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Feeding and Milking of Cows.

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BY

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WITH A FOREWORD

BY

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WITH NINETEEN ILLUSTRATIONS.

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FOREWORD

Veterinary and agricultural education is making rapid strides in this country, but literature on problems connected with cattle in India is hopelessly poor, and this book on the 'FEEDING AND MILKING OF COWS' by Mr. Aggarwala will come as a welcome surprise to *zemindars*, students of Veterinary Dietetics and others interested in Indian farming. India, in fact, has long wanted a book, plain in wording, of moderate size, dealing with the feeding, and general management of cows and their calves, which, whilst suitable for the use of veterinary students, should at the same time not be too technically scientific to be intelligible to practical farmers or to general readers. This book will fill this long felt want, and should prove useful to the more progressive of Indian agriculturists, especially in the Punjab.

Mr. Aggarwala has, in this book, made a valuable contribution to economical feeding and milking of cows. He has also touched on many side lines connected with the general management of cattle, one

of which—the chapter on 'Kindness to Dairy Cows'—is specially interesting. This point is sadly neglected by the people of this country. I know from experience that the statements contained in this chapter are very true, and it is one which ought to be brought to the notice of every one interested in dairy cattle.

Of the other chapters contained in Part I, if I may be permitted to single out any section for special mention, I would commend the chapter on 'Balanced Rations.' The *zemindars* here at present do not know what the value of a balanced ration is, how they can obtain better yield at a reduced cost, and keep their animals in a better condition withal. If Mr. Aggarwala's book will be successful in bringing this point home in the mind of the *zemindar* and the latter, as a result, will act upon his knowledge, even to a small degree, it will have achieved an enormous advance in economical dairying.

Part II, relating to the general consideration of food-stuffs is an excellent guide to the farmer, especially with respect to the indigenous fodder grasses and leguminous crops. Punjab grasses are given special consideration in this section. The importance of grasses in agriculture is very great, and the welfare of cattle largely depends upon them. Farmers, as a rule, take little interest in them, although profitable agriculture is impossible without

grasses.

There is a mass of useful information in the Appendices. I am sure the compilation of data contained therein must have meant a great deal of patient labour and trouble on the part of the author. Those interested in the economical feeding of cows will find the tables 'very handy.' By the intelligent use of these figures coupled with information contained in other parts of the book, it will be possible to determine rations from which cattle will derive the utmost advantage at a minimum of cost.

Part III, on the 'Art of Milking' deals with that portion of dairying which is little understood in this country. This has recently appeared in print, and the fact that it has been favourably reviewed by the English and Continental Journals and the Indian Press, and also much appreciated by agricultural institutions in this country, is quite sufficient to show that the subject is of paramount importance. To improve the knowledge in dairying is almost a national question in India.

The book, as a whole, contains a vast amount of serviceable practical information, elegantly arranged, pertaining to the farmers' activities in connection with dairying, the management and care of the cow and calf, the essentials of feeding and the best food-stuffs to employ. Mr. Aggarwala

has shown the *zemindar* how he can more profitably carry out his feeding and dairy operations. It is now for the *zemindar* to follow.

M. R. C. V. S., D. V. H., I. V. S.,
PRINCIPAL,

23rd March, 1931.
Punjab Veterinary College,
LAHORE.

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INTRODUCTION.

Agriculture is India's vital industry and cattle form its backbone. Bullocks provide the country with the necessary agricultural power for effective tillage and the cows and buffaloes provide millions and millions of the people of India, both children and adults, with milk — Nature's most nourishing and wholesome food-material. It is high time for the Indian people to recognise fully the great economic importance of the cow. The Hindus hold her in extreme love and veneration, but the other communities, Christians, Mohammedans, Sikhs, etc., also benefit from her alike. To maintain the cow in a healthy and profitable breeding condition, it is essential that she be fed well, *viz.*, on scientific and up-to-date economic lines.

Unfortunately very little organised work has so far been carried out on modern scientific lines in

this country in connection with the nutrition of animals in general, and on the nutrition of cows in particular. Literature, therefore, on the subject is hopelessly meagre at present, and this fact alone is enough to show how very backward we are in the recognition of the importance of this vital subject which controls the economic position of the country to such a large extent. For generations together the *zemindars* have been feeding their cattle according to the experiences of their fore-fathers and themselves, and very often their methods have proved to be fairly correct and sound, but, at the same time the practice has helped in handing down from father to son and from generation to generation mistaken notions and incorrect methods of feeding cattle, such that, they have become unchangeable truths and veritable facts. The result is that at present we find prejudices deeply established through constant usage and custom. There is no doubt about the fact that the farmer is very conservative all the world over and would not give up his old practices easily. In India, however, his troubles are further accentuated by the lack of proper scientific information and suitable type of propaganda work.

The main object of this publication is to place before the stock-owners, students of veterinary dietetics and others interested in the well-being of the cow, the main principles of feeding and milking cows in as simple and non-technical a manner as is possible. The whole subject has been discussed

very broadly in order to make it intelligible with little effort on the part of the reader. Practical common sense coupled with a general knowledge of the main principles of the management of animals and personal supervision of the stock by the owners go a long way to facilitate the art of feeding cows and their calves, as is outlined in this little book.

The subject of the " ART OF MILKING " as given in Part III of this book was originally published in the form of a Veterinary Bulletin (No. 20) by the Department of Agriculture, Punjab, in 1928. It was very kindly and favourably received by the public with the result that the Bulletin soon went out of stock. Since many requests have been received to republish the same, it has been considered desirable to include it in this book in a slightly revised form.

The chapter on the " Physiology of Lactation " has been added anew with four illustrations. It also includes the gross anatomy and histological considerations of the udder.

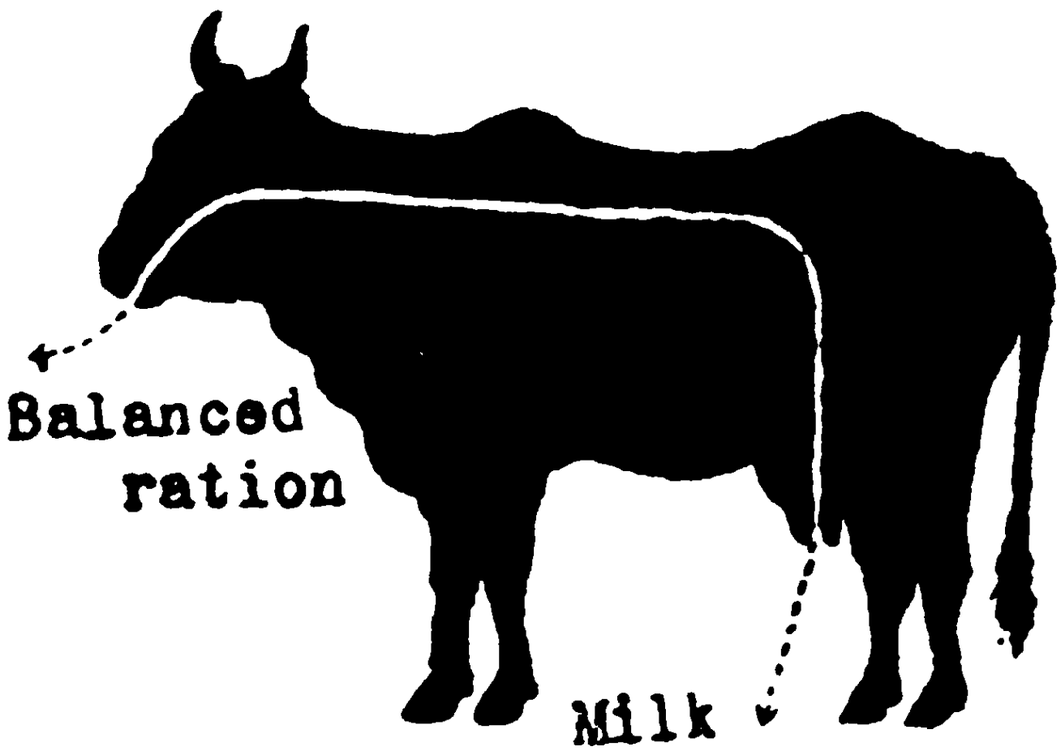
According to the latest statistics available in Vol. I. of " Agricultural Statistics of India ", 1924 and 25, there are 45,835,191 milch animals in the country. If, on the perusal of this book, the cow-keepers are able to devise economical rations for even one per cent. of the total number of cows and buffaloes, and save one pie per head per day in the cost of their feed and produce one per cent. more milk daily

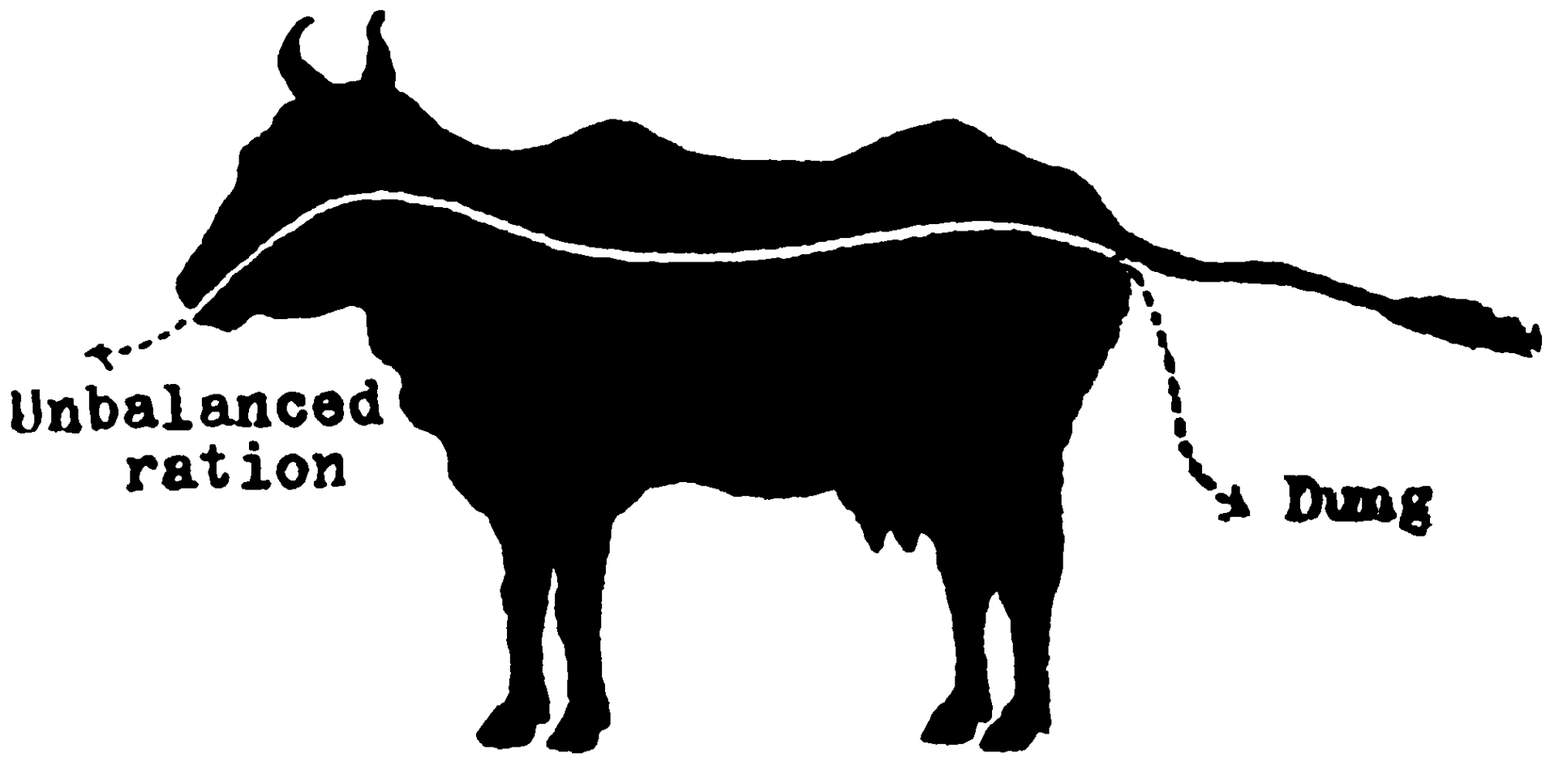
than the ordinary yield, my object of writing this book will be amply fulfilled. On a rough and conservative estimate it would make the country richer by one million of rupees annually.

I am greatly indebted to my younger brother, Mr. Shadi Lal Aggarwala, M.Sc.Hons., for passing the proofs through the Press.

A. C. AGGARWALA.

LAHORE:
PUNJAB VETERINARY COLLEGE.
1931.





BALANCED AND UNBALANCED RATIONS

(Highly diagrammatic)

Frontispiece to Part I.

PART I.

FEEDING OF COWS AND THEIR CALVES.

PART I.

FEEDING OF COWS AND THEIR CALVES.

1. General Needs of the Animal Body for Food.

The cow is an animal of great economic importance in any country—she is more so in India, a country which depends entirely on her agriculture. She produces milk—Nature's most nourishing food, she produces other cows that do the same, she provides meat for some and her male progeny is utilised on the fields for plough and draught work. She does all this for man in return for what she gets to eat. In other words, a cow may be looked upon as a 'living chemical factory' that is continuously converting her rough vegetable food-materials into products useful to man. She is rightly kept in extreme love and veneration by the Hindus and others, and certainly deserves her pet name 'Mother Cow'. She is really the 'Mother' of all prosperity in India. Mr. William Smith, the Imperial Diary Expert to the Government of India, while writing in the Journal of the Central Bureau for Animal Husbandry and Dairying (Vol. I., Part I., 1927), has rightly remarked, "It is no wonder that the people in India venerate the cow, she is the key-stone of Indian agriculture; and agriculture is and will continue to be the mainstay of economic prosperity in this land. We desire to protect the cow by increasing her efficiency and improving her economic capacity, so that she will be such a profitable animal that her owner will

protect and cherish her for the term of her natural life, because of the benefits she will bring to him.."

The dairy cow of to-day is, to a great extent, a product of civilisation, in the fabric of which she is well-nigh an indispensable unit. Originally, cow's milk was never intended by nature for human consumption. It was meant to be utilised solely by their young. Owing to man's skill in selective breeding, the productive qualities of cows have developed to such an extent that her milk now serves to a considerable extent as an important article of diet for man. This artificial strain of increased milk production on a cow means a draw upon the bodily resources which depend entirely upon her food. The losses sustained in milk production must be made good and recompensed by allowing her extra and increased ration. There is a great deal of truth in the old proverbs that 'Milk goes in at the mouth', and that 'Hens lay through their beaks.' The cow is, in fact, only a transforming machine, and if we desire to obtain milk we must introduce this milk into her udders through the food we give her. The same holds true in cows meant for breeding purposes and bullocks meant for draught and plough work.

The body of a cow is composed of a huge mass of small miscroscopic cells which are continually being worn out and shed or otherwise got rid of out of the system. They have to be renewed and replenished from certain ingredients of the food, in order that she may be kept in sound health and good breeding condition for the benefit of man. Milk is manufactured by first building up the cell system of the udder from the flesh-forming ingredients of food and then converting the same into milk.

The problem of feeding cows is a problem of great economic importance from the point of view of agricultural interests of the country, and there is no problem in which the cow-keepers are so very ignorant in India. With the *zemindar*, the cost of feeding his cattle represents a very big and important item of expenditure. Feeding necessarily costs money, and many farmers endeavour to reduce the cost of feeding their animals by curtailing the feed. This is bad economy. When the intake of energy is less than the output, loss in body weight is in due time bound to ensue. This is an obvious conclusion. To obtain maximum utility and best physiological results from a cow, it is essential that she be fed on modern scientific lines so that there may be least amount of waste and minimum of expenditure with the least risks of ill health to her. Much money is wasted because cow-keepers do not always purchase suitable food to balance. This waste can be avoided when food given to her is clean. hygienic. liberal. palatable. easily digestible and well-balanced in its constituents. This refers to both cows in active lactation and cows during the dry periods. It is a common practice with the *zemindars* to feed their cows well when in milk. but directly they run 'dry' their ration is stinted. This kind of badly thought out immediate economy tells very adversely upon the productive capabilities and health of their progeny and their own next lactation. The best results of continued proper feeding of cows are shown in their greater milk yield. their vigorous progeny and their own good condition.

* * * *

2. Pre-requisites of Successful Feeding.

Successful and profitable feeding, however, does not consist in merely placing the right amount and kind of food before the animal but demands certain other pre-requisites, some of which have little or practically nothing to do with actual feeding.

First of all, it is essential that the animal be good, well-bred and carefully selected. The cow meant for milk production must be a competent animal to deal efficiently with a competent ration. She must be capable of converting economically most of her food into milk, and that her milk be of good quality. No system of feeding, scientific or otherwise, will produce satisfactory results in an inherently unthrifty animal. Therefore, care in breeding and selection of the animal may be taken as the first condition necessary for successful feeding. Secondly, the person keeping the animal should be experienced and clever in the art of animal management. Feeding is one important item in the management of animals. The animal to be fed must first be maintained in a condition of sound health by constantly observing the activity of her digestive organs as shown in the dung, by keeping her free from parasites like ticks, by protecting her from cold, by providing her a suitable habitation with facilities for good drainage, ventilation and cleanliness, by giving her enough rest and reasonable amount of exercise, by adequate grooming, etc., etc. Cows doing well will eat heartily, have a sleek, well-filled, contented appearance, and spend much time lying down chewing their cud. If the dung is thin, watery and evil-smelling, or hard and in balls, digestive trouble is present. If cows do

not relish their food, are 'tucked up' in the flanks and have harsh coats, probably the rationing is wrong. The third essential is that a successful feeder should acquire as intimate a knowledge as possible of the fundamental laws governing the nutrition of animals, and the manner in which these laws operate under varying conditions. He must know what arrangements are provided by nature within the animal's body for the utilisation of food and how the digestive tract works.

* * * *

3. The Cow's Body and Digestive Tract.

Through the whole length of the cow's body runs a canal or passage which is commonly called the ' digestive tract. ' It commences with the mouth and ends at the anus, where unused food is voided in the form of dung. This passage takes a very tortuous course and varies considerably in diameter at different places, being enlarged at certain parts to accommodate considerable bulks of food, and small tube-like at other places where the food can only pass if it is reduced to a pulpy form. Roughly speaking, this tract may be regarded as made up of three distinct parts, the mouth, stomach and intestines, the two former serving mainly for the reception, storage and preliminary preparation of the food for its easy passage into the intestines where the important changes, collectively called ' digestion of food ' take place.

An animal's body may be likened to an engine which must be supplied with some suitable fuel if it is desired to be kept in good working order with a view to obtain maximum benefit from it. Not only

this, the component parts of the engine must also be looked after carefully and necessary repairs made good from time to time with suitable materials. Maximum utility from a cow is only available when suitable food containing the necessary ingredients for heat and energy production and for doing bodily repairs is supplied in sufficient quantities and under proper conditions. Power of resistance against disease, energy and vitality of an animal can only be gained and kept up, if one supplies the animal's body with the right quantity of such food elements as are necessary, otherwise starvation will result and blood, muscles, nerves, etc., will become debilitated with final break-down.

There is, however, a general complaint by the cow-keepers in India that their cows do not produce enough milk. This is in spite of the fact that cows are wonderful digesters of food, and are able, by the united digestive activities of the bacteria and enzymes, to make very efficient use of many types of food-stuffs which are of little or no use to man. The immediate solution of the problem of increased milk production must be sought in improved methods of feeding. The digestive capabilities of the cows must be utilised to the utmost to get the best results. A ' competent ' ration must be given to her to expect better yields.

* * * *

4. A Perfect Food.

A perfect food, in order that it may be suitable for purposes of nutrition and for the production of necessary heat and energy, must contain all the elements present in the animal's body in proper

proportions. Feeding stuffs, in general, are not simple substances. They are complex mixtures of intricate chemical compounds. The essential ingredients of a complete food may be grouped up according to the functions they perform in the animal's body into the following :—water, and dry matter consisting of proteins or albuminoids, carbohydrates including starches and sugars, fats, mineral matter and vitamins. It is only when a ration is properly built up of all the essential ingredients, both organic and inorganic, in the proper proportions that the maximum economic effects can be expected from the animal.

The animals use their food in two principal ways, viz., for ' constructive purposes ' to make losses good due to ' wear and tear, ' or for the production of additional new substances as fattening, growth, increase in milk yield and fœtal development ; secondly, for ' fuel purposes, ' viz., for supplying energy and heat in different forms. In constructive work, tissues like muscles, skin, hair, vital organs, bones, etc., are produced, or fat may get deposited in various parts of the body. Food when used for fuel work produces heat and energy which may appear as muscular activity and actual work, as heat and as chemical energy which accomplishes the digestive and other processes going on in the body. It is interesting to note that an animal even during absolute rest needs a certain amount of the so-called ' maintenance ration, ' so that it may keep in good healthy condition and may not lose weight. A true maintenance ration is one during the feeding of which the general metabolism is in a state of balanced equilibrium, the body weight being

maintained constant. It is because the ordinary bodily processes and the maintenance of bodily heat require some food both for constructive and fuel purposes. It is obvious that this state is merely one of apparent rest, but certain tissues must perform their normal work unremittingly, like the heart while the animal organism survives. It is necessary to have a clear conception about this state. The food requirements in this state are wholly different, both in quantity and character from those necessary for cows producing milk and carrying a calf, or bullocks doing work.

We shall now see what purposes the various ingredients of the food serve in an animal body.

* * * *

5. Functions of Water.

Water furnishes a very important medium in which the activities of all other ingredients of food take place. To begin with, it is needed for purposes of mastication and deglutition (swallowing) of food. Further, it helps the digested ingredients of the diet to pass through the walls of the intestines into the blood stream. The blood itself consists mainly of water, so that, it is water again which carries the digested materials to the various parts of the body where they can be utilised. It also serves the purpose of carrying away most of the waste products that arise from the activities of the body, particularly those excreted through the kidneys and bowels. The retention of these waste materials in the body soon becomes a source of a very serious menace to the health of the animal.

Water is an important constituent of every tissue, and may quite properly be regarded as an essential building material ; it constitutes nearly one-half of the weight of the body. Any neglect in furnishing an adequate supply of clean and wholesome water to an animal would tell badly on its productive qualities. In addition to the above mentioned functions of water in an animal body, it regulates the heat processes going on by its evaporation from the skin. This is of particular importance in the case of animals that are heavily fed. In such cases the digestion and utilisation of food gives rise to a considerable surplus of heat which must be quickly removed. This is brought about by the agency of water.

Deficiency of water delays digestion and assimilation on the one hand, and, on the other, delays the excretion of waste products in urine. If this deficiency be continued long the blood tends to thicken with a rise of temperature. or, in other words, feverish conditions are established which result in an accelerated wasting away of the tissues. Animals, like men, can stand lack of food much longer than lack of water.

Excessive consumption of water, on the contrary, need not, as a rule be feared very much. It is, however, wasteful of food, and if long continued will lead gradually to accumulation of water in the tissues, which will become flabby and swollen, the digestive juices being diluted will steadily impair the digestive powers of the animal, which ultimately will result in the reduction of power of resistance against disease and in the lowering of general vital activity of the animal.

