately commences to run, and in due course the corners of the cloth are tied together, giving slight pressure to the curd, and thus assisting it to part with its whey. When the curd has become sufficiently solid and acid as it lies in the whey, which some makers keep in the sink for some time, it is removed into coolers or trays to aerate, to dry, and to mature. Supposing this curd to have been produced
from milk of the morning, the milk of the evening being treated in the same way, there will be two lots of curd upon the following morning, one nearly twelve hours older than the other. Their difference in age will have caused a difference in their texture and condition, and when, after the proper stage is reached, they are broken up by hand in a tinned-iron mould, they are mixed together intimately, the mould being filled and left for further manipulation, until finally, after repeated turns, the metal mould is removed and the cheese is enveloped in a bandage which helps it to sit and alone. The bandage is changed every day, the cheese manipulated to maintain its form and character, when it is gradually covered with a crust until it looks like a Stilton.

![Camembert Mould](image)

It may now be observed that, owing to the difference in the condition of the two curds which were mixed together in the metal mould, they have failed to coalesce or unite into one solid mass as if they had been pressed, with the result that there are interstices in which the air remains, and which permit of the growth of the fungus from the spores which found their way into the curd from the air. As the cheese ripens these spores mature and the young plants commence to develop. There is, however, no possibility of their normal growth unless the conditions which are essential are maintained. These conditions involve sufficient moisture and warmth. Thus, if the temperature is too low they remain dormant. On the other hand, if the temperature is too high the cheese becomes so dry that they fail to grow from want of moisture. In the process of manufacture, too, all
depends upon the quantity of rennet used and the temperature at which the work was performed, or whether, owing to the excess of either, the curd becomes too dry and it cannot mature, for the reasons already given.

In practice there are always failures, but while the skilled manufacturer makes few faulty cheeses, the unskilled makes many; and so it is that Stilton cheese is frequently sold to dealers at 6d. a pound in normal times, whereas the skilled maker is able to obtain from 1s. to 1s. 3d. It should be observed that Stilton cheese is not made from cream or cream and milk, but from new milk alone, and that its creamy consistency is due to the milk, although its texture is improved where rich milk is used.

The manufacture of Gorgonzola is neither so perfect nor so clean nor made from such sound milk as Stilton, and knowing as we do, having visited Italy to gather information, how faulty and objectionable that process is, we are the more amazed that English people should exhibit so great a preference for a material which no one who knows anything about its production could possibly recommend, particularly in face of a much superior home-made article.

Soft Cheese.

Soft-cheese making is well known in the dairy schools of this country, and to some extent to those who have passed through them. The process of manufacturing matured or ripened soft cheese was introduced into this country by ourselves over thirty years ago, but
partly owing to the preference shown for established institutions, partly to the absence of markets which exist in France for the sale of these types of cheese, and partly to the difference in the type of farm occupied by French makers, soft-cheese making, in spite of its superior profits, is not acceptable to the English dairy-farmer. There is, however, no reason why it should not be exploited, and once one or two men build up a solid business with a variety like the Camembert, the Brie, or the Coulommiers there will be many followers. The producer of a Cheddar weighing 100lb. is able to sell it to a dealer without the slightest trouble, but there is practically no available dealer in soft cheese on the market, except the two or three individuals who import it from France, and who are not likely to be gainers by transferring their custom from experienced manufacturers to those who are to some extent inexperienced.

In making a soft cheese the average maker employs a small quantity of milk, and in order to retain its temperature after renneting it is placed in a wooden tub which can be covered with a lid, and if necessary, as in colder weather, with a blanket to prevent loss of heat. The curd must be sufficiently brisk or elastic to be removed in thin slices, and placed in tinned-iron moulds, which are usually round or cylindrical, sometimes perforated and sometimes
not. A cheese like the Camembert or Coulommiers is made from the milk of the morning and the milk of the evening. Thus the cylinder is filled with fresh curd in the morning, and this having parted with most of its whey by the evening and sunk halfway down to the table, is filled again with the evening's curd, and on the following morning turned upon its mat, a fresh one being supplied at each turning, until it has become solid and will stand without its mould or cylinder enveloping it. The newly-made cheese is subsequently removed and placed upon straw or rush-mats on a shelf, where it is daily turned upon a clean mat, subsequently salted one side at a time, and then removed to the first curing-room. Here it is daily turned until it is covered with a white velvety mould or fungus, which in course of time is in its turn covered with a blue fungus; and then it is taken to a second curing-room for the completion of the process. It may be pointed out here that when the white mould has grown the cheese is at its best for eating, for it is then mellow and rich on the palate.

The process of ripening or maturing commences from the outside, the half-ripe cheese being creamy and soluble near its coat, but still firm and insoluble in its interior. The perfect growth of the mould, exactness in temperature, and perfect ventilation are all essential to successful ripening. The cheese must not be too dry nor too moist. In the latter case it commences to run, and spoils, while in the former, whether owing to too high a temperature in the first process or to the use of too much rennet, the whey drains too freely, the mould fails to grow, and in consequence the cheese remains insoluble. It is not until, with the assistance of the mould, the casein, which is a nitrogenous substance, has decomposed and assisted in the formation of ammonia, that the acid cheese becomes neutral and subsequently alkaline, and that in consequence the bacteria within it become active and transform the neutral curd into one which is highly flavoured and mellow.

There are no more perfect cheeses in the dairy world than the Brie, the Camembert, and the Coulommiers.
They provide a much greater weight for a given sum of money than a pressed cheese. They are not only a delicious luxury, but highly nutritious, and adapted, whether in their green or ripe state, to the digestion of the most susceptible. Many persons who cannot consume pressed cheese, like Cheddar or Cheshire, Stilton or Gruyère, can eat a mild Brie or Coulommiers, and at each meal. Thus, too, a given weight of milk produces a greater weight of cheese of this type than of any type of hard cheese. If those who feel no interest, or only a half-hearted interest, in this industry were to visit the markets of Lisieux, Bayeux, or Caen, in Normandy, or the great cheese market at the Paris Halles, and realise how enormous is the number of cheeses produced for the public, they could scarcely fail to lament the fact that there is no corresponding industry of the kind in this country on even a small scale.

Soft-cheese making in France is essentially a smallholders' industry, although there are many large makers, one with whom we are acquainted having usually 10,000 Camembert in his dairy at one time. The work, too, is chiefly performed by women, and especially by old women, whose thought and care are so essential, and who are much more reliable than women who are younger. Among other varieties of cheese made in France three or four may be mentioned: Pont l'Eveque, which obtains its name from a small village near Havre well known to ourselves; Gournay; Bondon, a tiny loaf cheese made by peasant farmers; Neufchatel, which is a ripened and sometimes blue-veined Bondon; and, lastly, the Gervais or Pommel, made by manufacturers of these names at Gournay, to both of whom we have paid a visit. The last two varieties, which are composed of a mixture of cream and milk, are enveloped in jackets made of blotting-paper, and closely resemble a cream cheese, although they cost about half the money. These are as well made in this country as in France. In most instances the cheeses to which reference has been made are manufactured in our best dairy schools, so that the process can be learnt at a comparatively small cost.
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