In ordinary feeding, when the animal is allowed to drink as it pleases, the amount consumed will vary somewhat according to the nature of the food. If the food consists of green fodder and roots, the amount of water consumed from the pail will be reduced to the extent of water contained in the roots or green fodder. Roughly speaking, a cow weighing 8 maunds (about 650 lbs.) and receiving about 13 lbs. of hay will usually consume about 50 to 60 lbs. of water, or say, about 4 lbs. of water to each pound of dry matter consumed. A milch cow of similar size will naturally consume more water, owing to the necessity of providing for the water secreted in her milk. On a rough calculation, she will require for this purpose alone at least 2 lbs. of water for each pound of milk yielded. In other words, the total requirements of water of a 10 lbs. milk cow will be at least 50 to 60 lbs. for general purposes and about 20 lbs. for milk production, or a total of about 70 to 80 lbs. (about 8 gallons) of water daily. This is only a rough average figure from which the requirements of individual cows may show considerable deviations. The nature of food, the temperature of the surroundings and seasonal variations must also be taken into consideration.

When considering the water supply in connection with the keeping of cows, one should not overlook the quantity of water needed for general cleanliness of the cow-shed, the cow herself, and other purposes. At least 7 gallons (70 lbs.) should be allowed for this purpose, thus making a total of about 15 gallons of water per cow per day.

* * * *

6. Functions of Proteins.

Proteins or albuminoid constituents of food-stuffs are complex chemical compounds which always contain 16 per cent. of nitrogen, some amount of sulphur usually and occasionally a little of phosphorus in addition to carbon, hydrogen and oxygen, the last three being the essential elements present in all carbohydrates and fats. Very good examples of proteins are the albumin of white of eggs, the caseinogen in milk and gluten in wheat. They constitute an important ingredient in so far as they only, amongst all other constituents of foods, can build up or produce lean or muscular tissue, hide, hair, horns, hoofs, etc., and make good the so-called 'wear and tear' of the body organs. They are also required for the elaboration of internal secretions, glandular products, milk secretion and digestive juices. Even for the resting animal, that is, an animal merely living and not growing or producing work or milk, a certain amount of nitrogenous material is an absolute necessity for the maintenance of health. Unless a sufficient amount of it is given to meet the ordinary normal physiological requirements, proteins are withdrawn from the tissues and the body suffers as a result of protein starvation. Although proteins are not primarily concerned with the production of energy like carbohydrates and fats, still the more work an animal does or the more milk a cow yields, the more of proteins are required. Not only this, its deficiency leads to malnutrition of other constituents of the feed. Experience has shown that animals retarded in growth on the less advantageous mixtures promptly start to thrive better when the quantity and quality of proteins in food is improved.

Foods rich in proteins are called 'nitrogenous concentrates,' and include grams, oats, bran, oil-cakes, other leguminous seeds and animal products. Feeding on excessive amounts of proteins is just as undesirable as giving deficient amounts of it, because it is uneconomic on the one hand, being more expensive, and on the other, it throws too much work on the kidneys and is too heating. In addition, digestive disturbances with the production of evil-smelling fæces and gases in animals are generally due to feeding on rations containing more of proteins than are necessary.

The quality of proteins in a food, apart from their quantity and digestibility, is an important consideration. Certain amino-acids like tryptophane, glycine, lysine, histidine, cystine, etc., are absolutely essential in the ration if best results are to be obtained. Of these, tryptophane is very necessary for life and maintenance, lysine for growth, while histidine, cystine, etc., though not absolutely necessary, aid growth. One point of great importance in this connection is that all feeds do not contain all the essential amino-acids. Any one plant food is liable to be deficient in one or more of them. To avoid this deficiency, feeds from a number of plant sources should be given. Variety, furthermore, in the rations helps greatly to improve the appetite.

* * * *

7. Functions of Carbohydrates.

Carbohydrates in the foodstuffs include a great variety of substances of different composition but they essentially contain carbon, hydrogen and oxygen, with hydrogen and oxygen in the same proportions

as present in water. All sugars, gums, starches, and crude, woody or indigestible fibre are included in this category. The carbohydrates form the greatest proportion of the constituents of feeding stuffs generally used for cattle. Maize, barley, rice, wheat, grams, oats, millets and other cereals, country *gur*, potatoes, roots, straws, grasses, etc., are foods containing a high percentage of carbohydrates. Most of these carbohydrates, with the exception of hard woody and indigestible fibre present mostly in the straws and husks of cereals, are reduced to simpler substances by the action of saliva during ordinary mastication and rumination in the mouth of an animal, so that they may be absorbed and conveyed to the tissues of the body to be oxidized. By their oxidization heat and energy is supplied to the animal body for carrying out the normal physiological functions. Any excess over the necessary requirements is converted into fat and stored as reserve potential energy for emergency needs, or else it may be stored in the liver in the form of sugar. In ruminants—the class of animals to which the cow belongs, carbohydrates of the food are main sources of energy and heat, and therefore, should be supplied in large amounts. A supply of deficient quantity of carbohydrates in the diet of cattle would only mean that the animal would either draw upon its reserve of fat or sugar in the body, or else proteins of the body shall have to be disintegrated for supplying the required heat and energy. The diet as a result would become unnecessarily costly, proteins being more expensive, and the intake of larger quantities of nitrogenous materials would bring about disturbances of the system.

Carbohydrates are, therefore, the most economical of all foodstuffs, both physiologically and financially. They are the greatest 'sparers' of the more costly proteins. Fats may be supplied in place of carbohydrates upto a certain limit only. They, no doubt, produce heat and energy two and a half times as much as that produced by the carbohydrates but the power of the body to digest and absorb fats is very much less than what it is in the case of carbohydrates. On the other hand, to feed with a sufficiency of carbohydrates is a good practice because they are easily digested and have no detrimental effects on the body except when they cause too much deposition of fat which is not a very good condition in working bullocks, milch cows and breeding animals.

A certain amount of crude fibre is indispensable in all properly constituted diets of ruminants except when suckling. It is mostly indigestible and whatever amount is digested goes to form heat and energy as other carbohydrates do. Crude fibre is important in dietary in so far as it aids digestion by giving bulk and thus helping to mix the concentrated parts of the food with the digestive juices, whose secretion is also stimulated by it. It also gives to the animal a comfortable feeling of repletion and satisfaction by bringing about the distension of the stomach and intestines. It has often been described as the 'fill-belly' of the ruminants. A deficiency of crude fibre in ration produces serious effects. The animals fed exclusively on concentrated foods do not feel satisfied or repleted and become uneasy and restless. They may even gnaw at wood or eat earth, dirt, sand or manure. While sufficient amount of fibre is essential in cattle diets, an excess of it is harmful. It causes the

expenditure of too much energy in its digestion, and stomach and intestines are unduly distended with the result that animals may become 'pot-bellied'. It may also bring about serious digestive disturbances, like impaction and tympany. The Graph in Appendix I gives the minimum amount of coarse fodder along with the amount of total dry matter needed by cattle of varying weights. The figures along the bottom represent live-weight and the figures on the left hand represent the amount of coarse fodder and total dry matter needed in lbs.

* * * *

8. Functions of Fats.

Fats, like carbohydrates, are compounds of carbon, hydrogen and oxygen, but they are comparatively poorer in oxygen than carbohydrates. Fat is found in large quantities in oil-seeds, like linseed, rape-seed, mustard-seed, cottonseeds etc., cakes prepared from which are so frequently used for animal feeding. The fat in them varies from 20 to 40 per cent., whereas the cakes which are residues left after de-oiling of seeds in a compact mass contain only from 6 to 15 per cent. of fat. The cereals contain from 2 to 6 per cent. of fats, and hay about 3 per cent. In addition to the ordinary non-volatile fats, plants contain a certain amount of ethereal or volatile oils which are aromatic and help greatly in stimulating appetite.

Fats are digested and absorbed in an animal body like the carbohydrates and are oxidized to form energy or may be deposited as body-fat. Weight for weight fats are two and a half times more energy and heat-producing than the carbohydrates.

A certain minimum quantity of fat is always needed for the maintenance of health of animals. It helps mysteriously in the digestibility and the consequent utility of other food constituents. But, the animal's body can only make good use of a limited quantity of fats in the food. If given in large quantities, it decomposes and produces instead irritant substances with deleterious effects.

* * * *

9. Functions of Ash or Mineral Matter.

Careful experiments in animal nutrition have demonstrated that the presence of certain mineral ingredients in adequate amounts is absolutely essential in the food of cows for maintaining their health, and also indirectly for maintaining the maximum milk production of which they are capable. These elements are sodium. potassium, calcium, magnesium, iron, sulphur, phosphorus, chlorine, iodine, etc. Some of these elements like iodine and iron are required only in small amounts, while the others must be provided in amounts, which though apparently small when expressed in percentages of the food, are, nevertheless, sufficiently large when compared with the amounts present in most common foodstuffs, to attract the attention of the farmers when drawing up rations for rapidly growing or high producing animal.

The importance of mineral matter in nutrition becomes evident if one considers the functions which they perform in the body and the disturbances that follow if these functions are interfered with through deficiency or excess of them. In the

mature animal, mineral matter is necessary: (1) for the maintenance of proper osmotic pressure in the body fluids, (2) for the maintenance of neutrality of the blood and lymph, this being essential for the normal acting of the body cells, (3) to maintain a proper physiological balance between the various mineral ingredients in the blood, and (4) for the processes of digestion. In addition, the growing animal requires mineral ingredients for the formation of new bones and other tissues, and the milking animal requires these ingredients to make good the minerals secreted in milk.

In India, even till today the deficiency of any particular mineral ingredient in foods is not considered to be of any bad consequence for the healthy condition of the animal. At most, by some a little bit of common salt is given at times, to the animals. This is a bad state of affairs. Modern researches into the question of the necessity of mineral matter for animal body have shown clearly that mineral deficiencies are far more commonly responsible for unsatisfactory results in practical stock-raising than is hitherto suspected, and furthermore, that feeding results so far accepted as satisfactory could be appreciably improved upon by a more careful adjustment of the amount and nature of the mineral ingredients of the ration to meet the needs of the animal. The absorption of foodstuffs, digestive secretions, formation of bones, secretion of milk, growth of the fœtus, etc., all necessitate the supply of large quantities of mineral matter. It is not only necessary that a sufficiency of the mineral ingredients be supplied but also that the ingredients shall be suitably 'balanced' amongst themselves. This applies particularly to the balance

between the basic ingredients (soda, potash, lime and magnesium) on the one hand, and the acid ingredients (sulphur, phosphorus and chlorine) on the other hand. Thus the quantity of lime which might be adequate along with a small but sufficient supply of phosphoric acid, would probably be inadequate if given along with an excess of the latter. The proportion of protein and fat in the diet also affects the percentage utilisation of the mineral elements. The problem of adjusting a ration to ensure that a cow will have sufficient of all the essential mineral elements is, therefore, not solved merely by an arbitrary addition of any one of the elements. It is necessary that the whole ration should be so constituted that all the elements are present in sufficient amounts, and so balanced that the necessary amounts can be absorbed and utilised. Fodders like hay, oat straw and wheat straw, bran, cottonseed. etc., are foods rich in mineral matter. Cereals, their by-products and cakes contain a low percentage of lime and a relatively high percentage of phosphorus. Roots and tubers are deficient both in lime and phosphates.

Since the question of the suitable supply of minerals to animals has long been neglected, it is difficult to give more than a tentative guidance as to the actual requirements of cattle and other animals for different mineral ingredients. Advice on the matter, therefore, is mainly empirical until further researches produce requisite information on the question of systematic mineral rationing.

Most of the mineral salts needed by an animal are present in sufficient quantities in their common feeds. Common salt, however, should always be

given in addition. It is now definitely known that a diet containing too little salt produces in cows a staring coat, lustreless eyes and a condition of general mal-nutrition with a decrease in milk yield. Indian cattle do not as a rule get enough salt. Some stock-owners only rub into the mouths of their cattle a small quantity of salt once or twice in two or three months. Some even consider its administration a useless and a positively harmful thing particularly in the case of buffalo-cows. For profitable milk production salt is essential.

A French research worker* has recently conducted experiments to indicate the influence of salted feeds on milk production. The writer's work was carried out by noting in two byres and one sheep-fold the daily product of the milking of animals to whose ration salt has alternately for periods of two weeks been added or taken away in the proportion of 10 to 15 gm. per 100 kg. live-weight per day. It should be remarked that the tests have not covered a very long period, and that owing to labour difficulties it was not possible to constitute lots of animals homogeneous or comparable from all points of view. The following are the conclusions of the tests :—

(1) Taking into account the decrease of daily yield inherent in the lactation, it is observed that in cows and ewes the decrease of the milk was considerably modified by the addition of salt to the rations.

(2) As regards the influence of the salt on the quality of the milk, the fear expressed in certain quarters that the increased yield in the ewes would

* Live Stock Journal, July 27th., 1928.

be prejudicial to the richness of the milk does not appear to be justified. It has, in fact, been possible to ascertain, by an analysis of the samples of milk taken, some in the period of salted feeds and others in the period of normal feeding, that the addition of salt had not diminished the richness in solids and in fats, and had even slightly increased it in some cases.

Apart from air and water, salt is, perhaps, the cheapest thing consumed by a cow, and it is difficult to understand why so many of our cow-keepers do not provide all the salt required by their animals. At least 1 oz. of salt should be daily allowed for cows in their feed, and over and above this, provision should be made where the animals may lick as much more salt as they desire. Common salt for animals is not a luxury. It is a substance as essential to their lives as other food principles. In Western countries some feeders add 4 oz. of potassium iodide to every 100 lbs. of salt used. The feeding of this 'iodised salt' is very beneficial for breeding females who during their pregnant state are required to supply an extraordinary amount of these elements for the proper development of calves within them.

Another essential need of a high producing and breeding cow is calcium. It has been proved by Hart, Steen-bock and Humphrey* that deficiency of calcium in the ration may be the cause of the failure of cows to produce healthy calves. The results of carefully conducted tests showed that cows on rations

* Hart, Steenbock and Humphrey.—Res. Bull. 49, Wisconsin Agric. Exp. Stat. 1920.

markedly deficient in calcium tend either to be sterile or to breed weak calves, while perfectly healthy calves were born from the same cows after the ration was improved by the addition of calcium. Grains are deficient in calcium, but rich in phosphorus. Ration wholly made of grains will supply to the growing animal an amount of calcium dangerously near a critical level of intake. An additional supply of calcium, either as calcium carbonate, calcium phosphate, lucerne, clovers or other legume hays, is necessary. In continued and high milk-production the drain on calicum is heavy, and the supply may be dangerously low unless enough calcium is furnished in other ways. It is very probable that a condition of negative calcium balance in Indian milch animals widely prevails with all its existing ill effects on the yield of milk, resistance to disease and reproduction. To overcome this deficiency powdered chalk may be added to the concentrates at the rate of 1 oz. daily per head.

* * * *

10. Vitamins and Their Functions.

Vitamins or accessory food factors are substances of unknown chemical composition, which are better known by their absence than by their exact nature or constitution. They are present in natural foods in only minute quantities but exercise a very important influence in the nutrition of animals. As direct energy and heat-producers they are negligible, but their absence or deficienoy in the diet of animals brings about serious consequences. The precise manner, however, in which they act is not yet definitely known. Whether they act by promoting

alimentary movements, or by stimulating metabolic changes in cells as some drugs do, or by supplying an indispensable cellular ingredient as iodine does to the thyroid, or by some other mysterious procedure has not been yet determined. A diet sufficient in the essential food ingredients and deficient in vitamins fails to meet the physiological requirements of the body and the young and adult animals do not grow well, become weak and miserable, and contract certain so-called 'deficiency diseases'. Animals feeding under natural conditions generally consume all the vitamins necessary for their health, growth and production, but under modern artificial conditions of domestic feeding they do not, sometimes get a sufficiency of them unless special attention is paid to these important food factors.

There are at least five different kinds of vitamins definitely known so far, and they are called 'A,' 'B,' 'C,' 'D,' and 'E.' They are mostly present in abundance in fresh green forage plants, egg yolk, cod-liver oil, plant seeds, fruits, meat juices, cow's milk, etc.

Vitamin A is found chiefly in green vegetables, cod-liver oil, yellow corn and egg yolk. A diet deficient in it, but otherwise adequate, results in cessation of growth, loss in weight and ultimately, if the diet is continued, death will occur. Associated with the cessation of growth is a marked increase in susceptibility to infectious diseases, which frequently manifests itself in the development of an inflammatory condition of the eye, known as xerophthalmia. Deficiency of vitamin A shows itself most rapidly in young growing animals; but even in adult animals decrease in body-weight soon occurs. Vitamin B is

present in plant seeds. particularly in the germ of some seeds, milk, eggs, yeast, etc. A deficiency of this vitamin in diet causes beri-beri in man and poly-neuritis in birds. Vitamin C is the anti-scorbutic factor. It is present mostly in the juices of most fruits and fresh vegetables. Absence of this vitamin from the diet is indicated by failure of appetite, fall in weight, swelling and tenderness of the joints and reluctance to move. Vitamin D is the anti-rachitic factor and is found in cod-liver oil, egg yolk, cow's milk and meat juices. Its absence causes rickets. This vitamin is said to be particularly associated with the absorption and retention of calcium and phosphorus. Vitamin E is the newest reported member of the group and is found in red meat and in wheat-germ. It is said to be concerned with fertility in the animals. Its absence from a diet has been shown to cause sterility in rats.

Animals obtain abundant supplies of the necessary vitamins if they are allowed plenty af fresh green fodder, wheat bran, cereal seeds, etc., along with well ventilated stables where sunlight can gain direct access and enough of exercise. Polished rice contains no vitamins. Dairy cows which are generally stall-fed and calves reared on artificial foods should be given due attention in this connection, especially when they are confined to ill-ventilated houses where direct sunlight cannot enter. Milch cows are often kept in dark dingy places in most of the towns of India and it is quite frequently seen that they suffer from malnutrition.

Sir W. Arbuthnot Lane, one of the foremost medical men of the world, while writing towards the

end of 1926 to the 'British Australian' said with regard to the importance of feeding cattle on open pastures, "Australian butter is now arriving in large quantities on the British market. It is made from the milk of cows that feed in the open pastures all the year round, and is consequently very rich in vitamins A and D which are particularly valuable to us all".

If a stock-feeder gives his stock free run and exercise so that they may get the benefit of fresh air and sunlight, and provides them with a mixed diet containing a reasonable proportion of fresh green food, it is doubtful if he need worry himself about vitamins and risks of diseases due to the deficiency of vitamins.

* * * *

11. The Common Indian Foodstuffs; Their Composition and Digestibility.

A very good definition of 'foodstuffs' is given by Voit in the following terms: "The foodstuffs are those substances which bring about the deposition of a substance essential to the composition of of the body, or diminish and avert the loss thereof." In other words, foodstuffs, when taken in and digested, supply the body with the necessary heat and energy and make good the losses due to the 'wear and tear.' There are many substances which are used in the feeding of cows. They all vary very widely, indeed, in their chemical composition and consequently in their food values. They are conveniently grouped up in grains, products, green fodders, hays and straws. The tables given in Appendix II show the average chemical composition

of some of the most important Indian foodstuffs used for feeding cows.

Chemical analysis by itself, while giving an indication of the actual amounts of various food ingredients present, such as fat, proteins, carbohydrates, etc., tells but little of the way in which any particular animal will be able to utilise them for its general metabolism ; and a foodstuff, the chemical analysis of which shows a high content of fats, carbohydrates and proteins, may be of less value to an animal than one with a ' lower chemical value, ' if the contents of the latter are more digestible than those of the former. It is only the digestible parts of a food that are utilised by the system of an animal. A ration, therefore, may be chemically correct, but practically wrong.

It must be clearly understood that out of all the food taken in, a portion is undigested. Of the digested portion, a portion is lost through incomplete utilisation in urinary excretions and fermentations. Finally, a considerable deduction has to be made from the assimilated parts for the work of digestion which the ingestion of food causes. The residual or net energy after making all these deductions is really the amount which is available for carrying on the vital functions and for productive purposes.

The table on the next page gives some idea as to the magnitude of the deductions which have to be made and the net energy values of a few foodstuffs. These figures were calculated by Mr. F. J. Warth, Physiological Chemist to the Government of India, from Armsby's data, and the unit of energy *viz.*, the therm, is the unit used. A *therm* is equal to 1,000

calories. A *calorie* is the amount of heat necessary to raise one gramme of distilled water through one degree centigrade.

Table showing the Net Energy Value of some common Foodstuffs (Armsby).

(Therms per 100 lbs. foodstuff.)

100 lbs. of Foodstuff.	Gross energy in therms.	Undigested faeces.	Digested energy.	Further deductions.	Net energy.
Meadow hay ...	200	81·4	118·6	76·9	41·7
Clover hay ...	202	84·6	117·4	70·8	46·6
Oat straw ...	201	114·2	86·8	60·8	26·0
Rice straw ...	153	78·0	75·0	52·0	23·0
Wheat straw ...	201	116·7	84·3	73·2	11·1
Wheat bran ...	205	64·5	140·5	80·0	60·5
Cottonseed Cake	207	44·1	162·9	78·1	84·8

It will be seen from the above that the primary factor limiting the net energy value of a food is its digestibility. The more highly digestible concentrates give higher net energy values; or, in other words, the value of a foodstuff depends upon the proportion which can be digested. By feeding an animal on a known weight of a foodstuff, and collecting and analysing all its dung and urine, it is

possible to find how much of the foodstuff taken in is not capable of digestion. By subtracting this from the amount which was eaten, the amount which is digestible can be calculated. This has been done for almost every foodstuff in the Western countries.

Of the highest economic importance as it is, it is pitiable to find that very little organised and systematic experimental work in connection with the digestibility tests of the various Indian foodstuffs in cattle has so far been carried out in the country. Definite data, therefore, on the subject are not available for practical application by the stock-feeders. Such being the unfortunate situation, one cannot but have a recourse to the average digestibilities of different foods in cattle as found by Western workers, and apply them on the ingredients of Indian foodstuffs. In Appendix III (Columns 5, 6, 7 and 8) are given the average digestibilities per cent. of the various food constituents as borrowed from Western sources. In Appendix IV, it is ventured to apply the above-mentioned digestibility percentages on chemical compositions given in Appendix II for ready use in calculations for devising balanced rations. Until the time the results of the digestibility tests of Indian foodstuffs on Indian cattle become available, and it will take a long time before any thing tangible is forthcoming in this direction, the figures given in columns 4, 5, and 6 in Appendix IV will give a better measure of the nutritive values of the feeding stuffs than the figures in Appendix II.

* * * *

12. General Considerations Regarding the Feeding of Cows.

Generally speaking, a judicious mixture of about equal parts of grasses and clovers (clovers preferably slightly less) is the best for cows in milk as well as for cows going dry. A cow, when in full milk, requires about one-tenth of the weight of her body per day in food. On an average, the live-weight of an Indian cow is about 650 lbs. or nearly 8 maunds. Such a cow would require about 65 lbs. of the mixture of grasses and clovers or its equivalent in other foodstuffs per day. When these two staple diets are available, as when clovers are in bloom and before the grass seeds have ripened, the cows grazing upon them generally get what may be called a 'balanced ration,' i.e., about 75 per cent. of water and about 25 per cent. of dry matter. A *balanced ration*, really speaking, is one in which the various essential food ingredients are present in proper proportions and in amounts needed to meet the requirements of the animal. It is a ration which will adequately nourish without any waste. The balanced ration, however, is only a theoretical possibility and can be only approximated in practice. It will be seen from the tables giving the percentage composition of the various foodstuffs that such ingredients are contained in almost all foods, but in varying amounts. The foods must be mixed in such a judicious manner and proportions that the food, as a whole, may become cheap, easily digestible, palatable and well balanced. Herein lies the skill of the stock-feeder and his profits from animal products.

Out of the 25 per cent. of the dry matter in the food, only a part is digestible, and the rest is passed out of the body unused in the fæces. In this about 10 per cent. consists of the indigestible and about 15 per cent. of digestible or soluble parts, the latter being dissolved or digested by the digestive juices secreted by the glands and cells of the digestive tract, and absorbed into the blood stream ultimately to be conveyed to the different parts of the body to be used for their nourishment, growth and milk production. The soluble parts consist of about seven and a half pounds of carbohydrates, about one and a quarter pounds of proteins and about one third of a pound of fats. The following table shows this :—

Food-stuff.	DIGESTIBLE NUTRIENTS IN LBS.		
	Proteins.	Carbohydrates.	Fat.
In 100 lbs. of clovers.	2·470	8·352	0·330
In 100 lbs. of mixed grasses. (haying stage)	1·700	15·200	0·600
In 200 lbs. of a mixture of clovers and grasses.	4·170	23·552	0·930
In 65 lbs. of the above mixture.	1·355	7·654	0·302

The ration in the fore-going table represents a fairly good and balanced ration for milch cows. In this the different ingredients are in proportions that can be made full use of by the animals.

On the other hand, if only 65 lbs. of clovers are fed to the cow, she will get 0·25 lb. more proteins than she can make use of, and also 90 lbs. of clovers would be required to provide 7·654 lbs. of carbohydrates, and this would increase the loss of proteins to 0·892 lb. Again, with green maize alone, the cow would require about 183 lbs. to get 1·355 lbs. of the required proteins, and about 144 lbs. to obtain the right amount of carbohydrates. As it is a physical impossibility for a cow of this size to eat much more than 65 lbs. of green maize a day, she cannot, if fed on maize alone, eat enough to provide the requisite amount of proteins and carbohydrates to keep her in a healthy condition. With clovers alone, she would go on yielding her full milk, but at an extravagant cost since clovers are dearer than maize. Mixing of the two foods balances the ration and enables her to make proper use of both.

The above figures hold well in an average cow. They should be varied in order to suit individual circumstances. Cows giving a larger amount of richer milk must necessarily require an increased amount of food, so that they may get the raw materials in proper quantities to manufacture milk. The same holds true in the case of milch buffaloes, working bullocks and cows carrying a calf.

* * * *

13. Maintenance and Production Rations.

Careful investigations at different research stations outside India have given some useful data on which the rations may be worked out according to different needs. Roughly, it is found that for maintenance alone, i.e., for heat, energy, renewal of waste in tissues, etc., a cow which is merely living without any loss or increase in weight and producing nothing in the form of milk, fat or work, requires digestible proteins, carbohydrates and fats, as shown in Appendix V (Columns A, C, D and E) according to varying weights. This table also gives in column B the total amount of dry matter needed by such animals. It will be seen from the table that a cow weighing 650 lbs. will require for its maintenance alone 0·518 lb. proteins, 5·180 lbs. carbohydrates and 0·074 lb. fat. After this, for each pound of milk yielded of average quality (testing 3·5 per cent. fat) 0·049 lb. proteins, 0·22 lb. carbohydrates and 0·019 lb. of fats are required. Therefore, a cow giving 12 lbs. of average milk per day and weighing 650 lbs. would require :—

Purpose.	Digestible nutrients in lbs.		
	Proteins.	Carbohydrates.	Fats.
For maintenance alone.	0·518	5·18	0·074
For 12 lbs. average milk.	0·588	2·64	0·228
Total requirements	1·106	7·82	0·302

It has been said before that a cow yielding richer milk would require an increased amount of proteins, etc., from which to manufacture that milk. In 1864 Dr. Emil Von Wolff presented for the first time a table of feeding standards based on the digestible nutrients contained in feeding stuffs. TheWolff standards soon found their way to America where further scientific investigations resulted in Armsby's and Hœcker's Feeding Standards. The following table by Haecker gives the nutrients required by a cow for each pound of milk yielded by her of a given percentage of fat :—

Haeckers Feeding Standards for Dairy Cattle.

	Daily allowance of digestible nutrients in lbs.		
	Proteins.	Carbohy-drates.	Fat.
For support of the 1000-lb. cow ...	0.700	7.00	0.100
To the allowance for support add :—			
For each lb. of 3.0% milk	0.047	0.20	0.017
For each lb. of 3.5% milk	0.049	0.22	0.019
For each lb. of 4.0% milk	0.054	0.24	0.021
For each lb. of 4.5% milk	0.057	0.26	0.023
For each lb. of 5.0% milk	0.060	0.28	0.024
For each lb. of 5.5% milk	0.064	0.30	0.026
For each lb. of 6.0% milk	0.067	0.32	0.028
For each lb. of 6.5% milk	0.072	0.34	0.029
For each lb. of 7.0% milk	0.074	0.36	0.031

Now, a cow yielding 25 lbs. of 4 per cent. milk per day and weighing 800 lbs. would require :—

Purpose.	Digestible Nutrients in lbs.		
	Proteins.	Carbo-hydrates.	Fats.
For maintenance alone.	0.598	5.98	0.085
For 25 lbs. of 4% milk.	1.350	6.00	0.525
Total Requirements ...	1.948	11.98	0.610

It must, however, be borne in mind that all feeding standards given above or elsewhere are simply averages and approximations. They are merely meant for guidance, and are not, by any means, immutable or infallible prescriptions which may be applicable under all circumstances. These are given simply to give to the reader a scientific way of calculations for ordinary rationing.

* * * *

14. Balancing of Rations.

To make up a suitably balanced ration for any particular cow, proceed as follows:—

Supposing, it is desired by a *Zemindar* to draw up a suitable ration for a cow weighing 750 lbs. and yielding 20 lbs. of 4 per cent. milk daily, when wheat *bhoosa* and green maize are available in plenty at his farm. Turn first to the Graph in Appendix I. Follow the line going upwards from the figure 750 lbs. live-weight at the bottom until it

meets the lower graph line. From this point follow the line going across to the left until it meets the thick line at figure 10 lbs. Again, follow the 750 lbs. line still further upwards until it meets the upper graph line, which it does opposite 18.1 lbs. total dry matter. This means that the cow weighing 750 lbs. requires at least 10 lbs. of dry matter in the form of coarse fodders such as hay, wheat straw, *bhoosa* rice straw, etc., in order to make her feel fairly full in her stomach. Then, turn to Appendix V, column B against 750 lbs. live-weight giving the amount of dry matter needed purely for maintenance purposes, which is 13.9 lbs. Out of this 10 lbs. dry matter is provided by wheat *bhoosa*, the rest 3.9 lbs. dry matter should be sought in green maize.

Now, find wheat *bhoosa* (*turi*) and green maize (which are available) in the tables of "straws" and of "green fodders" in Appendix III and note that wheat *bhoosa* and green maize contain 94.29 and 11.08 per cent. respectively of dry matter. To get 10 lbs, of dry matter in *turi*, 10×100/94.29 or nearly 10.5 lbs. of *turi* is needed, and to get 3.9 lbs. dry matter in green maize nearly 35 lbs. of green maize is needed. These two roughages, therefore, shall form the basis of our ration. The rest of the dry matter *viz.*, 18.1 — 13.9, or 4.2 lbs. nearly shall have to be provided in concentrated foods.

Then, turning to Appendix V we find that for maintenance alone, a cow weighing 750 lbs. requires 0.573 lb. proteins, 5.72 lbs. carbohydrates and 0.081 lb. fats. Further requirments are for the production of 20 lbs. milk testing 4 per cent. fat. These are calculated by multiplying the digestible

nutrients given against milk testing 4 per cent. in Heacker's table given on page 38. The figures thus obtained are 1.08 lbs. proteins, 4.8 lbs. carbohydrates and 0.42 lb. fats.

Total requirements of the said cow may, therefore, be tabulated as follows :—

Requirements.	Digestible nutrients in lbs.		
	Proteins.	Carbohydrates.	Fats.
For maintenance alone.	0·573	5·720	0·081
For 20 lbs. milk testing 4 per cent. fat.	1·080	4·800	0·420
Total requirements	1·653	10·520	0·501

The digestible proteins in wheat *bhoosa* (*turi*) and in green maize are only 0·739 and 0·74 per cent. respectively, as is shown by the tables in Appendix IV against these foodstuffs. 10·5 lbs. wheat *bhoosa* (*turi*) only contains 0·739 × 10·5/100, or 0·077 lb. digestible proteins; similarly 35 lbs. green maize contains 0·74 × 35/100, or, nearly 0·259 lb. of digestible proteins, thus making a total of 0·077 + 0·259 or 0·336 lb. proteins. The total proteins needed by the cow in question as shown above in the table is 1·653 lbs. daily. Therefore, 1·653 — 0·336 or 1·317 lbs. proteins more have to be provided. If only

green maize is given to the cow in addition to the above-mentioned basal ration, 178 lbs. more of green maize will be required to provide the necessary 1·317 lbs. of proteins, which amount it is not possible for a cow of this size to accommodate in her stomachs. It is, therefore, essential that these proteins be looked for in other concentrated foodstuffs, like grams, cakes, etc. 1·317 lbs. proteins are available in about 3 lbs. of *torea* cake (rape-seed cake) and 5 lbs. grams. The results now may be tabulated as under :—

Table showing the component parts of the ration.

Particulars	Digestible nutrients in lbs.		
	Proteins.	Carbohydrates.	Fats.
10·5 lbs. of *turi* (wheat bhoosa)..	0·077	4·889	0·031
35 lbs. of green maize ...	0·259	1·861	0·091
3 lbs. of *torea* cake ...	0·688	0·763	0·214
5 lbs. of grams ...	0·780	2·535	0·172
Total ...	1·804	10·048	0·508

The digestible nutrients in the above feed coincide very closely with the total requirements of the above cow as tabulated before.

If, in the above case only *juar* (cut green) is available, 13·9 × 100/30·24, or nearly 45 lbs. would be required to supply the necessary coarse fodder and the ration then will stand as follows :—

Particulars.	Digestible nutrients in lbs.		
	Proteins.	Carbohydrates.	Fats.
45 lbs. of *juar* (cut-green).	0·109	7·788	...,
3 lbs. of *torea* cake.	0·688	0·763	0·214
5 lbs. of grams.	0·780	2·535	0·172
Total ...	1·577	11·086	0·386

The above ration is a little deficient in proteins and fats and is to a certain extent richer in carbohydrates. The richness of the carbohydrates would make up for the deficiency in fats, and the deficiency in proteins can be brought up to the required level by the addition of half a pound more of grams.

Take another instance, when only green oats are available. In this case such a cow as discussed above would require about one-tenth of her body weight, or about 75 lbs. of green oats to supply her enough bulk. Then the ration may be made up as follows :—

Particulars.	Proteins.	Carbohydrates.	Fats.
75 lbs. green oats	0·510	5·899	0·194
2 lbs. *torea* cake	0·458	0·509	0·142
2 lbs. grams	0·780	2·538	0·172
Total ...	1·748	8·946	0·508

The afore-mentioned specifications show that the ration is somewhat poorer in carbohydrates which can be made good by the addition of a couple of pounds of foods rich in carbohydrates such as molasses (*sira* or *rab*).

Further, the roughages and concentrates in any ration may have to be changed by other roughages and concentrates according to the prices in the market of the different foodstuffs to make the production of milk cheaper. Thus, a certain more costly foodstuff in a prescribed ration may be replaced or substituted by one or a mixture of cheaper foodstuffs, so long the digestible nutrients in a certain amount of the former are equal to those contained in the latter. Supposing, in the previous rations the price of grams has gone higher from Rs. 5/8 a maund to Rs. 8 per maund. This means that the feeder has got to spend annas 8 now to obtain 5 lbs. of grams which he used to purchase for only annas $5^1/_2$ before. If he were to persist in feeding grams to his cows, it would obviously increase his cost of production. He should now see which foodstuffs are selling cheaper in the market. Supposing he finds that oats are selling Rs. 4 a maund, bran Rs. 3 a maund and *soya* bean Rs. 6 per maund. He should now try to substitute the digestible ingredients present in 5 lbs. of grams by the same amount of digestible nutrients in a judicious mixture of bran, oats and *soya* bean. The digestible ingredients present in 5 lbs. grams are 0·780 lb. proteins, 2·535 lbs. carbohydrates and 0·172 lb. fats. These can be provided in a mixture of 3 lbs. *chokar* (bran), 2 lbs. *jawi* (oats) and 1 lb. of *soya* bean. The following table shows the amounts of digestible nutrients in the

newly substituted mixture :—

Particulars.	Digestible nutrients in lbs.		
	Proteins.	Carbohydrates.	Fats.
3 lbs. of *chokar*...	0·298	1·315	0·072
1 lb. of *soya* bean	0·301	0·167	0·079
2 lbs. of *Jawi*	0·158	1·023	0·040
Total ...	0·757	2·505	0·191

The cost of the above mixture calculated on the rates in the market as mentioned above comes to only annas 5 and one pie.

Now supposing, in the ration devised first, *turi* and green maize become scarce and dearer and mixed hay and *senji* are cheaper and available in plenty. 10½ lbs. of *turi* and 35 lbs. of green maize contain 0·336 lb. of proteins, 6·750 lbs. carbohydrates and 0·122 lb. fats. These are found in 15 lbs. of hay and 5 lbs. *senji* as shown below .—

Particulars.	Digestible nutrients in lbs.		
	Proteins.	Carbohydrates.	Fats.
15 lbs. of hay ...	0·248	6·578	0·111
5 lbs. of *senji* ...	0·094	0·231	0·011
Total ...	0·342	6·809	0·122

The new ration devised for a cow weighing 750 lbs. and yielding 20 lbs. of 4 per cent. milk may according to circumstances read as follows :—

Particulars.	Digestible nutrients in lbs.		
	Proteins.	Carbohydrates.	Fats.
15 lbs. hay ...	0·248	6·578	0·111
5 lbs. *senji* ...	0·094	0·231	0·011
3 lbs. *Torea* cake	0·688	0·763	0·214
3 lbs. *chokar* ...	0·298	1·315	0·072
1 lb. *soya* bean	0·301	0·167	0·079
2 lbs. *jawi* ...	0·158	1·023	0·040
Total ...	1·787	10·077	0·527

The substitutions and calculations given in the fore-going pages are only intended to serve as a guide to the cow-keepers in devising balanced rations for their cows according to different conditions of the market prices and periods of availability of different foodstuffs under varying conditions of the requirements of cows. In Appendix VI. are given a few ration statements of some of the very important farms in India, a perusal of which should prove useful to the readers. Owing to the various types of milch cattle in India and their individual differences, it is not possible to make up a fixed ration that would be suitable under all conditions. The ration for each animal varies according to its body weight and the quality and quantity of milk yielded by it. Dry animals need only the maintenance

ration while those in lactation need an additional allowance for milk production.

An intelligent and experienced feeder who knows his cows should try to fit a standard to his cows rather than attempt to fit his cows to a standard.

* * * *

15. Principles of Feeding Cows.

Feeding standards as discussed before are not immutable, and merely serve as guides indicating approximately the amounts of the various digestible nutrients required by different animals under varying circumstances. Apart from feeding standards, certain other factors which influence the usefulness or otherwise of a ration must also be taken into consideration. This is specially important in the compounding and mixing of foodstuffs in a ration. Most of these factors are simple and can be easily controlled but their neglect may lead to serious results economically. Feeding of cows and the production of milk are essentially inter-dependent economic problems in which factors governing both must be thoroughly understood and controlled by due attention. These factors are :—

(*i*). *Liberal Feeding.*

Milch cows generally produce plenty of milk just after calving, not necessarily because they are being properly fed,but because they inherently do so. Milk yield, however, dwindles after a few weeks if the animal is not fed liberally. Liberal feeding at once assumes greater importance when continued heavy production is in view throughout the cow's period of

lactation. Liberal feeding should, on no account, be mistaken for ' overfeeding, ' which is as undesirable as underfeeding. Sometimes overfeeding is due to lack of interest, but, more often it is due to the feeder not knowing exactly what the capacity of the digestive system of the animal is for feeding stuffs. An inexperienced and over-zealous stockman may make the foolish mistake of trying to obtain better results by increasing the food to the uneconomic and dangerous point of overfeeding, when he should really feed less. Underfeeding may only render the animal weak and thin, whereas overfeeding may directly induce digestive and other systemic disturbances. Overfeeding is like overloading which may at a certain limit break the animal's back, whilst underfeeding will only mean gradual weakening of the animal and lesser profits.

Overfeeding in doubly wasteful. It wastes food and it injures the animals. There is no sense in feeding beyond the limits of the animal to digest, assimilate and make into flesh, fat or milk. With unnecessary quantities of food in the digestive system, smaller returns are given from that portion of the ration not counted as excessive because the over crowded organs cannot deal as effectively with the food as they would do, were only the proper amount fed.

It costs more to underfeed a producing cow than to feed her properly. A cow giving her maximum amount of milk will return nearly half her feed she eats in milk. The rest of her feed is used up in maintaining her body. A cow that is underfed will keep using enough feed to maintain herself and

let the milk pail suffer due to her feed shortage. Present day economic feeding demands that milch cows should be fed liberally.

(*ii*). *Cows should be fed Individually.*

Cows of the same breed and age and receiving practically the same feed and care, vary widely in their productive ability. This is due to their individual tendencies, In order to obtain maximum profits, cows must be fed individually according to their individual production and requirements in stead of allowing the same ration to each animal in the herd. For ordinary purposes it will be sufficient to determine first their requirements and then to give practically the same amount of roughages to each animal in a herd, and later to adjust the allowance of concentrates according to their production. Roughly speaking, a milch cow will need about 2 lbs. of dry roughages of good quality per 100 lbs. of live-weight, or 1 lb. of dry roughages and 3 lbs. of green fodder.

(*iii*). *The Ration should be Properly Balanced.*

With a correct and balanced ration a cow can get the best out of all the constituents present in the feed and production of milk is consequently cheaper, whereas with an improperly balanced ration much of it is wasted. It is not what the cow eats, but what she digests that produces milk, and with a balanced ration maximum of digestibility of the total feed is ensured. (See Frontispiece to Part I.)

(*iv*). *The Feed must be Palatable.*

Digestive powers and appetite are not the same in cattle at all times and under all circumstances.

Much depends upon the availability of foodstuffs, force of habit and usage at a certain locality. It is doubtful if an unpalatable and unappetising ration does not depress the digestive powers, but this much is certain that cows getting foods they like will eat, relish and thrive better than if they are given foods they dislike. Further, feeding to the maximum of their appetite is essential for profitable production, and this can only be obtained by palatable rations which stimulate digestive and assimilative functions. Therefore, stock-owners should always try to give rations which they have found by experience to be altogether acceptable and palatable to their cows. Evil-smelling, musty, mouldy and spoiled inferior foods are seldom liked by animals and their use, therefore, should be rigidly avoided. Certain foodstuffs may be improved in their flavour and palatibility by special preparation or by the addition of salt and condiments, but these tactics should not be employed to mask the bad odours or the poor quality of inferior foods.

(*v*). *Variety of Foods in the Ration.*

A variety of foods in a ration makes the ration more palatable, and skilled feeders have invariably obtained better results by adhering to this important factor. By combining many foods in a ration a better balanced mixture of proteins and vitamins is furnished than by depending on only a few. Variety in the rations shonld not be mistaken for sudden changes in the diet from day to day, which should be strictly avoided.

* * * *

(*vi*). *The Foods Composing the Ration should be Good and Sound.*

This is self-evident. The inclusion of unsound, mouldy, musty and poor quality foods in a ration reduces the feeding value of the mixture. Apart from this, foods of low quality may contain poisonous or other unwholesome ingredients, like the products of invasion of vegetable and animal parasites, dust, dirt, etc. They may cause disease directly in animals eating such foods. Cleanliness is an important condition of quality : dirty feeding may produce intestinal disorders. In India fodders and food grains and other products fed to cattle are often of low quality, very dusty and contain pieces of stone and earth. Particular care as to cleanliness of all the foodstuffs is essential on the part of the feeder. The mistaken notion that ' any thing would do for the cattle ' is baseless and incorrect.

(*vii*). *The Ration should contain enough of Mineral Matter.*

Every *seer* of milk yielded by a cow contains a little more than half a *tola* of mineral matter which has to be derived ultimately from the food. If the amount of mineral matter in the ration is deficient to meet the demand in milk yield, the cow shall have to draw upon her own body supplies or fall down in milk yield. The former will mean a loss in health and vigour, not only to herself but also to the calf which she may be carrying, and the latter will bring about a rapid loss in her condition and milk yield. At the end of her lactation she will be left a scraggy, worn-out and emaciated animal, and probably will give birth to a weak calf.

(*viii*). *The Ration should be fairly Laxative.*

This is important, because otherwise the food will be incompletely digested, which means the wastage of a certain amount of the ration. Constipation is the proverbial cause of most of the digestive troubles and this is not infrequently the result of consuming foods that are dry and not laxative in character. All green fodders have a laxative and cooling action.

(*ix*). *The Ration should be fairly Bulky.*

The stomachs of cattle are very capacious, and the animals will not feel satisfied unless they are properly filled up. From the point of view of nourishment and energy and heat producing values the indigestible fibre is not of any great importance, but it plays an important role in giving a feeling of fullness to cattle. If the bulk of the ration supplied is small, however rich it might be in its nourishing constituents, cattle may fall a victim to the depraved habit of eating earth, bones, rags, dirty refuse, etc., in fact anything that will fill up their stomachs.

(*x*). *Allow as much of Green Fodder as may be possible.*

Green succulent foods are of great importance in the feeding of milch cows because of their cooling and slightly laxative action. They aid appetite and keep the animals in good condition. In India it is possible to obtain practically throughout the year a large variety of green fodders suitable for cattle-feeding. Green grasses, clovers, lucerne, maize, oats, wheat, *shalgham* (turnips), *chiral* (a kind of bean plant), *jawar*, *bajra*, silage, etc. etc., are all available. So long a judicious mixture of green

fodders can supply the necessary digestible nutrients to the milch animals, there is no necessity of having a recourse to concentrates and other commercial products. Green fodders are bulky, easily digestible, laxative and contain enough of the necessary vitamins. Lucerne, berseem, *shaftal*, clovers, and other leguminous plants are very rich in proteins. Their allowance, therefore, should be duly calculated and restricted. They are better given in conjunction with other foods like *bhoosa*, green oats, wheat and maize in small quantities. Turning the milch cattle out on pasture is very useful because it provides enough of exercise and sun-shine so essential for health. Green fodders are rather scarce in winter from the end of November to the beginning of March and in this part of the year cattle generally lose condition; their flanks look hollow and coat gets harsh and staring. If the farmers could learn to save enough of green fodders in the form of silage, it could be managed to supply green and succulent fodders throughout the year. It is quite possible that the cattle would refuse to take silage in the beginning, but later on they would begin to relish it. Ordinarily, in winter *shalgham* (turnips), carrot leaves, cabbage and some of the leguminous plants are only available. The rule should be to allow milch cattle as much of green fodders as can be available. In Appendix VII the table shows how the proprietors of the Jehangirabad Cattle Farm, Multan District, manage to supply green fodders to their stock throughout the year. In Appendix VIII is given a general table showing the availability of various green fodders in the Punjab during the year. Again, a reference to the ration statement No. 8 in Appendix

VI will show (*a*) that the green succulent roughages combined with proper quantities of dry fodder have wholesome influence on the productive capacity of the cows, (*b*) that the concentrates can be economized by plentiful supply of green succulents, e. g., berseem and other pulses and cereals either fed in stalls or grazed in the field and the ratio of concentrates to milk yield can be widened to the extent of 1 to 3·3 lbs. of milk, (*c*) that grazing on dry coarse grass in hot weather needs concentrates on a high scale to the extent of 1 to every 1·3 lbs. of milk, and (*d*) that during the cold weather when jungle grazing is coarse and dry, green berseem plays an important part and effects a cut in the ration bill, the ratio of concentrates to milk yield going down to 1 to 2·42 lbs.

(xi). Avoid Sudden Changes in Diet.

Sudden changes in diet are a fruitful cause of many digestive troubles in milch cattle and other animals, the more notable amongst these being tympanites (blown or *uphara*), impaction, etc. These diseases sympathetically reduce milk yield and have a depressing influence on the general constitution of the animal. All changes in food must be gradual and slow. With milch cattle the changing period is usually regarded as the losing period. An animal's system receiving a certain food or a mixture of foods for sometime gets accustomed to it and by sudden changes it gets upset. If it is desired to change from pasturage to indoor feeding, or from green foods to dry ones, or from one particular food to another, always begin gradually by taking away a small part of the usual food and replacing it by a

small requisite amount of the new one. This change can be increased from day to day until the animal's system gets used to the new food. During all this period of change in the diet one should remain on guard for any untoward symptoms shown by the animal. The help of a properly qualified veterinary surgeon should at once be sought if the animal's symptoms are grave and if the system appears to be out of order, instead of administering concoctions of doubtful value prescribed by laymen and quacks.

(*xii*). *Maintain Regularity in Feeding.*

A sensible owner of cattle is always regular and uniform from day to day with regard to the feeding, milking and general routine in connection with his animals. Cattle, like other animals, are creatures of habit and get so much used to the routine that they resent changes and show restlessness. As the feeding hour approaches their glandular secretions become active in anticipation of the the meal. Irregularity in milking and feeding tells very badly on the productive powers of an animal. A skilled feeder should evenly distribute the dietary throughout the day so that the cows are not kept too long without food. Along with this enough time should be allowed between the meals so that the animals may get sufficient rest and quietitude to chew their cud and have grooming done. A suitable time table should always be prepared and rigidly adhered to according to circumstances and needs. The routine time table at the Jehangirabad Cattle Farm, Multan District, is given on the next page and refers to the routine followed in winter only, from November to the end of March. In

summer, from April to the end of October, the cattle are watered three times daily, at 8 A. M., 2 P. M. and 7 P. M.

4 to 8 A. M.	...	Morning milking of the cows.
8 to 10 A. M.	...	Watering.
10 A. M. to 2 P. M.	...	Grazing in the fields.
2 P. M. to 3 P. M.	...	Watering.
2.30 P. M. to 4 P.M.	...	Green fodder and concentrated ration.
4 P. M. to 8 P. M.	...	Evening milking of the cows.
7 P. M. to 4 A. M.	...	Fodder (Green and Dry).

(*xiii*). *Kindness to Animals.**

On this point Babcock of the Wisconsin Station, U. S. A., writes in the Wisconsin Report, 1889, " I would recommend, therefore, in order to obtain the best results from any cow, that first of all she be treated kindly, all sources of excitement being avoided so far as possible. She should also be fed and milked at regular intervals by the same person, and all conditions should be maintained as nearly uniform as possible at all times. It is my opinion that kind treatment and pleasant surroundings will have a greater influence upon the quantity of milk than the kink of food, provided the ration given contains sufficient nutriment for the maintenance of the animal ".

Further, on the general treatment of the herd Haecker of the Minnesota Station, U. S. A., offers the following sage advice:—(Minnesota Bulletin, No. 130).

" We know of many instances where the best

* From Henry & Morrison's 'Feeds and Feeding'. 1917.

of the dairy cows were kept, and where good methods of feeding were practised ; and still results fell far short of what might reasonably be expected, simply because the animals did not receive that kindly treatment which is so essential to a cow giving much milk for a long period. The herd as a whole should always be moved slowly. Never hurry a cow, or strike her or speak loudly and harshly. A gentle voice and a caressing touch are quite as potent as is digestible protein. If you so handle the cows that they are fond of you, you have learned one of the most important lessons that lead to profitable dairying. The most successful milk producers are always in close touch with every cow in the herd. The milk producer has to do with motherhood, in which affection always plays an important part. A cow's affection for the calf prompts the desire to give it milk ; if you gain her affection, she will desire to give you milk. If you have not been in the habit of caressing the cows, the time to inaugurate the practice is when they approach the time of calving, as it is that particular time when they take kindly to grooming and to gentle rubbing of the udder.

"Each cow should have a name, which should always be spoken when approaching her. This one point counts for much in the successful handling of a herd. Suppose the cows are slowly filling the barn, and you see that Rose is about to go into the wrong stall. A quick call of 'Rose' will attract her attention, and she will forget that she was about to go into her neighbour's stall to steal a mouthful of her food. If Rose, when in the yard, is about to hook another member of the herd, and just at that

moment hears her name called, she will forget what she was about to do. Again, suppose the herd is slowly wending its way down the lane to the pasture, and some one has thoughtlessly left a side gate open, leading into a grain field. Rose is in the lead, and, you see her turning towards the open gate, a quick sharp call of 'Rose' will exert a wonderful influence in bringing her back into line. It is by such methods that a herd can be gradually taught to do the right things, to save you so many steps, and at the same time bring a larger return."

(*xiv*). *Order and Frequency of Feeding the Daily Rations.*

It has been mentioned before that regularity and uniformity in the hours of feeding is essential. As a general rule, feeding a cow twice daily, morning and evening, should be enough preferably with a small allowance of roughages at mid-day. The concentrates should better be given first and then the roughages. In India it is a common custom to feed the cow with concentrates first and then with roughages just prior to and during the process of milking. People think that by doing so cows let down milk copiously. Probably it is only a matter of habit. Whatever the system of feeding, it is desirable that it should be as simple as possible, and once established it should be rigorously continued. *Bhoosa*, hays, straws and other dry food-stuffs should not be fed till after milking, since they raise a lot of dust in the air which may contaminate milk. Foods liable to impart their characteristic odours, like cabbage, turnips, etc., should be given after the operation of milking.

(*xv*). *Cows must get enough of Clean and Wholesome Water.*

This point has already been discussed in some length on pages 14 to 16. All cattle must be offered water at least twice daily and cows in milk three or four times.

(*xvi*). *The Feed should be properly Prepared.*

Different foods require proper preparation before administration in order to render them more digestible and more palatable. Hard grains, like gram, wheat, maize, oats, barley etc., should be given ground, crushed or bruised, so that their mastication may become easier. Course forages like *jawar*, *bajra*, straws, and certain green fodders like oats, wheat, maize, etc., should be given cut or chopped. Cooking, heating or boiling of vegetable feeds for healthy cattle is not necessary. They increase palatability and digestibility in certain instances, and may, therefore, be resorted to in the case of sick and debilitated animals only with a view to induce them to eat, but as soon as they begin partaking of ordinary foods, cooking, heating or boiling of feeds should be stopped. *Shalgham* (turnips) and other roots should be given sliced or pulped so that the roots may not get lodged in the throat and cause choking. Dry foods should be moistened with advantage. Soaking of foods like cakes, cottonseed etc., overnight in winter renders them softer and more palatable and is not objectionable, but in summer too much fermentation may occur if kept too long. In the latter case cows may even refuse to take highly fermented concentrates. Linseed should be crushed or bruised or boiled before administration.

(*xvii*). *Economy in Labour and Cost.*

A properly organised system of feeding balanced rations to cows according to their milk yield should obviously not entail more labour or cost than any haphazard and rough method. Proper feeding should mean no waste of food and the food fed should bring forth maximum results and keep the animal in a sound and healthy condition. The profit and loss side of the problem of keeping cows should always be calculated before venturing to keep cows. Haphazard methods always mean haphazard results entailing more of cost and waste.

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16. Feeding of in-Calf Cows and Heifers.

Pregnant cows have to meet with a double strain, that of milk secretion and of nourishing the calf in the womb. In the Western countries matings of cows are so arranged that the high type dairy cows run dry only for about 6 to 10 weeks prior to the next calving, but in our country cows are generally dry for about five months on an average between the lactation periods. From the economic point of view such a long dry period is wasteful and objectionable, being non-productive in the way of milk secretion. It is due to mating of cows with bulls at wrong periods. Milch cows should be mated to conceive after the second month of calving. Generally speaking, this would allow a dry period of about three months between lactations. Long continued heavy milk secretion and giving birth to calves in quick succession mean a great strain upon the energies of a cow. Dry period is essentially a resting period for the cow and is really meant for

making good and recuperating her previous losses. During this time the cow should be prepared for work and strain of the following year. She should be liberally fed so that she may build her reserve stores and may provide sufficient nourishment to the growing calf inside her. Unfortunately, in our country dry cows receive the most indifferent treatment and poor feeding from their owners simply because they do not yield any milk during those days. One must admit that we are very conservative and short-sighted in our economics. We do not look ahead. We want to calculate our immediate gains rather too soon, and altogether ignore that by incurring a little more expenditure and by putting in a little more of effort now we might expect to reap better profits later. We do not allow sufficient food to our dry cows and then expect them to drop healthy calves and yield enormous amounts of milk. Any cow that is not properly rested and is continuously underfed will only produce a small, scraggy, ill-formed, ill-nourished and weak calf. She will continue utilising her bodily resources for the development of the weakling and consequently will herself remain in an impoverished and low condition. She would never yield milk to the best of her capacity. It is, therefore, essential that all dry cows, more especially those in calf, be fed liberally and treated kindly in every way.

A common practice amongst the cowkeepers in India is to send their cows out, more especially the dry ones, for about 5 or 6 hours daily under the care of *palis*, *gawallas* and *gujjars* to the so-called grazing grounds at the rates of about rupee one to rupees two per month per animal. The practice is

useful in so far as the animals can get enough exercise and sun-shine, but not for grazing purposes as is erroneously thought by the people. These lands are more exercising grounds than grazing lands, and if there happens to be any grazing at all it suffers very much from over-stocking. The owners believe that their cows are getting enough of grazing, and therefore, the ration allowance of the said animal at home or in the stall is very materially stinted.

Another common practice amongst the cow-keepers, especially in the towns, is to hand over the charge of their dry cows to *zemindars* in the villages on the so-called '*adhiara* system.' The *zemindars* look after the cows until they calve, or are about to calve, when they are evaluated, and half the price settled upon is paid to the *zemindar* as his remuneration. During this period cows generally do not receive a sympathetic treatment and good feeding at the hands of their trustees. The cows on *adhiara* system may be looked upon as step children put temporarily in the charge of careless adopted parents. Lack of good feeding and kindly treatment during her resting period tells very adversely upon the constitution of the calf, her own health and milk yield.

A good pasturage is usually enough for a dry cow if she is not in a low condition otherwise extra rationing of concentrates must be done in order to improve her. A judicious mixture of grasses and clovers (legume plants) which is also slightly laxative is just what she requires. Heifers require heavier feeding proportionately than the mature cows as this means their better growth and

development. They must be given a sufficiency of proteins and mineral matter. For them a mixture of about 8 lbs. legume hays, a pound or two of concentrates and green fodder as much as they can consume should answer well.

All pregnant cows should be treated kindly. Rough and unkind handling, abusing the animals or kicking spoils their temperament, which once established is difficult to get rid of. Pregnant animals should not be made to walk long distance, run fast, be chased by dogs or frightened and allowed to fight with other animals. Any kind of violent exercise should be avoided also. Their feeding and general management must be regular and based on sound lines. Turning the cow out for grazing is the best form of exercise while she is pregnant. They should not be allowed to mix or tied in the same stalls with animals that have aborted.

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17. Care and Feeding of Cows Approaching Parturition.

The period of gestation or pregnancy in cows is about nine months or 283 days. Sometimes, however, she may carry her young for only 250 days, and sometimes this period may extend to even 300 days. The average may be conveniently put down at 283 days. If the cow-keeper keeps a careful record of the date of service by the bull (which he should always keep), he can approximately forecast the date of calving and keep the cow under careful observation when she is approaching calving time. In Appendix IX. is given the calving table

from which the approximate date of calving can be easily found if the date of service by the bull is known.

A few days before actual delivery the udder fills and becomes enlarged and prominent. The teats also swell up and actual milk flow is not altogether uncommon. The vulva becomes enlarged, loose, soft and to a certain extent inflamed, and muscles and structures on each side of the tail become relaxed and appear to fall. At this time the cow should be kept in a clean, comfortable, calm and quiet place with plenty of clean bedding underneath her. She is about to calve. Any kind of interference with her should be avoided, and nature should be allowed to take its course. But, a careful watch and help should be at hand if there appears any difficulty in calving. In all serious and difficult cases of delivery the help of a qualified veterinary surgeon should be sought, and inexperienced *gujjars* and *gawalas* with all their unclean habits should not be allowed to interfere with the most delicate genital organs of the animal.

To make the most of the milking cow it is necessary to start feeding well at least two months before she freshens to get her fit and prepare her for the work that is ahead of her. It is folly to expect milk from a cow if she calves in a poor condition.

The last week's feeding should be of a cooling nature, soft and laxative. If her bowels are constipated it is better to administer her a dose of Epsom salts (one pound) or a pint of linseed oil, but too free a use of strong purgatives should be avoided, as it may bring about premature delivery of the calf. A

good drench to give to a cow a day before she is expected to calve is a mixture containing 1 lb. Epsom salts, and a table spoonful of ground ginger in 3 pints of tepid water. This drench should be repeated after calving. For two or three days prior to calving she should get luke-warm water to drink and should be protected from cold winds and extremes of temperatures. It is because she is in a low and delicate condition. Her feed should be limited and should consist of bran mashes and green fodder. Besides this linseed meal or oatmeal, etc. may be given in small amount. To bring about the desired laxative effect a mixture of wheat bran, two parts and linseed oil one part by weight is very valuable. Feeding on bulky rations and roughages too much should be avoided, so that the digestive system may not be distended and interfere with easy parturition.

In the case of heifers nearing calving time the udder develops very much and often becomes very highly congested and swollen, the swelling frequently extending half way along the belly in front of the udder. People who have not had much experience are frequently alarmed at this state. It is a natural condition and there is no necessity for any concern. Heifers sometimes become very irritable at this time. They should be left alone undisturbed and a careful watch kept all the while until she calves successfully. After the heifer has calved her udder should be thoroughly but gently rubbed at each milking, using camphorated oil for a lubricant. The rubbing increases the circulation and also relieves the congestion. Older animals are not, as a rule, troubled in this way.

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18. Care and Feeding of the Cow Immediately after Calving.

Calving means a great and severe strain on the cow's constitution. It is essential, therefore, that her diet be lighter and limited for a few days immediately after calving. Within one or two hours after delivery she should be given a refreshing and stimulant mash. A useful mash which may be given at this time is one prepared by boiling in water crushed wheat or barley or *bajra* to which a little crude sugar (*gur*), ginger powder (*Sunth*) and salt have been added. Later she should be fed on bran mashes and green fodder alone two or three times in a day. The water given to her for drinking should with advantage be slightly lukewarm. Linseed meal, oatmeal or *bajra* meal also serve well at this time. Such a refreshing and laxative diet should be continued for about ten or twelve days, and afterwards the concentrated ration should be gradually added in increasing amounts to her daily feed. It requires nearly a month to bring her round to her full concentrated feed. Any sudden increase in the diet is likely to bring about indigestion, tympanites and other troubles of the digestive tract. The changes in the food or their quantities must necessarily be slow and well thought out, until she attains her maximum production, when her ration should correspond to her yield. Much, however, would depend upon the cow's condition. If she has cleansed herself properly and shows good appetite, there is no point in keeping her on stinted rations for long. Careful nursing and proper feeding of the cow during her dry period and both before and after calving is of paramount importance. It gives her a good start for her yield

during the lactation period.

As soon as the cow has calved, attention to the calf and the mother is essential. The mother should be cleaned with a moist cloth which may be frequently dipped into a basin containing warm water, and a clean bed should be provided to her. She then begins to fondle her newly-born calf by licking it. The cowkeeper should then keep a watchful eye on the after-birth, which in most cases is removed within forty-eight hours. If it is retained proper veterinary surgeon's help should be sought. Most of the *gawalas* and *gujjars* can easily remove the after-birth, but their methods are too rough and insanitary. Therefore, wherever possible it should be left to experienced hands.

As soon as the cow has calved, the udder must also be attended to. If the calf has sucked, it will not require feeding for the present. If not, the cow should be milked dry and some of her first milk or colostrum given to the calf.

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19. Care of the newly born Calf.

As soon as the calf is born, particularly careful attention should be paid to it. Any membranes or sticky matter adhering to the nostrils, eyes, ears and the body should be carefully removed so that the calf my breathe freely. Generally speaking, the cow will lick her calf dry and cleanse it fully if she is allowed to do so. In cows that are indifferent and do not lick their calves immediately after delivery, it is customary to sprinkle a little common salt on the calf to stimulate them to lick. If the calf is to be taken away

and weaned immediately after birth, as is done in most of the Government Dairy Farms in India, it should be cleaned and rubbed dry with a clean straw wisp or a sponge, and kept warm and protected from extremes of climatic conditions. The place provided to the newly-born calf should always be clean, well ventilated and provided with plenty of fresh clean straw bedding.

Sometimes, the newly-born calf shows no sign of life. In such cases artificial respiration should be done by pulling out the tongue, moving the forelimb forwards and backwards and by applying friction to its body with straw wisps. The revival to life and the beginning of respiration is often indicated by a gasp or a little cough by the calf.

The next thing to do is to see if all the natural openings are patent, especially the anus. If it is found imperforate, proper veterinary aid should be had to make the necessary surgical incisions.

Attention should then be paid to the cord with which the calf is attached to its mother. It is generally found severed; if not, it may have to be cut. If proper care is not exercised at this time to disinfect the navel stump, a big abscess soon develops to the great disadvantage of the calf. Later, severe contagious diarrhœa appears which greatly weakens the calf and often proves fatal. This trouble is very common in India. To prevent losses in this way, the best is to clean the stump well with an antiseptic lotion (lysol lotion or phenyle lotion serves well), dry it and apply a ligature about an inch and a half from the navel. Any extra length of the cord beyond the ligature may be cut away. The stump should then

be swabbed with methylated spirits and then steeped in tincture of iodine for some time.

Under normal conditions, the calf will try to stand itself and make its way towards the udder to suckle. It may have to be helped on to the teats. The calf should have its mother's colostrum in sufficient quantities for the first few days. Colostrum acts medicinally and possesses a laxative and disinfectant action on the bowels. It is Nature's provision for the easy removal of the first feacal matter of the calf. Too much allowance of it, however, should be avoided as it may cause diarrhœa.

During the first two or three days of delivery, it must be decided whether the calf is to be weaned or not. As a rule, weaning of calves is very little practised in India because a majority of the people consider it sinful to deprive the young one wholly of its mother's natural milk. Apart from this, India being primarily an agricultural country requires huge bullock power for her agricultural operations, and it has been found by experience that weaned calves seldom develope into useful working bullocks. Moreover, special attention has to be paid for raising calves by artificial hand-feeding. Weaned calves generally remain weaklings and often die off. Their mothers fall down in their milk yields tremendously. Allowing the calf to suckle has further advantages also. The custom is to allow the calf fore-milk and the end-milk. Fore-milk is generally very rich in its germ content, and being suckled in by the calf, leaves the rest of the milk comparatively of a better quality and poorer germ content. Suckling the end milk means the removal of the last

traces of milk from the udder, which condition stimulates further secretions of milk. Due to the aforesaid economic factors, weaning of calves at birth or two or three days after it, is practically unknown in India, except in the Government Military Diary Farms. In any case, if weaning has to be practised it should be started from the cow's first delivery and not later.

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20. Calf Rearing.

The future of a herd depends upon the care and attention bestowed by a stockowner upon scientific breeding and upon the rearing of the farm calves. Good dairy herds are raised rather than purchased. Cows, well nourished and well looked after, generally give birth to strong and well developed calves, whereas, poorly nourished and weak cows drop weak and small calves which are rather hard to rear. Really speaking, feeding of calves is begun before they are born. The food elements necessary for the development of the calf are taken in by the cow, digested, assimilated and transmitted to the calf in the womb through the umbilical cord—the connecting link between the mother and the young one. It is evident, therefore, that if the cow, while pregnant is not properly looked after and liberally fed, she will not be able to maintain herself in a good thrifty condition and withal give birth to a strong and healthy calf. Our cowkeepers generally handicap themselves very seriously right from the start by not feeding the pregnant cows properly. This important question of the care and feeding of in-calf cows has already been discussed on pages 60 to 63.

As has already been mentioned calves should receive a sufficiency of colostrum after birth for the first 2 or 3 days. Later, if weaned, fresh, warm whole milk may be substituted for colostrum. When the calves are a week or ten days old they should get a little dry meal put into their mouths immediately after suckling. This will prevent them from suckling the ears or other parts of their mates. After a few days they will learn to take the meal from a trough. A fairly good mixture for the purpose is one containing 1 part of linseed meal, 2 parts oatmeal, 2 parts maize and 1 part bran, all mixed finely ground and made into a gruel. It is essential that gruels be prepared in scrupulously clean vessels. A good gruel, though thin, should not show any sign of settling to the bottom leaving a large quantity of watery fluid on the top. Such a meal is apt to form lumps, which may be difficult to digest. In addition, a lump of common salt should be put at a convenient place to allow them an easy and good lick whenever they desire.

At this time, it is often difficult to teach the calf to drink milk from the bucket. If the calf is weaned directly at birth, as a rule it learns to drink soon, but, since weaning soon after delivery is not considered a very desirable practice and calves are left with their mothers for first two or three days, some difficulty may be experienced in making it to take milk from the pail. In such cases begin to teach the calf to drink when hungry, because it will then prove to be a better and more receptive pupil. The milk may be put in a clean bucket and one or two fingers put in the calf's mouth which it will begin suckling. When the calf is busy doing so, the

hand may be lowered gradually until it is in the milk. The calf will begin to drink milk now. When the calf gets used to it for some time, the fingers should be gradually withdrawn. In this way after a few trials the calf will easily learn to drink from the pail. Care, however, should be taken that only small quantities of milk are allowed for the purpose in the beginning.

With regard to the quantity of milk to be given to the calves, much will depend upon their size, age and vigour. On an average, a calf just removed from its mother would require 4 to 6 lbs. of fresh whole milk daily. This should be divided into three feeds during the day until the calves are about a fort-night to three weeks old. Then, the whole milk ration may be gradually substituted by increasing quantities of skimmed or separated milk (*mohwa dudh*), which is generally available in large amounts at most of the dairy farms. This substitution should always be slow and may be completed in about three weeks. At this age the calf should be receiving from 10 to 14 pounds of skimmed milk daily, given in two feeds. As the calf grows the amount of skimmed milk should be gradually increased, provided it is available in plentiful quantities at the farm. In addition, a suitable grain mixture should be given partly to meet the lack of fats in skimmed milk and partly to keep up the growth and development of the calf. The following is a useful grain mixture which may be supplemented to the daily milk ration : Linseed crushed 1 part, Grams ground 2 parts, Bran 1 part and Oat-meal 1 part by weight.

The above mixture should be put in a sufficient

quantity of boiling water to make a thick gruel. and then allowed to cool down before being fed with skimmed milk. Quarter of a pound of this mixture per head may be fed daily, increasing the amount gradually to half a pound or more as found necessary. Ground millets (*bajra* and *jawaree*) are also useful for the purpose.

When the calves are from five to six months old milk ration may be gradually stopped and the calves turned out to pasture, the females being kept separate from the males. Lucerne, clovers. nourishing succulent grasses, good fine hay. etc.. etc.. answer the purpose well. An important factor to keep in mind is to feed the calves liberally on good nourishing diet because they are continuously growing. Overfeeding, however, should be avoided and scrupulous cleanliness maintained in every stage of feeding and general management. In addition. sun-light, fresh air and exercise are essential to the healthy growth of young calves. All changes in feeding should be made gradually. Sudden changes often prove harmful. Care should also be taken that all milk supplied to the calf, whether whole or skimmed, is of the same temperature as fresh cow's milk is, *viz.*, about 100 degrees Fahrenheit.

Probably there is no class of animal to which an adequate mineral supply is so important and essential as it is to the calf. which is often deprived of its mother's milk and put on to various types of 'milk substitutes', in which very seldom an effort is made to correct mineral deficiency. It has been estimated that a calf putting on about a pound and a half of body-weight daily should absorb no less than half an ounce of lime and phosphates every

day. It is evident, therefore, that the daily food of the calf should contain from two to three per cent. of suitable mineral matter. Deficiency of these elements results in general malnutrition, rickets, bone diseases, stunted growth and reduced constitutional strength. If salt is supplied in a lump placed conveniently within easy reach of the calves for licking, lime may be given in drinking water in the form of lime water. Lime water is easily prepared by putting some quicklime in a tub and filling it with water. After sometime when it settles, clear water on the top is lime water. An ounce or so of this may be put in a bucket of drinking water. Care should be taken that tinned vessels are not used for lime.

In the case of suckling calves the problem of feeding is comparatively simpler. The calves are left with their dams and get natural milk just before and after the milking operations. Enough, however, should be allowed each time so that the calves may obtain the necessary nourishment. In about a fortnight or so they begin to nibble their mother's food within their reach in increasing quantities. At this time both grain and roughages of the best possible quality should be provided. This food should be fed sparingly at first and increased only if the calves get used to it. The essential point is that the roughages must be of good quality and kept clean. Access to good pastures is excellent for growing calves. Special attention should also be paid to provide sufficient quantity of fresh wholesome water daily.

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PART II.

FOOD-STUFFS.

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It has been shown before that the chemical composition of food-stuffs and the digestibility of their component ingredients along with the way they are compounded are the principal factors determining the value and quality of a ration. Nevertheless, in order to make assurances doubly sure with respect to the suitability of rations, one must know other special characteristic features of food materials. A farmer uses a great diversity of feeding stuffs both farm-grown and purchased for his stock, but he always prefers his own farm produce, partly because it is cheaper and partly because he has realised by long experience that purchased fodder and other substances for feeding stock have a peculiar and mysterious trick of disappearing rather too soon. For the sake of convenience the various foodstuffs may be grouped up as follows :—

A. FORAGE PLANTS, both belonging to the Grass family and Leguminous (fresh green, dried or otherwise conserved).

B. FOOD GRAINS.

C. ROOTS.

D. BY-PRODUCTS OF INDUSTRIES.

and E. FOODS OF ANIMAL ORIGIN.

It will be well nigh impossible to deal separately with the various members of each group, and therefore, only general characteristics of some of the important and outstanding foodstuffs in each will be discussed broadly.

A. Forage Plants.

In this group are included the so-called ' rough-ages' , green and dried and silages, which give bulk to the ration and consist of leaves and stems, and in some cases partially formed or mature seeds or grains of plants.

There are two main families of the forage plants. Most of them belong to the family of the common grasses and cereals (Gramineæ), and others belong to the family of legume or pod-bearing plants (Leguminosæ) like grams, peas, lucerne, *chiral*, *shaftal*, clovers, *senji*, *guara*, etc. The first family forms the staple bulky diet of cattle in India. It includes all grasses, *khasil*, *jawi*, *jawar*, *bajra*, maize, wheat barley and rice straws and *bhoosas*, hays, etc. Their feeding value depends largely upon the stage of their growth. The dry matter in them, as in other plants, in the early stages is rich in proteins and becomes progressively poorer in proteins and richer in carbohydrates and indigestible fibre as the plants ripen. The second family of forage plants is more important in so far as its members are very rich in proteins and mineral matter in all stages of growth. Their judicious use in limited quanities along with the non-leguminous plants is most beneficial for milk production and rearing of young stock. Generally speaking, all forage plants, when green and young contain a high proportion of water and are soft and succulent, and hence are easily masticated and digested. The dry matter in them is comparatively rich in proteins and poor in carbohydrates and consequently they possess a high feeding value. As the plants grow and ripen, the amount of carbohydrates in them tends to increase along with the proportion of

indigestible woody fibre which becomes progressively harder and tougher with age, and the proportion of proteins and water decreases steadily. When ripe and hard they are rather difficult to masticate and digest. At the time of seeding, most of the valuable nutrients are transferred to the seeds leaving behind straws which contain so little nutrient matter for the economy of animals beyond giving bulk. Forage plants, therefore, meant for grazing should be consumed by the cattle before flowering and seeding. The same is true of plants meant for cutting and feeding to stock in the stables or for silage making. If this precaution is not carefully observed much of the food value will pass into the seeds which are almost all lost in the process of harvesting. Almost all the forage plants grown for feeding animals are best utilised when green. If there is a large excess, part of it may be made into hays, straws and *bhoosas* or into silage. Green fodders are easily digestible, succulent and rich in vitamins, and as much of green stuff should be allowed to milch cattle as can be available, Roughly speaking, green crops contain as much as 70 to 80 per cent. of water and 15 to 30 per cent. of dry matter with soft fibre. Hays and straws contain about 15 per cent. of water and the rest consists mostly of hard, tough and indigestible fibre.

Grasses, Hay and Silage.

Grasses constitute nature's healthiest and most nutritious food-materials for live-stock. Pastures are economically important because they provide with a method of feeding animals at a low cost. Once the pastures are established very little labour and

attention is needed afterwards. The exercise which the cows get while at pastures is of inestimable value and keeps them in good condition. Pastures, well looked after, should contain a variety of very good grasses, and if possible they should be supplemented with clovers and other leguminous plants. The latter increase the protein content of the feed and a greater variety of grasses adds to the palatability of the forage.

Good pastures in our country are very few and wherever they exist they suffer from overstocking and improper manuring. Further, weeds which lower the value of a pasture should be carefully kept down. As a rule, grasses are abundant and grow luxuriantly in the rainy season. They should be fed green to cows liberally and the rest conserved either as hay or as silage.

Hay is dried grass, but, as is stated in para 184 of the Report of the Royal Commission on Agriculture in India, 1928, "Indian hay is seldom 'hay' in the sense in which the term is understood in the Western countries : it consists of dry grass, on which seed has ripened and usually has been shed. It corresponds in feeding quality to the straw of cereals rather than hay made before seed has ripened. The reason for this inferior condition is that, during the latter part of the monsoon season, when grass is ready to be cut for hay, the weather is often so wet that hay-making cannot be attempted, and, at the end of the monsoon, when there is still a chance of making fair hay from grass not greatly over-ripe, cultivators are very busy in their cultivated crops."

As will appear from the above, hay-making is very little practised in our country because of economic difficulties. When climatic and other conditions are favourable good hay should be made from tender and leafy good sweet grasses cut at the commencement of flowering and properly dried. It should not be rain-washed, musty or mouldy. It should possess a pleasant odour and should be about a year old when used. It should be hard, clean, fresh and free from dust. Under all conditions, a certain amount of nutrients of the grasses are always lost in hay-making through crumbling, fermentation, etc., and the mastication and digestion is rendered more difficult than in the case of green fodder, which entails a further loss of energy from the economy of an animal. It is, therefore, obvious that green fodder has more feeding value than the hay made from it. Where good hay-making is not possible due to unfavourable rain conditions, green grasses may be stored in the form of silage. The making of silage for an average *zemindar* in India is comparatively a new thing, although the process has been worked with advantage and good results since long at some of the Government Farms and Agricultural Institutions. Broadly speaking the method consists in storing fodder in its green state in pits dug out in the earth or specially made silo towers. The former have proved very useful and inexpensive in India. In filling the pits the fodder is put in layers and well stamped down to exclude air. At the top of the filled pit a layer of straw or chaff is laid with a thick layer of earth. Green fodders thus stored in the pits undergo a certain amount of useful fermentation and produce 'sour silage' which can be

advantageously used for feeding cattle at times when green fodder is scarce. Cereal crops, like maize, *jawar*, *bajra*, oats, sugar-cane tops, etc., and leguminous plants like clovers, lucerne, etc., can also be made into silage. Most of the cereal crops if too long and a bit tough may be cut into smaller pieces about an inch or two in length before storing. Silage making is simpler than hay-making. It improves the quality of fodders through fermentation and makes the farmers independent of weather conditions. Some of the inferior and coarse plants and weeds which cattle refuse to eat in the green stage when good grass and other forage is available in plentiful quantities, are relished by them all the more when made into silage. In the rainy season grass grows rank and rapidly. If not cut early, it soon rots and cattle refuse to take it. If it is cut early when green and siloed, a fresh crop of grass will be available for grazing, siloing or hay-making after about a month and a half of the first cutting, The loss of grass in the wet season in India is enormous and the process of silage-making can be very usefully adopted to prevent these losses.

Some farmers complain that their cattle would not eat and relish silage. This is true to a certain extent in the primary stages of silage feeding simply because Indian cattle are not used to it. Silage should be fed in winter months to cattle and they soon become exceedingly fond of it because fodder is not available much in green state then. It is better to give only one feed of silage daily, and that after the morning milking. The full ration should consist of about 20 to 30 lbs. daily for an average sized cow. When the silo pit is once opened, feeding

from the same should be continued until finished, otherwise the mass will lose its weight and flavour.

The following is a brief description (alphabetically arranged) of some of the most important indigenous grasses of the Punjab :—

Common Fodder Grasses of the Punjab.

1. Andropogon annulatus, Forsk. Andropogon pertusus, Wild. Palwa or Palwan (Punjab); Jargi (Hissar). A perennial grass common in the plains of Northern India. It is considered to be a good fodder grass both for grazing and stacking purposes. It is supposed to be specially good for buffaloes. It makes good hay and is very nutritious. It is a useful winter grass.

2. Andropogon laniger, Desf. Bur (South Punjab) ; Khawi (Central and N. W. Punjab). A jungle perennial grass which does not grow about the cultivated lands. It is grazed when young and tender. Cattle eat it with impunity, but it is said to cause colic in horses. It is also stacked and is often useful in times of scarcity. In stacks it keeps well for many years. It is one of the fragrant grasses which when eaten by cows and buffaloes imparts a scented odour to their milk. Its roots are also used like *khas-khas* for making *tatties*. On the whole it is not recognised as a grass of good nutritive qualities.

3. Andropogon muricatus, Retz. Panni (Punjab); Khas-khas roots. A perennial grass with wonderfully spreading and tough roots. These roots are composed of long spongy brownish coloured fibres and the so-called '*khas khas tatties*' are made of it—

these are grass screens kept wet to cool rooms in summer. The roots are very difficult to eradicate. The grass is mainly used for thatching and is not grazed except when young and tender, and then even it is given to cattle only in seasons of drought. It is not stacked. The roots are also used for making ropes and weavers' brushes; stems are used for basket making.

4. Andropogon schoenanthus, Linn. Rauns (Hissar) ; Buj (Punjab). A perennial grass usually growing on low-lying swampy grounds. It is not very good either for grazing or for stacking. Cattle graze upon it when hard pressed, but not otherwise. It is mainly used for thatching and screening (*tatties*). It gives gripes to horses. A fragrant oil (*rusa ka tel*) is extracted and is used as a remedy for rheumatism. Good hay cannot be made of it as it is a coarse tall grass. It contains little nutrition.

5. Aristida depressa, Retz. Lamp (Hissar) ; Lam (Punjab). It is a slender, feathery sort of an annual grass of average quality, generally produced after heavy rains. It is common on sandy grounds. It is grazed to a certain extent but its value as a fodder grass is questionable. It is too short and light to be stacked and cannot be cut easily with a scythe as it is fine and soft. It is particularly relished by cattle and is fairly nutritious when it is wetted by rains. There are many varieties of this grass, some small others large, but the characteristic feature of feathery appearance is recognisable in all.

6. Cenchrus catharticus, Del. Bhurt (Hissar); Leha or Aleha (Ferozepur). An annual grass growing on sandy soils. It is only grazed when

tender, but is not suitable for stacking. Its seeds stick to the clothes of travellers and are a source of great annoyance and worry. The seed is mixed with *bajra* and eaten by poorer classes.

7. *Cenchrus montanus*, *Nees*. *Cenchrus biflorus*, *Roxb*. *Pennisetum cenchroides*, *Rich*. Dhaman or Anjan (Punjab). An annual grass. There are two varieties of this grass, one white and the other black with more compact spikelets. Both varieties are of almost equal value, the black for choice. It is indigenous to black cotton soils but under cultivation it may be grown almost anywhere. It is a thick juicy pale green grass and is considered to be one of the best of the most nutritious Indian grasses. It is very good for grazing and makes excellent hay when cut in time as it ripens very early and soon gets burnt up especially on poorer soils and in years of scanty rainfall. On a rich soil it grows most luxuriantly and yields a heavy crop; it fails on a sandy soil. Its grain is also eaten by the people. It is said that this grass is extremely good for increasing the milk yield, so much so that it is supposed to have a semi-intoxicating effect on the milk of buffaloes that graze on it. It requires good soil to grow upon.

8. *Chloris barbata*, *Swartz*. Ganni (Hissar); Chhota takria (Hissar). This grass is common about the cultivated and sandy lands. It is not much grazed or stacked. The cattle graze upon it only up to the time of flowering and afterwards refuse it.

9. *Chloris tenella*, *Roxb*. Barchinti bari (Hissar). This grass is common in cultivated lands, but is too small to be stacked. It is, however, a very nutritious grass and is much grazed in the rains.

10. Cynodon dactylon, Pers. Dub (General); Khubbar and Khabbal (Central and Western Punjab); Talla or Tilla (Western Punjab). A perennial grass with prostrate and creeping runners. It flowers nearly all the year round, and is by far the most useful and nutritious grass in India both for cattle and horses. It makes excellent hay which will keep for many years in a stack. It grows near cultivated lands and its presence is a sign of good soil. It is hard to beat as a grazing and stacking grass.

11. Eleusine aegyptiaca, Pers. Makra (General); Madhana (Lahore, Shahpur, Gujranwala and Salt Range). This grass generally grows on cultivated lands which have been manured by cattle dung. It is generally considered to be a very nutritious grass and is good for grazing as well as stacking. The seeds are eaten by the poorer people in seasons of scarcity. It makes a good silage and grows very quickly. Madhana is so called because of the resemblance of its flowering head with a churn-stick, the spikelets in it being digitate (3 to 5).

12. Eleusine flagellifera, Nees. Ghantil (South Punjab); Chhimbar (Punjab); Chhembri (Multan). Perennial. It is a well known useful fodder grass both for grazing cattle and horses. It is also stacked. It is common in fields and is supposed to be specially good for donkeys. It is a prostrate grass with extensively creeping rhizome. It grows very fast after the rains. This is one of the best grasses growing on good sweet soils.

13. Eleusine verticillata, Roxb. Jharna (Hissar). It is a fairly good grass for cattle but will not stack well.

14. Eleusine scindica, Duthie. Bhobra (Hissar). A perennial grass good for grazing and stacking. It grows both in barren wastes and in cultivated lands. It bears some resemblance to *makra*, but is a much more slender grass.

15. Elionurus hirsutus, Munro. Sin (Hissar), It is a perennial desert grass with a hard rhizome. The grass is fairly common in North Western India and is considered to be very nutritious. It is good for grazing when young and tender and is generally stacked. When mature it gets hard and is then used mainly for thatchwork. Weavers make their brushes from its roots. It is a rapid grower. In Bikaner elephants are fed on it. This grass is, perhaps, classically known as '*Kusha ghas.*'

16. Heteropogon contortus, R. & S. Surwala (Hissar); Sariala (Kangra, Salt Range and Gujranwala). It is a jungle grass, not very much found in the cultivated lands. In Hissar Bir it is fairly common. It is a fairly good grass and can be stacked, but is generally fed to cattle when young and tender. The cattle refuse it when dry and mature because of its barbed seeds. It keeps well in the stacks.

17. Iseilema laxum, Hack. Gandhi (Punjab and Hissar); Luinji (Kangra); Chhat (Rawalpindi). The grass is common in the plains of Northern India and on the low-lying swampy lands where soil is good. It is fragrant when green and hence the Indian name 'gandhi' (perfumed). It is both grazed and stacked and is much eaten by the buffaloes. It is fairly common in the Hissar Bir swamps. It is good for horses also.

18. Melanocenchrus royleana, Nees. It is an annual, rather a small grass seen generally in the sandy soils. *Zemindars* do not regard it as a grass at all, but it is not altogether bad for grazing.

19. Panicum antidotale, Retz. Ghirri or Ghamur (Hissar); Ghamrur (Simla and Kangra) ; Gharam (N.W.F. Province). It is a tall coarse looking perennial grass with erect and woody stems thickened at the joints and long linear leaves. Ghirri is perhaps an unripe form of ghamur. It is not considered a useful feeding grass for animals and has a bitter and saltish taste and therefore is not much grazed except when young and tender. It is not stacked. It generally grows on rich soils at the roots of bushes and hedges. It is said that cattle eat it when dry, and if eaten too young it swells up the cattle often with fatal results. The smoke from this grass is at times used for fumigation purposes, especially in smallpox. In Madras it is said to be used for medical purposes in throat affections.

20. Panicum colonum, Linn. Samak (Hissar) ; Swank or Sanwak (Punjab). An annual grass growing on rich and firm soils. Its grain is sold in the *bazaars* which is boiled with milk and made into *khir*. The grain is also eaten by the Hindus on fast days. By poorer classes it is made into a paste (*bhat*) and eaten with milk. It is one of the very nutritious fodder grasses which can also be stacked. All kinds of cattle eat it with greed. It is said that it fattens cattle and soon brings them into condition.

21. Panicum crus-galli, Linn. Swan, Sanwak (General) ; Bara swank (Multan) ; Bharti (Hissar). It is a coarse annual grass largely cultivated in the

Punjab as a rainy season crop. It is a rapid grower and its grain is consumed by the poor people. This grass is very much similar to Panicum colonum but is comparatively coarser. It makes good fodder and in U. S. A., it is much valued under the name of 'Barn-yard Grass.' It is greedily eaten by horses and cattle and makes a good hay.

22. *Panicum flavidum, Retz.* Kangna (Kangra): Palon (Patiala) : Bharti (East Punjab). An annual grass common throughout the plains. It is considered to be a good grass both for horses and cattle. It produces a large quantity of grain which is collected and eaten by the poor people. It is extensively fed to birds.

23. *Panicum helopus, Trin.* Kuri or Kuriya (Punjab) ; Thun (Kangra). It is an excellent fodder grass both for grazing and stacking. Both cattle and horses do well on it. It is generally seen in cultivated lands. It grows rapidly and makes good silage.

24. *Panicum jumentorum.* Guinea Grass of Tropical Africa. It is a perennial grass with tall stems and broad and flat leaves. It is really a native of South Africa, but is now also cultivated in U. P., Punjab and South India. It is said to be very rich in nutritive qualities. Its cultivation should be encouraged all over India. It is capable of yielding 7 to 10 cuttings a year, each 8 to 12 feet tall and averaging to about 250 maunds per acre, provided the land is well irrigated and manured. Guinea grass is suitable for all kinds of stock. It is said that it disturbs the digestive organs in certain animals, but this is only a temporary effect. It is a

quick growing grass, free from pests and fungus diseases, and yields the largest quantity of grass in a given time from a given area. It is least expensive to grow and once it takes roots it hardly needs any attention. Even weeding is not necessary. In addition it is a hardy and drought-resisting fodder plant.

25. *Panicum, miliare, Lamk.* Chin (Hissar). It is an annual grass not uncommon in plains. It generally grows in the fields and is said to be very good for grazing and stacking.

26. *Panicum sanguinale, Lamk.* Dobra (Simla Hills) ; Bara Takria (Hissar). It is one of the very good fodder grasses which is good for grazing and stacking. This grass is highly prized in Rajputana. It is a rapid grower and makes good silage. Horses thrive as well on it as on *Dub.*

27. *Saccharum spontaneum, Linn.* Kanah (Punjab). A perennial grass with extensively creeping roots which are very difficult to eradicate. It generally grows in damp soils. Buffaloes and elephants eat it when young and tender. In Jhang and Muzaffargarh Districts it is considered to be a useful grass. It is certainly very valuable for thatchwork. In many parts of the Punjab where better grasses are available this is seldom used.

28. *Setaria glauca, Beauv.* Bandra or Bandri (General) ; Ban Kangni (Central and East Punjab). An annual grass common in the Punjab plains and along the water courses. The *Zemindars* in the Punjab do not recognise it as a grass but it is fairly good for fodder. It is, however, not good for

hay making. In U. S. A., it is called ' Pigeon or Bottle Grass. '

29. Setaria verticillata, Beauv. Chirchira (Hissar). A coarse annual grass common in shady places, along the canals and in the rich soils. It is not reckoned among the useful grasses and cattle eat it before the flowering spikes appear. The grain is fairly big and is eaten by the poorer people in the south eastern parts of the Punjab.

30. Sporobolus orientalis, Kunth. Kheo (South Punjab) ; Tandua (Kangra) ; Harnak (Hissar). It is a perennial grass confined to saline soils. It is good for grazing and stacking. Horses are said to do particularly well on it.

31. Sporobolus pallidus, Nees. Palinji or Palonji (Hissar). This grass is not considered of any use for feeding purposes. It grows gregariously in sandy grounds and gives a fair grazing, but is not much good for hay making and stacking.

32. Sorghum halepense, Pers. Baru (Punjab) ; Johnson's Grass (U. S. A.) It is a tall perennial grass common about the cultivated lands and fields ; grows both in soft and hard soils. It is much grazed and is relished very much by the cattle. It will also stack to a certain extent, but decays soon when dry, and therefore, is short-lived. If this grass is grazed when very young, say when only 6 inches to one foot high before flowers have appeared, it is said to be poisonous to cattle sometimes with fatal results. Its seed is collected and mixed with *bajra* and eaten by the poor Bikaner people. In Gujrat, Shahpur and Gujranwala Districts it is said to be

poisonous until the rains are over, after which time cattle eat it with impunity. It is a fairly nutritious grass and yields large quantities of fodder. Due to this it is very much prized in America. It is good for making silage. This grass has self-propagating propensities by roots and seeding is tremendous; it soon ousts everything else in a field.

33. Tragus racemosa, Hall. Barchinti chhoti (Hissar). This grass grows commonly at Hissar, both on the Bir and in the cultivated land. It is also found in the Punjab plains and sandy soils. It is much too small to stack, but is fairly nutritious and is much grazed in the rains.

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LIST OF FODDER GRASSES OF THE PUNJAB OF VERY GOOD QUALITY.

1. Andropogon annulatus, Forsk. Andropogon pertusus, Wild. *Palwa* or *Palwan* (Punjab); *Jargi* (Hissar).

2. Cenchrus montanus, Nees. Cenchrus biflorus, Roxb. Pennisetum cenchroides, Rich. *Dhaman* or *Anjan* (Punjab).

3. Chloris tenella, Roxb. *Barchinti bari* (Hissar).

4. Cynodon dactylon, Pers. *Dub* (General); *Khubbar* or *Khubbal* (Central and Western Punjab); *Talla* or *Tilla* (Western Punjab).

5. Eleusine aegyptiaca, Pers. *Makra* (General); *Madhana* (Lahore, Shahpur, Gujranwala and Salt Range).

6. Eleusine flagellifera, Nees. *Ghantil* (South Punjab); *Chhimbar* (Punjab); Chhembri (Multan).

7. Eleusine scindica, Duthie. *Bhobra* (Hissar).

8. Panicum colonum, Linn. *Samak* (Hissar); *Swank* or *Sanwak* (Punjab).

9. Panicum crus-galli, Linn. *Swan*, *Sanwak* (General); *Bara Swank* (Multan); *Bharti* (Hissar).

10. Panicum flavidum, Retz. *Kangna* (Kangra); *Palon* (Patiala); *Bharti* (East Punjab).

11. Panicum helopus, Trin. *Kuri* or *Kuriya* (Punjab); *Thun* (Kangra).

12. Panicum jumentorum. Guinea grass of Tropical Africa.

13. Panicum miliare, Lamk. *Chin* (Hissar).

14. Panicum sanguinale, Lamk. *Dobra* (Simla Hills); *Bara Takria* (Hissar).

15. Sorghum halepense, Pers. *Baru* (Punjab); Johnson's Grass (U. S. A.)

* * * *

List of fodder grasses of the Punjab of average quality.

1. Eleusine verticillata, Roxb. *Jharna* (Hissar).

2. Elionurus hirsutus, Munro. *Sin* (Hissar).

3. Heteropogon contortus, R. & S. *Surwala* (Hissar); *Sariala* (Kangra, Salt Range and Gujranwala).

4. Iseilema laxum, Hack. *Gandhi* (Punjab); *Luinji* (Kangra); *Chhat* (Rawalpindi).

5. Setaria glauca, Beauv. *Bandra* or *Bandri* (General); *Ban Kangni* (Central and East Punjab).

6. Sporobolus orientalis, Kunth. *Kheo* (South Punjab); *Tandua* (Kangra); *Harnak* (Hissar).

7. Tragus racemosa, Hall. *Barchinti Chhoti* (Hissar).

* * * *

List of fodder grasses of the Punjab of poor quality.

1. Andropogon laniger, Desf. *Bur* (South Punjab) ; *Khawi* (Central and N. W. Punjab).

2. Andropogon muricatus, Retz. *Panni* (Punjab) ; *Khas khas* roots.

3. Andropogon schoenanthus. Linn. *Kauns* (Hissar); *Buj* (Punjab).

4. Aristida depressa, Retz. *Lamp* (Hissar) ; *Lam* (Punjab).

5. Cenchrus catharticus, Del. *Bhurat* (Hissar) ; *Leha* or *Aleha* (Ferozepur).

6. Chloris barbata, Swartz. *Ganni* (Hissar); *Chhota takria* (Hissar).

7. Melanocenchrus royleana, Nees.

8. Panicum antidotale, Retz. *Ghirri* or *Ghamur* (Hissar) ; *Ghamrur* (Simla and Kangra) ; *Gharam* (N. W. F. Province).

9. Saccharum spontaneum, Linn. *Kanah* (Punjab).

10. Setaria verticillata, Beauv. *Chirchira* (Hissar).

11. Sporobolus pallidus, Nees. *Palinji* or *Palonji* (Hissar).

* * *

Maize. Maize is a very valuable fodder crop which returns heavy yield of green food. It is fairly nutritious when cut green, but after ripening and removal of cobs it gives fodder of very inferior quality. It can be made into silage. Green maize is succulent and fairly rich in water and poor in proteins. It contains about 5 per cent. of sugar which makes it specially palatable and is therefore readily

consumed. Stalks of maize should better be given cut up into smaller pieces.

Maize grains are hard and flinty, and should always be given crushed, ground or boiled. It is very useful for fattening stock. The grains have low protein and mineral content. They are specially deficient in lime and phosphates. When feeding maize grains these factors should always be borne in mind and an attempt should be made to overcome these deficiencies by mixing it with other highly nitrogenous foods rich in mineral matter.

Jawar. Jawar is a very important fodder crop in India, and is fed both in the green and dry conditions. It is most nourishing when cut and fed in flower. Very young *jawar* plants are dangerous to be given to cattle because of their poisonous effects, and should therefore be kept away from them. Good fodder *jawar* has thin stalks. To prevent wastage through tossing about of the food it should be cut into smaller pieces. Whole *jawar* stalks (*karbi*) are far too coarse for feeding. The use of chaff-cutters in the country is becoming more and more popular. It needs further encouragement. *Jawar* grains are also at times given to cattle. It makes good silage. Now-a-days, *jawar* is almost exclusively grown for fodder, '*charri*', and is generally mixed with *guara*.

Bajra. *Bajra karbi* is inferior to *jawar* stalks and is fed to cattle when other fodder is rather scarce. Its grain is often crushed and boiled with water to make a mash. *Gur* is often added to this mash. *Bajra* and *jawar* mashes prepared in this way are considered very useful for milch cattle. It makes good silage.

Oats, wheat and barley. Green oats, wheat and barley are important *rabi* green crops. They yield a fair amount of fodder, but given alone, they do not furnish enough of nourishment. They are best fed in mixture with some leguminous crops like lucerne or clovers. These crops are primarily meant for grain production and often ripen quickly. They yield green fodder only for a limited period when plants are young and luxuriant in vegetative growth. The crop is then partially topped and given to cattle.

Lucerne, Clovers, Shaftal, Chiral, Senji, etc. These are leguminous crops. They are very valuable and exceptionally good roughages for cattle, being rich in digestible crude proteins and mineral matter. Lucerne yields as many as ten cuttings in a year if it is properly looked after and manured, thus producing an immense amount of fodder for small acreage. Further, it leaves the land much richer in nitrogen than when it was sown. Both lucerne and clovers can be used green, made into hay or turned into silage. During the first year, lucerne is not a strong grower, but once established, it will produce large quantities of fodder year after year with only little attention. Clovers have to be grown afresh every year. Leguminous plants are generally very palatable and cattle eat them with great relish. They are, however, specially useful for balancing other cereal fodders with which they should be fed mixed in reasonable amounts. Growing calves and cows in poor condition and of low producing powers do very well on them, the latter beginning to produce more milk. Hay made from lucerne and clovers is also valuable for milch cattle, but it is liable to be dusty and

wasteful. The daily allowance of these crops should not exceed 8 to 12 lbs. per cow. Freshly cut plants, if fed too soon, are liable to cause tympanites and other digestive troubles in cattle and may even impart their peculiar flavour to milk. It is, therefore, advisable to feed the plants cut in the evening with the morning feed and those cut in the morning with the evening ration. The plants are most nutritious at the beginning of the flowering time, when they should be cut to obtain the maximum nutriment out of them.

Other leguminous crops like *shaftal senji*, *chiral*, etc., are also useful and rich in proteins and mineral matter. They should be given only in small amounts mixed with other fodder. *Chiral* is liable to become woody soon and should, therefore, be cut and fed before it is too much ripened.

Straws and Chaffs (Prali and Bhoosa) of Rice, Wheat, Barley, Oats.

Straws are dried stems and leaves left after the full ripening and removal of the seeds from plants. They mostly consist of indigestible lignified fibre, a variable amount of soluble carbohydrates and very little of proteins and fats. All straws are coarse and bulky containing very little of nourishing ingredients. Their mineral content is high but it is poor in calcium and phosphorus.

When reduced to small pieces, about one inch to two inches in length, either by machine-cutting or by being threshed under the feet of cattle, straws form *bhoosa* or chaff. Wheat and barley chaffs are very largely used in India as bulky fodders both for milch and working cattle, more especially when

green fodder is scarce. Oat *bhoosa* is seldom seen as most of the plants are consumed while green. Their low nutritive value is largely responsible for the poor condition of cattle in the country. Cereal *bhoosa* when mixed with *missa* or leguminous *bhoosa* from grams, peas, etc., however, obtains better nutritive properties than when fed alone. Another better way of using chaff is to mix it with other green succulent foods.

Good *bhoosa* should be clean, free from dust, dirt and mouldiness, and of a golden yellow colour. The quality of *bhoosa* is very materially lowered if it is stored in damp places or when it is attacked by parasites.

Whole straw should not be fed as it causes many digestive troubles. Straws are most useful for bedding purposes.

* * * *

B. Food Grains.

Food grains constitute a very important group of food-stuffs, being mostly concentrated with respect to their energy-producing values. They are numerous and their composition varies within very wide limits. The kind of the grain, its condition of ripeness at the time of harvesting, the soil on which it has grown, the way it has been saved, stored and prepared for feeding, are the principal factors which determine the nutritive values of the food grains. Grains are usually either coarsely ground, crushed or soaked in water before feeding. Before purchasing the food-grains for feeding cattle one should carefully see that the grains are sound, clean, uniform and free from parasites or pieces of small

stones or other impurities.

For the sake of convenience the food-grains may be divided into three classes: cereal grains, leguminous grains and oil-seeds according to their feeding characteristics.

1. Cereal Grains. This class includes oats, wheat, barley, maize, *bajra*, *jawar*, etc. They are all rich in carbohydrates (about 60 per cent.) and poor in proteins and fats. The amount of fibre in them varies because of the varying amounts of husk attached to the grains. Some of the so-called 'naked' seeds like wheat and maize have only a small proportion of fibre, while oats, barley, millets etc., are fed along with their adherent husks, and therefore contain a comparatively large amount of fibre. Further, nearly all the cereal grains are deficient in lime, and this factor must be duly corrected when feeding them to growing calves or high producing milch cattle. This point is very sadly overlooked by the Indian cattle owners in their feeding practices.

Oats (Jawi). Oats are comparatively of recent introduction into India, but are gaining popularity with respect to their feeding value for domestic animals. They are specially suited to horses but for cattle also they constitute a very safe grain food. Indian oats contain a comparatively higher proportion of husk than the English oats, but this fact aids mechanically in producing beneficial effects on the digestive tract of the herbivores. Good oats should be uniform in size, plump, firm and bright in colour. Dull colour indicates weathering. Newly-harvested oats must be fed with caution specially when damp. otherwise digestive troubles may arise. Mouldy and

musty oats are risky to use. For dairy cows oats make an excellent grain ration, but in our country they are rather expensive. Crushed and ground oats with crushed linseed are specially useful for feeding calves. For cows in poor condition oats mixed with other concentrates help well in starting them to put on fat. Oat grains are not extensively met with in the Indian markets since most of the oats grown in the country are consumed in the green stage.

Wheat (Kanak, Gandam.) There are many varieties of wheat met with in our country, but a great bulk of the wheat crops is used for human food and it is only the inferior and damaged grains that are retained with the farmers for feeding their cattle. Under ordinary circumstances wheat is seldom fed to cattle. Probably its price prohibits its general use for that purpose. Wheat grains are greatly relished by cattle and they often engorge themselves with them when opportunity arises. The grains swell up in the digestive tract, become sticky and thus cause trouble. Wheat should only be given in small quantities and cautiously if fed to cattle at all. One of its very useful products for cattle feeding is bran.

Barley (Jau.) Barley grains have a coarse husk, and when cheap should be prepared either by crushing or parching before feeding to cattle. They are useful specially in summer in conjunction with grams. Barley meal is very palatable and its nutritive properties rank intermediate between wheat and oats, being richer in carbohydrates than the latter. It is a good heat-producing and fattening food. When fed to cows it should be given mixed with

other foods. From barley grains beer is brewed and this industry leaves the so-called 'brewer's grains' as a by-product which are very useful for feeding milch cattle.

Maize (Makai.) Like wheat it is very rich in carbohydrates. It is richer in fats than wheat. Like barley it is a good heat-producing and fattening grain, and is, therefore, useful for feeding growing animals. For milch cattle it requires balancing with other foods rich in proteins and lime. In the form of maize-meal it is a favourite food for calves and milch cows. It, however, tends to soften butter if fed too much.

2. Leguminous Seeds. Grams, *massar*, *mash*, *mung*, *koolthi*, peas, beans, etc., are all leguminous seeds, but amongst them grams are most important in connection with the feeding of domestic animals. As a class they are richer in proteins and poorer in carbohydrates. They are, further, rich in mineral matter, specially phosphates. Generally speaking, leguminous seeds tend to cause distension and constipation if fed too much and improperly prepared. They are far too heating if fed alone. They are most advantageously given mixed with other food-stuffs like bran, crushed barley, etc., in proper proportions. Leguminous seeds are very useful for growing calves and milch cows. In Northern India grams form the principal grain food for cattle and horses. Its daily allowance for cows need not exceed 4 to 6 lbs., which may further be supplemented by other grains or products. The seeds used must be well ripened. In fresh condition they are liable to cause digestive disorders with diarrhoea and evil-smelling faeces. The grain should be given crushed or bruised and moistened.

3. Oil Seeds. All oil-seeds are very rich in oil (fats). The principal amongst them are mustard, rape, *torea*, linseed, cotton-seed, sesame, groundnuts, etc. Due to their high price they are seldom fed to the animals excepting linseed and cotton-seed. Primarily they are important for oil extraction, but the residues or cakes left after the expression of most of the oil in the seeds are very extensively used for feeding animals. Oil-seeds and the cakes prepared from them are rich in fats, proteins and mineral matter, and therefore, are much prized for feeding calves and milch cows.

Linseed (Alsi.) Linseed is fed crushed to calves generally and occasionally to cows. The seeds have a hard, smooth, chocolate coloured exterior, and if fed whole they are liable to pass out in the faeces unacted upon and undigested. Linseed meal has a sedative action on the bowels and is used extensively for sickly and debilitated animals. In the rearing of calves it is fed by making it into a jelly by crushing and mixing it in warm water. It is desirable to mix with it starchy foods to reduce its laxative properties to a certain extent.

Cottonseed (Binole.) Cottonseed is fed extensively in India to milch cattle after simply being soaked or boiled in water for a variable length of time. This is a wasteful process. The seed coats are very hard and fibrous and are difficult to digest. It should be thoroughly crushed before soaking or boiling and feeding. Feeding milch cattle on cotton-seed tends to increase the hardness of butter. Its use is specially recommended for buffaloes.

* * * *

C. Roots.

This group of foodstuffs includes turnips, carrots, mangels, swedes, potatoes, artichokes, etc., but only turnips and carrots are important in the feeding of cattle in India. Their water content is high, being roughly from 80 to 90 per cent., and this imparts succulent properties to roots. The dry matter in them is rich in carbohydrates and poor in proteins, fibre and mineral matter. Their digestibility of dry matter is high. Roots are specially useful for milch cattle during winter months when green fodder is scanty. They are palatable and also provide vitamins. Both turnips and carrots should be fed sliced, chopped or mashed, otherwise they are liable to get stuck and cause choking. The daily allowance of carrots to cows need not be more than 5 lbs. per head, but turnips may be given much more. Turnips should only be fed as a subsidiary food to milch cattle and no more than 20 to 30 lbs. should be allowed daily, otherwise milk and butter will acquire an objectionable turnippy odour. They should be better given after milking the cows and when the milk has been removed to the dairy proper. Generally speaking, they have a laxative effect and aid in the stimulation of milk production, but they should always be given in moderation.

Many farmers experience trouble with their cows in winter when no roots have been fed. They often do not come in season until spring, and so a lot of time is lost. When roots are fed the animals are kept in a good breeding condition all the year round, and this applies especially to winter when the cattle are stall-fed and housed for most part of

the day. Roots also possess a cooling effect on the digestive organs, helping to prevent digestive trouble when cows are fed on all the rich concentrates they wlll consume.

Some people imagine that roots should not be grown as a winter food adjunct for cattle because they contain 80 to 90 per cent. of water. This is all a twaddle ; we eat oranges or other fruits knowing perfectly well that they contain even more than 90 per cent. of water. It is what is contained in the water which makes all the difference. The cultivation of roots is a phase of agriculture which should not be neglected. They must be grown, first of all as a rotation crop, and secondly, as a really valuable, cheap succulent food, especially for winter and early spring consumption.

* * * *

D. By-Products of Industries.

The most important industries the by-products of which are utilised for animal feeding are milling, oil extraction, brewing,, etc. There are numerous useful by-products, but bran, oil cakes, brewers grains, etc. are some of the most commonly used products in India.

Bran (Chokar.) Bran consists of the outer coats of wheat grains left after milling. It contains a high proportion of proteins and fibre. The amount of carbohydrates in it varies with different samples according to the efficiency of the process of milling. Bran is also rich in minerals, especially phosphorus but it is poor in lime. It is a very useful light and bulky food. It is palatable and possesses laxative

properties due to its mechanical effects on the digestive tract. For cows in delicate and poor condition bran is best given in the form of mashes. Bran greatly helps the digestibility of other concentrated foodstuffs with which it may be given. Good bran should be light, clean and flaky with a pleasant fresh smell. Wet, mouldy and lumpy bran with sand, saw-dust, small pieces of stone, etc., is a useless and risky food.

Oil-cakes (Khali.) The commonest oil-cakes used in India for cattle feeding are those prepared by the expression of a variable amount of oil from linseed, mustard, rape, *sarson*, sesame, ground-nuts, cocoanuts, etc. They are rich in fats, proteins and mineral matter. Linseed, sesame, *sarson* and ground-nut cakes are the best. They possess a sedative and laxative effects. For dairy cows and growing calves they are highly prized because of their high feeding value and palatability. Rape and mustard cakes are pungent, and therefore, should be given only in small amounts and mixed with other foodstuffs. Oil-cakes are specially useful for feeding milch buffaloes in winter. They are often hard, and should be broken up into smaller pieces and soaked in water for sometime before feeding. The common custom in India is to soak oilcakes with other concentrates overnight. In summer this is liable to bring about a certain amount of fermentation which some cows do not like.

* * * *

E. Foods of Animal Origin.

The foods derived from animals for the feeding of cattle include bone-meal, meat and bone-flour,

blood meal, fish meal, etc., etc. Such foodstuffs are becoming more and more popular in the Western countries, but in India their use is practically unknown.

METHOD OF MILKING IN THE TIME OF ABRAHAM.

This photograph is of the Inlay Frieze of the Temple of Tell El Obeid, ruins of which have been found on the site of Ur in Babylonia. On the right it shows the method of milking some 5,400 years back when the milker seated himself under the tail of the cow. On the left of the Frieze is given some ancient method of separating cream.

It may be of interest to know that the Temple from which this Frieze was taken was built in honour of the goddess Nin-Khursag, by one A-an-ni-pad-da, who was the second of First Dynasty of Ur, known in the Bible as "Ur of the Chaldees," from whence Abraham sallied forth. (*From the Alfa-Laval Co., Ltd., London.*)

Frontispiece to Part III.

PART III.

THE ART OF MILKING.

PART III.

THE ART OF MILKING.

1. General.

Few, if any, of the operations in the daily routine of the dairy farm have undergone so little change throughout the centuries as the hand-milking of cows. It is unique in its primitiveness, but the act of milking would be more efficiently carried out if the milker possesses some modern knowledge about the work he does.

In India the situation is very disappointing. The old-fashioned *Gujjars* have been at a crude kind of dairy business for generations together, and have become used to the antiquated and dirty methods so much that they refuse to learn anything new and beneficial. Any progressive person, on the other hand, would always be alert and eager to learn modern and up-to-date methods and note the principles pursued by others, and if beneficial, follow in their footsteps. Western nations have achieved marvellous improvements recently in the dairy industry by the practical application of scientific research; they are always alive to any new beneficial ideas. It is high time for our dairy-men to benefit by their example and experience.

It is possible for one to lose money in dairy business or even when one or two animals are kept purely for private home necessities. Unless the process of milking is complete and conducted properly by an expert milker to obtain the maximum yield of milk from each cow every time of milking, money is

lost, not only for one particular season, but also for the succeeding seasons, and even in the progeny of the cows which do not develop to their fullest milking capacities.

From the owner's point of view the udder is the most important part of a cow's body. Its proper use develops it to a profitable production. Any misuse of the part would soon result in lowering the capacities of the animal and decreased income to the owner. The process of milking is the chief exertion on the udder and should, therefore, be paid due attention to. The author believes that the present day affections of the udder and teats so common in Indian milch animals are mostly due to the improper ways the animals are milked and kept. Some of the dangerous contagious diseases in man are also carried by dirty milkers or through milk drawn under unclean conditions. Thc right method of milking should be learnt from the calf and imitated so far possible. The calf must behave properly if it wants to get most of the milk, and not in a haphazard and brutal manner ; the expert milker should do the same.

* * * *

2. The Physiology of Lactation.

For the proper comprehension of the physiology of milk secretion, the art of milking cows and other facts and principles pertaining to milk hygiene in general, a thorough knowledge of the gross anatomy and histology of the mammary glands is indispensable. A short review of these, therefore, is first given.

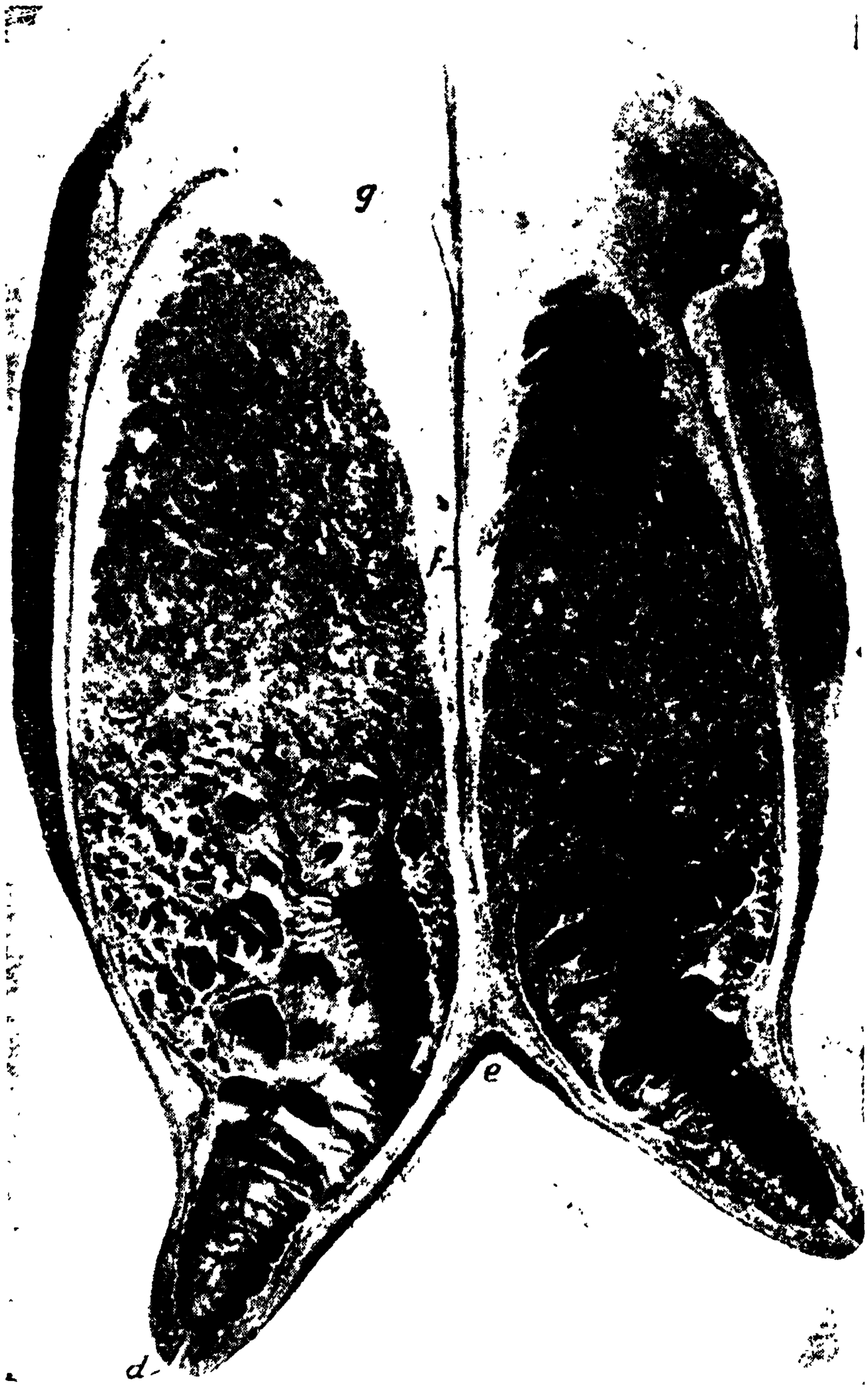

FIG. 1 CROSS-SECTION OF MAMMARY GLANDS OF COW.
(*After Sisson*)

a. Body of gland; *b*, milk cistern; *c*, cavity of teat; *d*, teat duct; *e*, intermammary groove; *f*, septum between left and right glands; *g*, supramammary fat.

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Gross Anatomy of the Udder. The mammary glands are characteristic of all mammals and are the seat of milk formation and secretion. They are present in both sexes, but, as a rule, in the male they do not develop to the stage of actual milk secretion as is the case in the female under normal conditions. Lactation in a few males has also been observed although it is essentially a physiological abnormality. A Malvi bullock was found by Idnani † to yield milk throughout the year from all the four rudimentary teats to the extent of two to four ounces daily at the Bombay Veterinary College.

It is customary to regard the udder in cows as consisting of four glandular masses or 'quarters', although there is no visible septum between the two quarters of the same side. Really speaking the glands are only two in number, (Fig. 1) the right and the left ones, each consisting of the so-called two quarters, the anterior and the posterior ones. Each one of these four quarters is provided with a well-developed teat averaging about three inches in length. The glands are more or less spongy organs consisting of skin, muscles, nerves, arteries, veins, lymphatics, milk ducts, secreting glandular parenchyma, fat and connective tissue.

The mammæ are racemose glands consisting of a large number of alveoli or acini arranged in lobules or bunches (Fig. 2) held together by connective tissue and surrounded by a net-work of minute blood-vessels or capillaries. The alveoli of each lobule communicate with a common duct, which after emerging from the lobule, continues its course

† Idnani, H. A., Agri. Journ. India. Vol. XIX. 1923, p. 320.

in the interlobular connective tissue towards the milk cistern. The ducts from the several lobules unite to form the larger milk canals, which in turn,

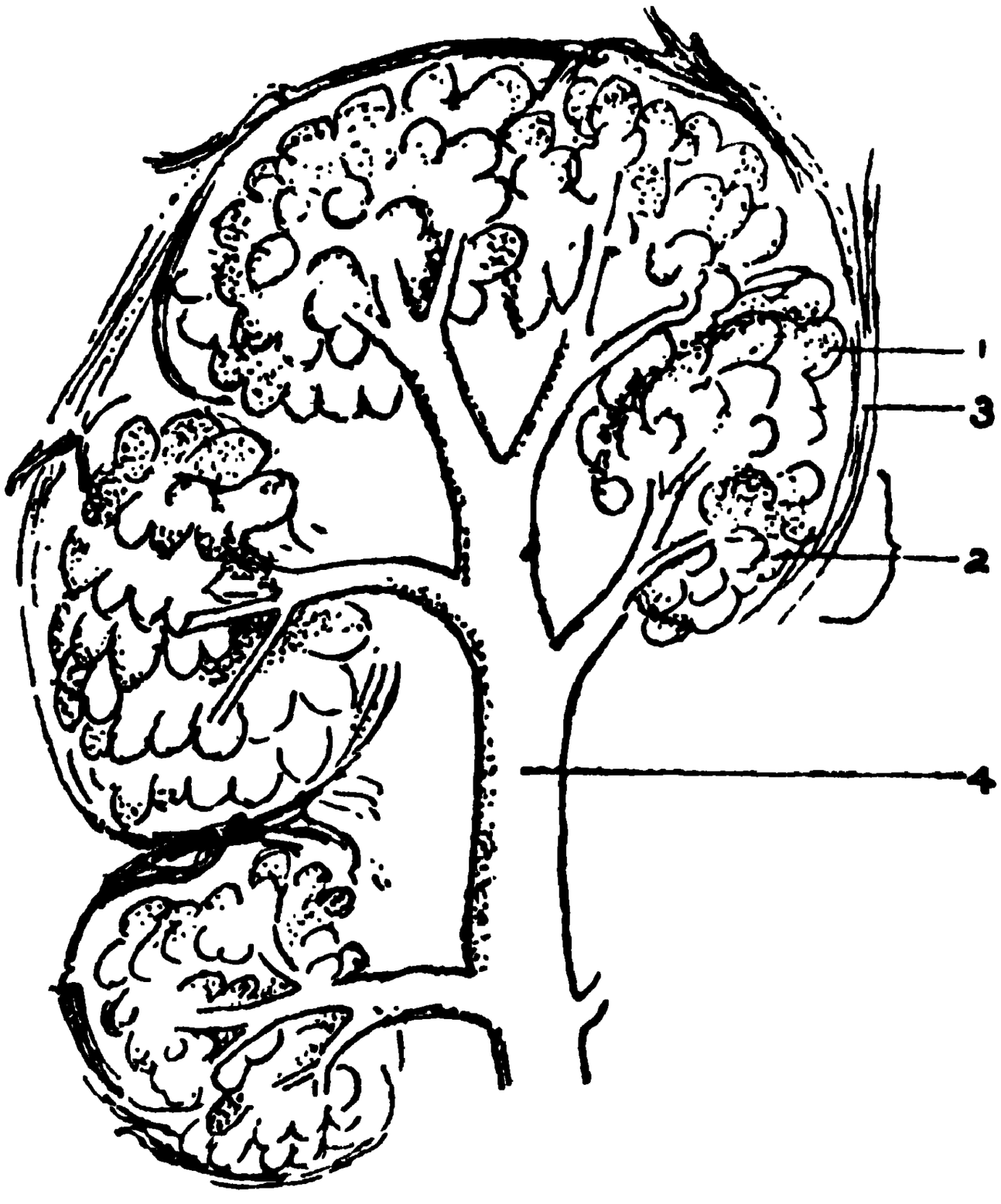

Fig. 2. HIGHLY DIAGRAMMATIC REPRESENTATION OF A PORTION OF MAMMARY GLAND.

1, An alveolus; 2, a lobule; 3, Connective tissue; 4, duct.

finally empty themselves into the milk cistern. The milk cistern is greatly dilated in its upper part and constricted in its lower part. From the constricted bottom of this milk cistern a single short narrow canal, called the *teat canal*, extends through the lower end of the teat to the exterior. The lower part of the teat canal is closed by a sphincture or gripping muscle, over which the cow has no control.

Taking the same the other way about, each teat has a single excretory canal which widens superiorly and opens into a capacious milk cistern. In this open the excretory ducts originating from the lobules which are made up of a group of acini and cul de sacs. The skin covering the udder is fine, slightly hairy and extends backwards and upwards into the escutcheon or the so-called 'milk mirror.'

The size and form of the udder varies greatly in different breeds and individuals. In certain heavy milkers it may attain enormous dimensions, but the size is not necessarily a sure sign of the animal's productivity, since in certain so-called ' fleshy ' udders there is relatively a larger amount of interstitial connective tissue and less of the milk secreting parenchyma resulting in comparatively a less yield of milk.

As the formation and secretion of milk takes place in the udder, a well formed udder is an important point in a milking cow. It should be even, rectangular in shape and wide, extending back and well up between the thighs. When empty, it should be soft and flexible to the touch, rather than firm and meaty. The teats should be even in size, an equal distance apart and hanging straight down. Defective udders may be pendulous or pear-shaped or may lack one or more quarters. The skin covering such udders is often coarse and the hair long.

The arterial blood supply of the udder is derived from the branches of the external pudic artery. The veins form a circle at the base of the udder from which the blood is drained by the subcutaneous abdominal (the milk vein), the external pudic and

the perineal veins. The lymph vessels are numerous and enter the supra-mammary glands chiefly. The lymph thence passes to the lumbar glands and into the thoracic duct. The nerves originate from the inguinal nerves and the posterior mesenteric plexus of the sympathetic.

Histology of the Mammary Gland Tissue. As mentioned before, the glandular tissue of the mammae is made up of a number of lobules held together by fibrous connective tissue. These lobules resemble so many bunches of grapes. (Fig. 3.)

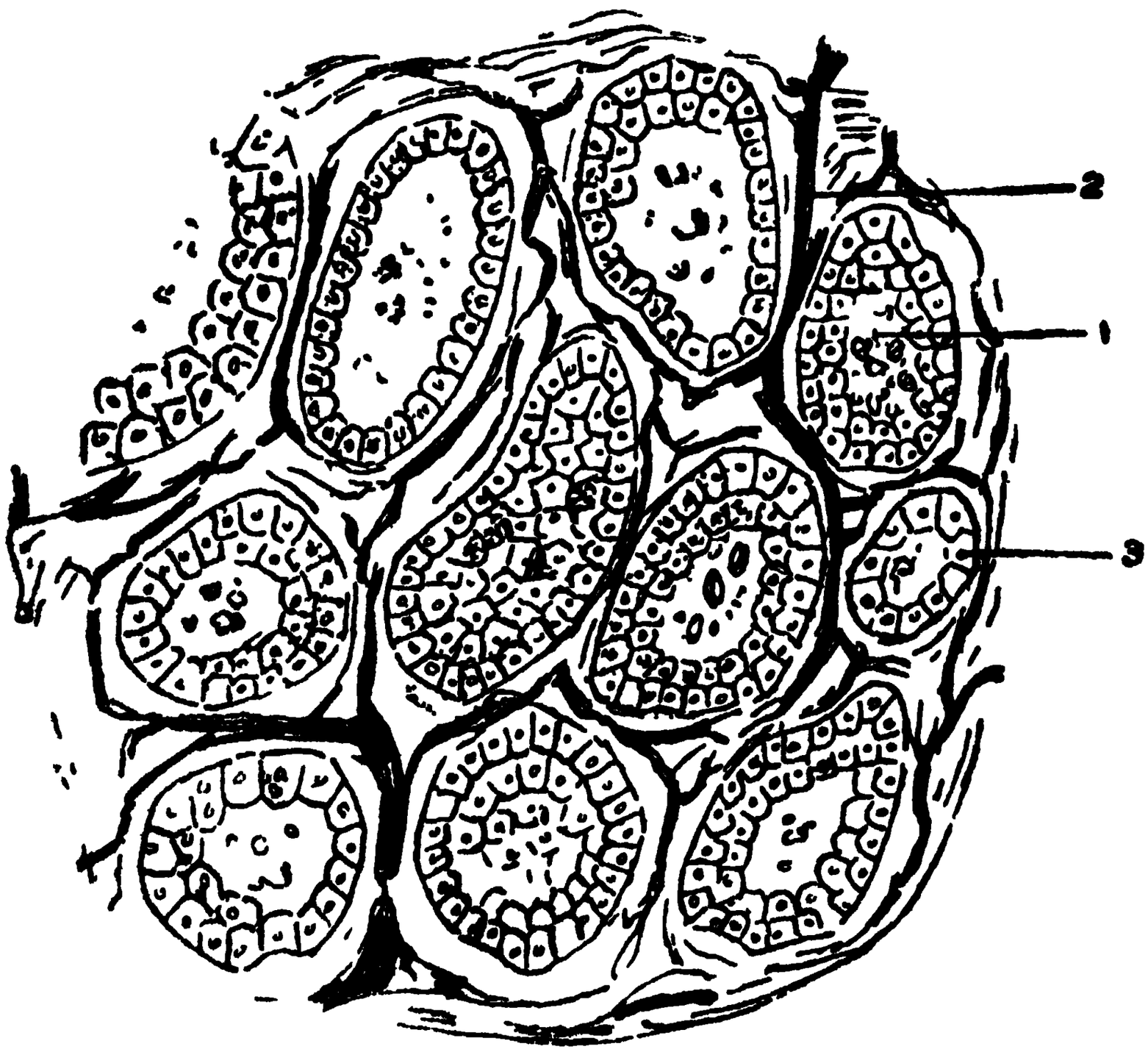

Fig. 3. TRANSVERSE SECTION OF A LOBULE.

1, An alveolus 2, inter-alveolar connective tissue;
3, glandular epithelial cells.

FIG. 4. TRANSVERSE SECTION OF A PORTION OF THREE ALVEOLI. (*After Grimmer*)

1, glandular epithelial cell; 2 its nucleus; 3 & 7, interalveolar connective tissue; 4, central cavity of an alveolus; 5, fat-droplets in the epithelial cells; 6, a white blood cell in an epithelial cell.

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Each lobule taken singly consists of excretory canals and secretory cul de sacs. The latter are rounded or pyriform, and consist of a very thin basement membrane of a hyaline structure and glandular epithelial cells covering this membrane. These cells are small, flattened and more or less oval in shape (Fig. 4), and are arranged in a single layer on the internal aspect of the basement membrane, and define a central cavity in which the secretion accumulates. The glandular cells possess a peculiar property of selecting from the circulating blood certain raw materials which they subsequently convert into substances which are found in milk. When these cells get filled up, their protoplasm contracts and the contents are discharged into the lumen of the alveolus—the central cavity. This process is repeated many times until in course of time these epithelial cells are worn out resulting in the stoppage of secretion. This change is called 'involution.' The involuted alveoli remain inactive until the next parturition when regeneration of the alveoli takes place. During this time the alveoli are increasingly getting inactive and the amount of milk secreted decreases. The cow then is said to be 'going dry' until the secretion of milk stops altogether when the cow is said to be 'dry.'

The milk secreted in the alveoli of a lobule is collected in a common duct which unites with others to form interlobular canals, and these, in their turn. unite to form larger canals going towards the cistern. Each of these canals is formed of a basement membrane thicker than that of the acini and a single layer of epithelial cells lining it. These cells have large nuclei which nearly fill the cells.

Secretion of Milk. The function of milk secretion is very closely related to the function of reproduction. The factors which, however, are responsible for the development and functional activity of the mammary gland have been much speculated upon and many theories with little or no scientific foundation have been propounded from time to time on the subject. The exact source of the stimuli causing mammary hypertrophy and development, and those initiating and responsible for the continuance of milk secretion still remains enshrouded in mystery.

Normally the alveoli (the true secreting tissue of the mammary glands) are not present in the virgin animal and do not develop unless the animal becomes pregnant. After first pregnancy the gland tissue is stimulated to active growth, and as a result, more alveoli lined by milk forming cells are formed. Late in the period of pregnancy, approaching parturition, there develops a scanty and imperfect secretion of fluid which later becomes colostrum or first milk drawn after delivery. Why the udder begins to secrete milk at this time is not exactly known; but it is obvious that it is a provision of Nature for the nourishment of the young animal. That the development is not stimulated through the central nervous system has been shown by the researches of Goltz and Ewald*, Ribbert† and Pfister‡, in which mammary glands that were severed from all possible nervous connections developed during pregnancy and secreted

*Goltz and Ewald : Pflugers Arch., vol. lviii, p. 362, 1896.
†Ribbert: Arch. f. Entwick. Mechanik, vol. vii, 1898.
‡Pfister: Beitrage Zur. Geb. und Gynak, vol. v, 1901.

milk on parturition. Starling and Lane-Clayton* have shown that an extract from the unborn rabbit injected subcutaneously in a young female rabbit that has never bred, produces an apparent development of milk glands, exactly as is seen as a result of normal pregnancy. This seems to prove that some influences from the body of the unborn young, probably chemical in nature, travel by way of the blood and lymph vessels and stimulate growth in the milk glands. C. Foa†, Biedl and Konigstein‡, and Aschner and Gregorin§, repeated Lane-Clayton and Starlings experiments and obtained similar results. Aschner and Gregorin, however, concluded that the placenta also produces a substance stimulating mammary growth. O. O. Felner‖ has obtained a marked growth of the mammary gland of a virgin rabbit and the formation of true glandular acini by the injection of placental extract, and consequently considers the placenta as the source of a mammary hormone. K. Basch$ transplanted the ovaries of a pregnant bitch into a young virgin dog and obtained two weeks later an increase in the size of the mammary gland, and in six weeks a marked hypertrophy of the same. Eight weeks after the transplantation, as a result of the injection of placental

*Lane-Clayton and Starling: Proc. Roy. Soc. London, vol. lxxvii-B, pp. 515-522.

†Foa, C. Arch. Fisiol., vol. v, 1908; Abs. in Centbl. Physiol. Vol. xxii, No. 23, pp. 741-750, 1908.

‡Biedl and Konigstein: Zeit. fur Exper. Path. und Ther Bd. viii, H. 2, pp. 1119, 1910; abs. Biedl Innere Sekretion, Zweite Aufgabe, T. 2, p. 245.

§Aschner and Gregorin: Arch. fur Gynak, Vol. xciv, 1911; abs. in Biedl Innere Sekretion.

‖Felner, O. O. Centr, fur Allgemein Path. und Path. Anat. Vol., xxiii, p. 673, 1912.

$Basch, K., Monster. f. Kenderheik., vol. viii, No. 9, 1909; abs. in Biedl Innere Sekretion.

extract, he obtained milk secretion. He, therefore, concludes that the ovaries are the source of growth promoting substances of the mammary glands and considers the placenta as the seat of a galactagogue hormone. Frank and Unger* by experimentation showed that the corpus luteum controls the growth of the mammary glands for both the first and last stage of its growth, and that the developing foetus is responsible for the maintenance of the corpus luteum during the latter part of the gestation period, and therefore, is indirectly responsible for the development of the mammary glands during this period.

Further, there are numerous instances in which young animals have been brought into lactation by being suckled and having the udder manipulated. In these it would seem that the mechanical stimulus was all that was required to cause sufficient growth of the mammary gland to permit of milk secretion. Ruben L. Hill† described the case of a suckling doe-kid which spontaneously commenced to secrete milk without having reached sexual maturity, and without udder manipulation or any other known stimulus to mammary growth involving the ovaries, corpora lutea, foetus or placenta, etc. It is possible that some other of the internal secreting glands have a prominent part in regulating the growth and secretory activity of the mammary glands. There is some evidence in favour of the theory that the pituitary body may function in this way.

*Frank and Unger; Proc. N. Y. Path. Soc., Ser. 2, nos. 1 and 2, 1911 ; Arch. Inter. Med., vol. vii, p. 812, 1911.

†Hill. L. Reuben—Journ. Dairy Science, Vol. II. No. 1. Jan. 1919, p. 19—27.

On actual parturition the udder does not secrete milk, but secretes a substance called *colostrum*. Its secretion may begin even a few days before the calf is born. It differs from milk materially in its composition and physical properties, and is specially suited for the nourishment of the newly-born calf for the first few days. It is yellowish, reddish yellow or brownish in colour; it is viscid, slimy and sticky. On standing it has a tendency to separate out in layers. It possesses a peculiar animal-like odour and saltish taste. It contains albumin and globulin in greater quantity than in milk. There is less casein and sugar, but it contains more mineral salts. The fat globules in it are larger in size than those in normal milk. It is easily digestible by the young animal, and acts as a laxative upon its bowels. This helps in the removal of meconium, the first excreta of the newly-born. To deny the newly-born calves a full and generous feed of this richly nitrogenous milk is liable to stunt the calves in their future growth. Colostrum coagulates on boiling. This fact is sometimes used as a rough test to determine whether or not milk has passed the colostrum stage. It is not considered a desirable food-stuff for human consumption. It is not injurious, however, but its odour and taste are obnoxious and its appearance rather unappetizing. If given to children, it is apt to produce diarrhoea, colic and other digestive disturbances. In India, after the first two days of parturition people use cow's colostrum for culinary purposes.

In about a week's time after parturition, the colostral secretion changes into normal milk. The quantity and quality of milk secreted depends upon

the hereditary peculiarities of the individual cow, her health before and after parturition, her food, the time she has been milking, the period of gestation, the condition of her nervous system and to a considerable extent upon the quantity of blood passing through the udder.

Although the mammary gland is one of the most important parts of a cow, its capacity at any one time, performance and the actual mechanism of the secretion of milk are none too well understood. By reference to the literature on the subject one finds that different investigators have held different views.

Curtis* states that the size of the udder is indicative of its capacity for milk production, just as the size of the barrel is indicative of the capacity for food consumption. Isaachsen,† on the contrary, in referring to cows producing 5 to 6 kilos of milk at one milking, says that "no udder contains so much". He continues by stating, "In our animals, the maximum capacity is about 3·5 kilos (about 7·75 lbs.) or a little more, and 2 to 2·5 kilos must be formed in these animals at the moment of milking." Marshall‡ refers to calculations showing that, "the udders of a cow could not contain the quantity of milk which can be obtained from them at one milking." According to Woods§ "The flow of milk

*Curtis, R. S. 1925. Fundamentals of Live Stock Judging and Selection. 3rd. Ed. Lea & Febiger. p. 29?.

†Isaachsen, Haakon. 1923. Proc. of the World's Dairy Congress. p. 1021.

‡Marshall, F. H. A., 1910. The Physiology of Reproduction. Longmans, Green & Co., p. 557.

§Woods, H. H. 1913. Milk & its Products. The Macmillan Co., 1913.

at the time of milking is usually much greater than the capacity of the milk cistern, but this is readily accounted for, as the irritation of the nerves causes the contraction of the wall of the glands and milk ducts." According to Scott*, "The reservoir or milk cistern seldom holds more than half a pint of milk. There is only one of these reservoirs in each quarter, so the volume of milk in the four cisterns is only 2 pints. This is the amount of milk which is to be found in the average dairy cow's udder at any one time. If you could look inside an udder just before milking time you would find the milk cistern and ducts distended with milk which, as I have already mentioned, would only be about one-half pint in each quarter." Gaines†, on the other hand, presents data showing that (*a*) the capacity of the mammary gland of the goat is greater than the volume of the milk drawn at one time; (*b*) the udder shrinks in volume during milking to nearly the same extent as the volume of the milk drawn; and (*c*) practically all the milk drawn is present as such in the gland at the beginning of milking.

Those contending that the capacity of the gland is decidedly too small to contain the quantity of milk secured at one milking, assume that milk secretion is greatly accelerated during the act of milking. Many of the exponents of this view claim that nearly all the milk, except approximately one-half pint contained in each cistern, is actually secreted while the milk is being drawn. Gaines and Woods, however, are of opinion that milk secretion is a

*Scott. L. P. 1925. The Ohio Jersey, 1925. p. 189.

†Gaines. W. L. 1915. Amer. Journ. Physiolo. xxxviii. 1915. p. 285-312.

continuous process. Woods contends that the manipulation of the teats and udder stimulates the nerves, causing a muscular contraction and expression of the milk. Gaines concludes that nursing or milking excites a reflex contraction of the gland and musculature with the consequent expression of milk. Swett* concludes by actual experimentation that (*a*) milk secretion is to a considerable extent a continuous process, (*b*) a large proportion of the milk secured at any milking is collected and stored within the gland before the milking process is commenced, and (*c*) the internal capacity of a lactating cow's udder appears to be greater than the volume of the milk secreted.

Further, regarding the secretion of milk Bitting† has outlined a theory supported by many that in the secretion of milk the water serum and salts are separated from the blood, and that a fatty degeneration of the cells lining the alveolar cavities produces the fat globules as the degeneration product and the casein as the undegenerated portion of the cells. In other words, the process of milk secretion may be regarded as a process of metabolism of the epithelial cells, which undergo decomposition and discharge the resulting products into the excretory ducts. Bertkau, on the contrary, stated that milk formation is a true secretory process and is in no manner associated with a total or even partial degeneration and necrosis of the secreting epithelium.

*Swett. W. W. Journ. of Dairy Science. U. S. A., Vol. X. No. 1. 1927.

† Bitting, A. W., 1902. 19th. Annual Report, Bureau of Animal Industry, U. S. A., Dept. Agri., p. 254-273.

Generally speaking, the removal of milk encourages further secretion of milk, while accumulation of milk in the udder induces stasis and discourages secretion. This means that pressure in the milk ducts and milk cavities checks the manufacture of milk, and as soon as the milk contained in the udder and therefore pressure upon the cells—is removed, secretion starts again. In other words, the pressure brake is released and the wheels begin to revolve again. The act of emptying the cow's udder and thus relieving pressure upon the milk producing cells. therefore, amounts to a natural stimulus of milk cell activity. Keeping this principle in view it is necessary that the milk should be removed at regular intervals and as completely as possible, if the maximum amount of yield is to be obtained from a cow.

Regarding the duration of lactation period, lactation ceases after a lapse of time, the actual duration varying in different individuals to a certain extent and in different species. In the wild animals, the period of lactation is usually short, being just long enough to allow the young to attain sufficient size; and, as soon as the young animal develops and begins to nibble and take increasing quantities of food the demand upon the mother decreases, and secretion gradually ceases under natural conditions. But in certain heavy milking dairy cows the function of the udder is greatly stimulated and developed by improved methods of breeding and feeding, and lactation may continue as long as two years if the cow does not come in calf again and provided the milk is regularly withdrawn. When, however, another pregnancy occurs during the period of

lactation, some influences from the mother's uterus, and, perhaps from other organs, naturally lead to changes in the composition of milk and normally the secretion lessens and ultimately stops before the next delivery. As a rule, the milk gets thicker, is of bitter animal-like taste and acquires an unpleasant odour. It is a good practice at this stage to give the animal rest and let her dry off gradually in order that she may recuperate her health before a new lactation period begins. This is done by reducing the animal's succulent food and gradually stopping milking. Periodical and careful emptying of the udder is necessary during this drying off period. In some animals, however, the natural tendency to marked changes in the composition of milk, and to stoppage of secretion toward the end of a succeeding pregnancy is not present, and lactation may continue from one parturition to another. Such examples of high type dairy cows are called 'persistent milkers.' Physiologically long continued milk production during pregnancy is an abnormal thing.

Secretion of milk may be interfered with in milch cows due to rough handling, noises, fright, sudden anxiety, strange milkers or from sore teats, etc. The cow is then said to 'draw the milk up,' or 'will not give down.' This drawing up of the milk due to such causes indicates an intimate relation between the cow's nervous system and the process of secretion, since the only possible connection between the noise, rough handling, etc., is by way of the nervous system.

As the cow advances in age some of the alveoli are not regenerated. With each lactation period

after the animal has passed its prime an increasing number remains permanently inactive and breaks down, thus diminishing gland tissue and increasing interstitial connective tissue. Finally in the case of very old cows the udder becomes firm and hard and may not secrete milk at all.

In England the ordinary dairy cows yield, on an average, about 600 gallons of milk per year. There are. however, many which give 1,000 gallons of milk annually. In 1922 the record cow was a non-pedigree Short-horn which yielded 26,145 lbs. of milk in 365 days (about 71·5 lbs. or about 35 seers of milk daily). Such cows, however, are only freaks and strange curiosities yielding quantity and no quality.

The table on the next page gives the average lactation periods and milk yields of some of the Indian breeds of cattle and buffaloes.

AVERAGE LACTATION PERIOD AND MILK YIELD OF INDIAN BREEDS OF CATTLE AND BUFFALOES.

(*After Kartar Singh.*)

	Breeds.	No. of Animals taken.	Locality.	Days in milk.	Days dry	Yield per lactation period.	Yield in lbs. per day for milk and dry periods.
Cows. Buffaloes	Jaffarabadi ...	6	Poona College dairy	353	188	4036	7·50
	Surti ...	83	Do.	323	162	3422	7·00
	Delhi ...	245	Rawalpindi.	291	178	3110	6·63
	Deccani ...	27	Poona.	303	210	2283	4·50
	Montgomery ...	135	Rawalpindi.	291	159	2775	6·17
	Sindhi ...	103	Poona.	357	77	2925	6·70
	Kankrej ...	115	Surat.	274	157	3083	7·84
	Gir ...	36	Poona.	278	120	2518	6·30
	Aden ...	15	Poona.	310	140	2118	4·70

3. The Art of Milking.

THE milking of cows is an art requiring skill and experience. The process should be conducted quietly, gently, quickly, cleanly, and completely without any pain or annoyance to the animal. A gentle and expert milker will not only draw a comparatively greater amount of milk from the udder than a rough and inexperienced person, but will do so with more comfort to the animal, who will stand pleased and quiet, placidly chewing her cud and letting down the milk copiously. It is no use spending a lot of money in getting good cows and devising scientific rations unless milking is efficient. A bad milker would do more harm by his clumsy and incorrect methods than an expert milker by neglecting scientific feeding. On the right and skilful performance of this operation depends to a considerable extent the success or otherwise of a dairy concern. It may be regarded as almost a key to the situation.

In India *Ahirs* or *Gawalas* for cows, and *Gujjars* for buffaloes, constitute a bulk of the class of professional milkers. They are brought up to this particular business from their youth and get well accustomed to their job. Unfortunately their absolute ignorance of hygienic principles and cleanliness, which is of paramount importance in the production, handling and distribution of milk, leads to the contamination of this Nature's most nourishing and perfect food and later tells badly on the general tone of public health. They do not realise the importance of keeping foreign matter like dirt, disease germs or other bacteria out of milk. They do not

know that milk, when warm, forms one of the best media for the growth and multiplication of germs, which when taken along with milk may prove to be a positive danger to public consuming it. On the one hand, underfed cattle are housed under notoriously insanitary conditions, and on the other, milkers have no conception of personal cleanliness, and conduct the milking operation without the slightest attempt at preventing contamination. They wear dirty greasy old clothes saturated with filth and dirt which may be rubbed against the animal's flanks during milking, introducing thereby a large number of evil bacteria into the milking utensils. They have a bad habit of washing their dirty fingers with the first few drops of milk to moisten their hands before milking; some may even spit on their fingers with the same object ; and it is not uncommon to see some of them spitting chewed beetle-leaves and tobacco on every side of them and blowing their noses between the fingers. Under these insanitary conditions they ' carry ' disease from one animal to another and play an important role in the spread of contagious diseases in man, such as, diphtheria, typhoid fever, cholera, sore-throat, etc. Taking these factors into consideration one cannot but be surprised that milk, so very widely drunk, still continues to be so carelessly produced, collected and distributed. A widespread propaganda to enlighten the public and professional milkers on lines of modern principles of cleanliness and general hygiene is imperative to get over the ill results of contaminated milk supply. Besides this, a pernicious practice of incorrect method of milking is prevalent (Fig. 5) especially among the Ahirs. They

Fig. 5. Wrong method of milking with the thumb doubled up inside the palm of the hand, exerting unequal pressure on the teat.

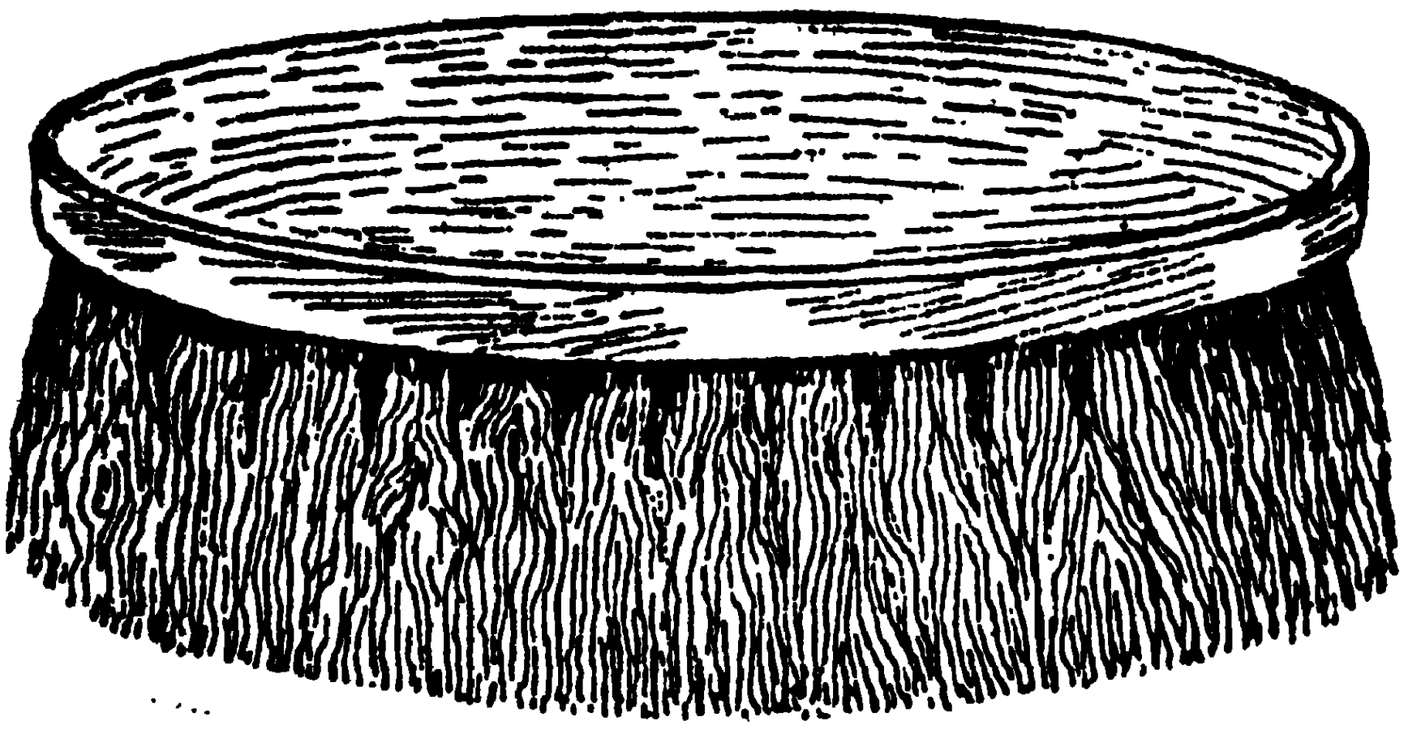
[*To face page 128.*]

grasp the teat with four fingers closing round it and work with the thumb doubled inside the palm of the hand, thus exerting heavier and unequal pressure at the point high up on the teat which often gets bruised or permanently injured. Sore teats and thickening of the milk duct at that point ultimately leading to complete obstruction or blocking of the outlet is not an infrequent result. This practice should be discountenanced and the right methods adopted.

An expert milker must know fully the preliminaries to actual milking, how to milk and when to milk. He must possess some knowledge of the internal structure of the udder, of the mode of milk formation and how the thoroughness of milking may be effected. It is necessary that no detail, however minute and seemingly unimportant, be left unattended tc.

To safeguard milk against pollution great care must be taken, and milking should be conducted under as clean and sanitary conditions as possible. The milking place should be absolutely clean and the floor on which the animal stands free from straw, litter or dung. If possible, thoroughly swill and wash the floor with clean water beforehand. Dry and dusty hay or other such foodstuffs should not be fed just previous to milking. Milk is very delicate and its flavour and keeping qualities are readily spoiled. It easily absorbs taints and odours. Scrupulous care should, therefore, be taken to prevent its pollution not merely by dust and dirt, but also from the smells and taints given off from dung heaps, rubbish and filth. These should not be

allowed to accumulate or remain near places where cows are milked. The cleaner the milk is kept, the longer it will keep sweet and wholesome.



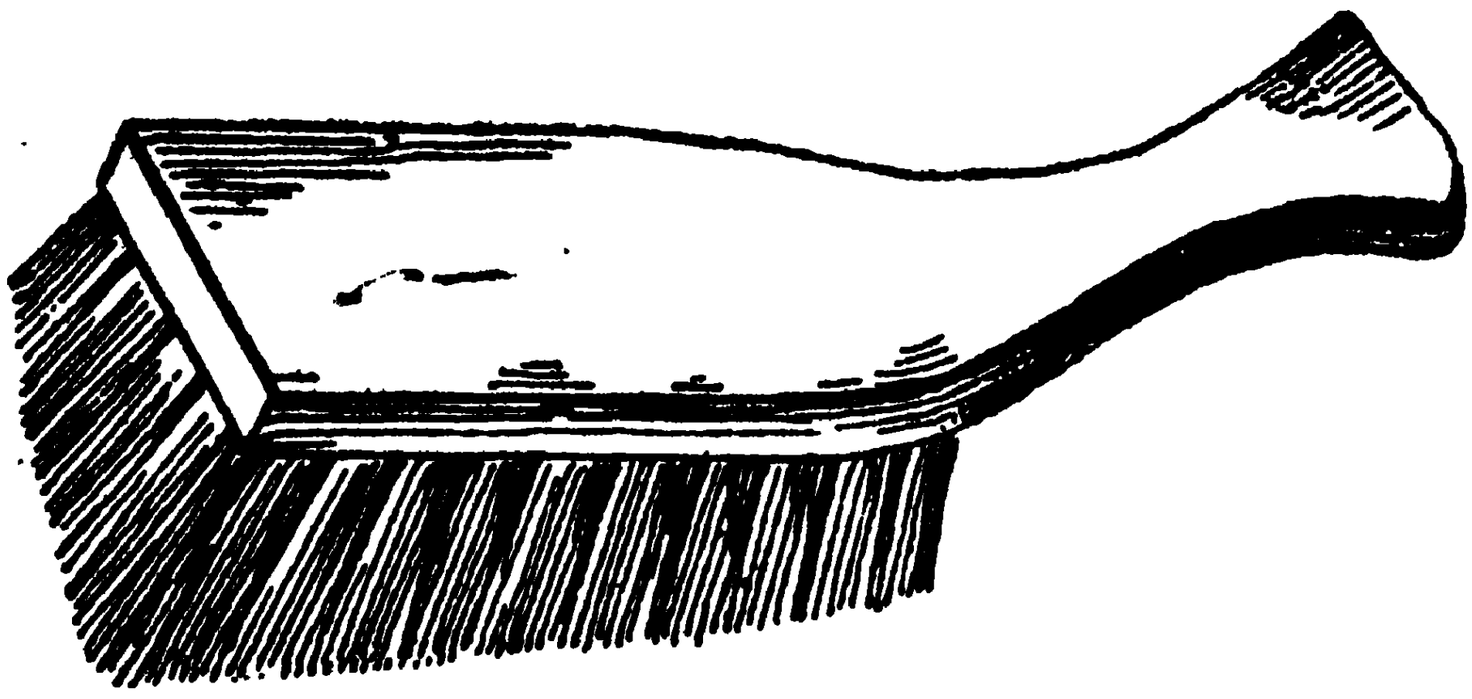


FIG. 7 BRUSHES FOR CLEANING THE FLANKS.

The milker should ensure that the animal to be milked is healthy and as clean as possible. If any swellings or lumps or tenderness in the udder, sores on the teats, or blocked milk channels are observed, or the milk looks unnatural, the owner or other responsible person should at once be informed and proper veterinary help sought. The tail, flanks,

the body in front of the udder and the udder itself should be clean. Any foreign matter of the nature of dirt, dung, dried mud, hair, crusts, etc., should be removed and the flanks washed down (Fig. 6) with a stiff brush (Fig. 7) as far as the tail reaches. The udder requires special attention. It must be well washed (Fig. 8), cleaned, and wiped dry with a clean dry cloth. The milker himself should wear clean clothes (Fig. 9) and wash his hands and arms

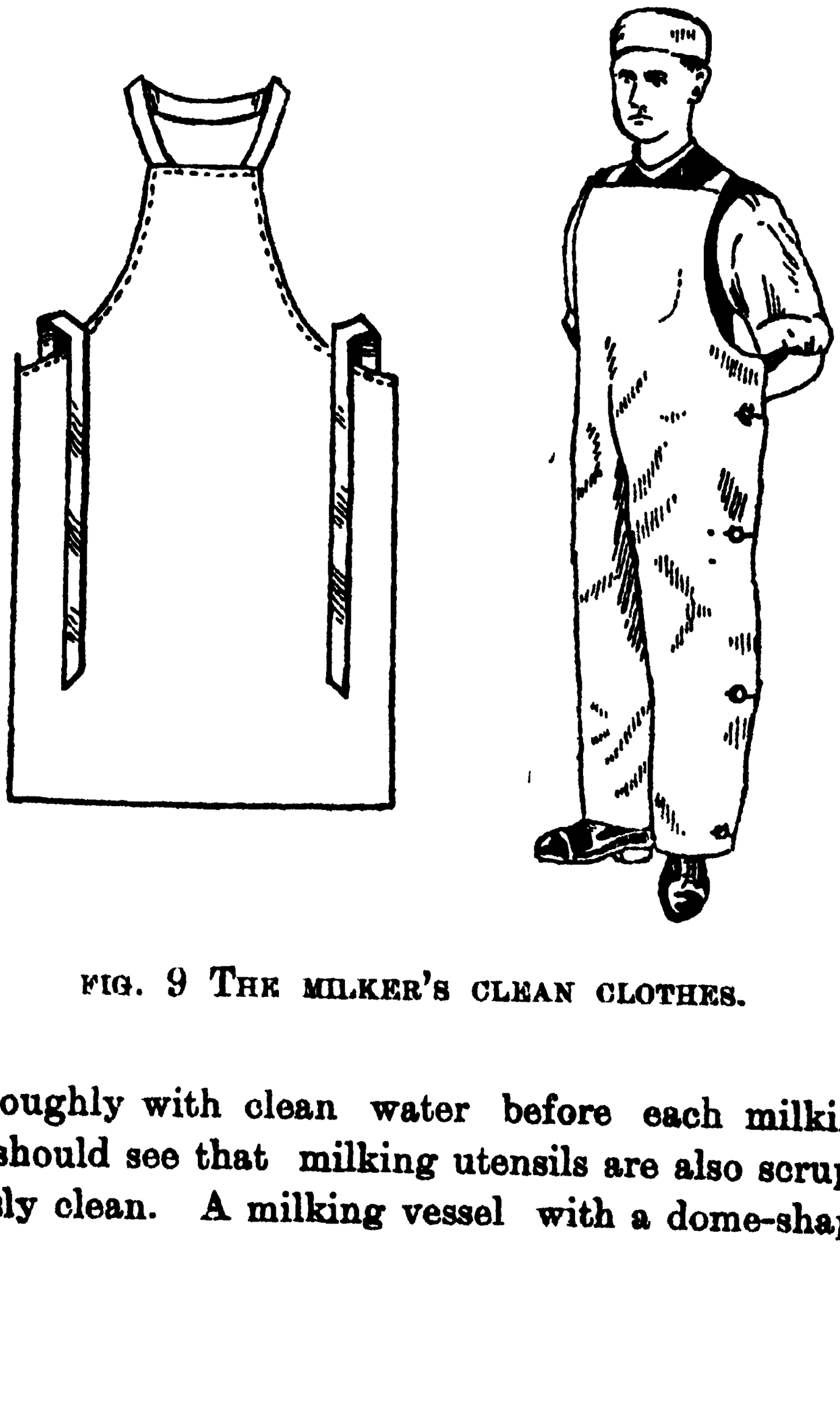


FIG. 9 THE MILKER'S CLEAN CLOTHES.

thoroughly with clean water before each milking. He should see that milking utensils are also scrupulously clean. A milking vessel with a dome-shaped

top (Fig. 10) and fitted with a filter cloth is preferable. The milking vessels chiefly used in India are of the types of *garwas* and *waltohies* (Fig. 11) or buckets. Both are insanitary to use. The former are difficult to clean and the latter expose a big area for the dust and dirt to gain entrance (Fig. 12). To ensure cleanliness of milk vessels, they should be scrubbed thoroughly first in hot water containing some soda and then scalded in boiling water. Lastly, they should be turned upside down or allowed to stand in an inclined position until needed. The

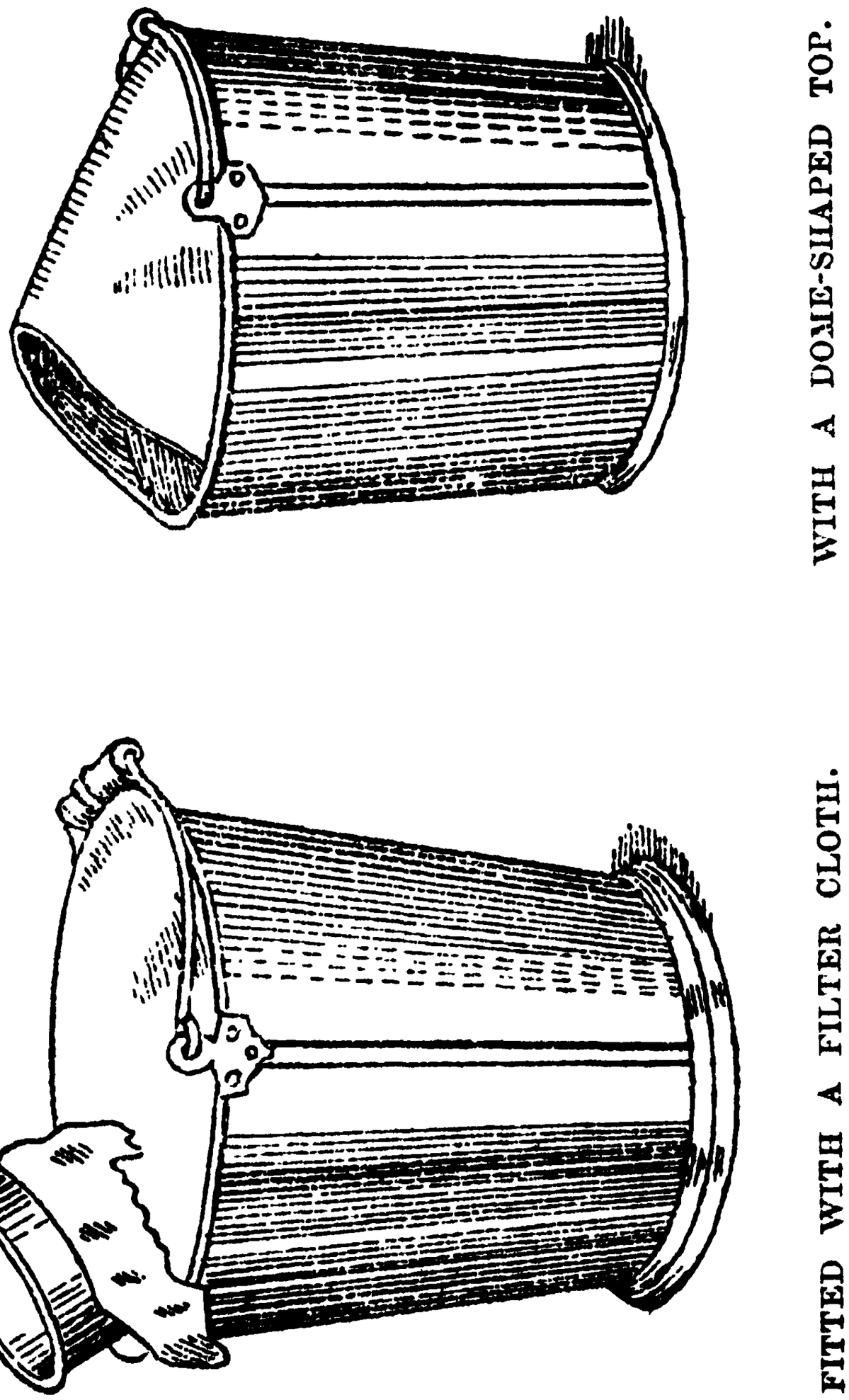
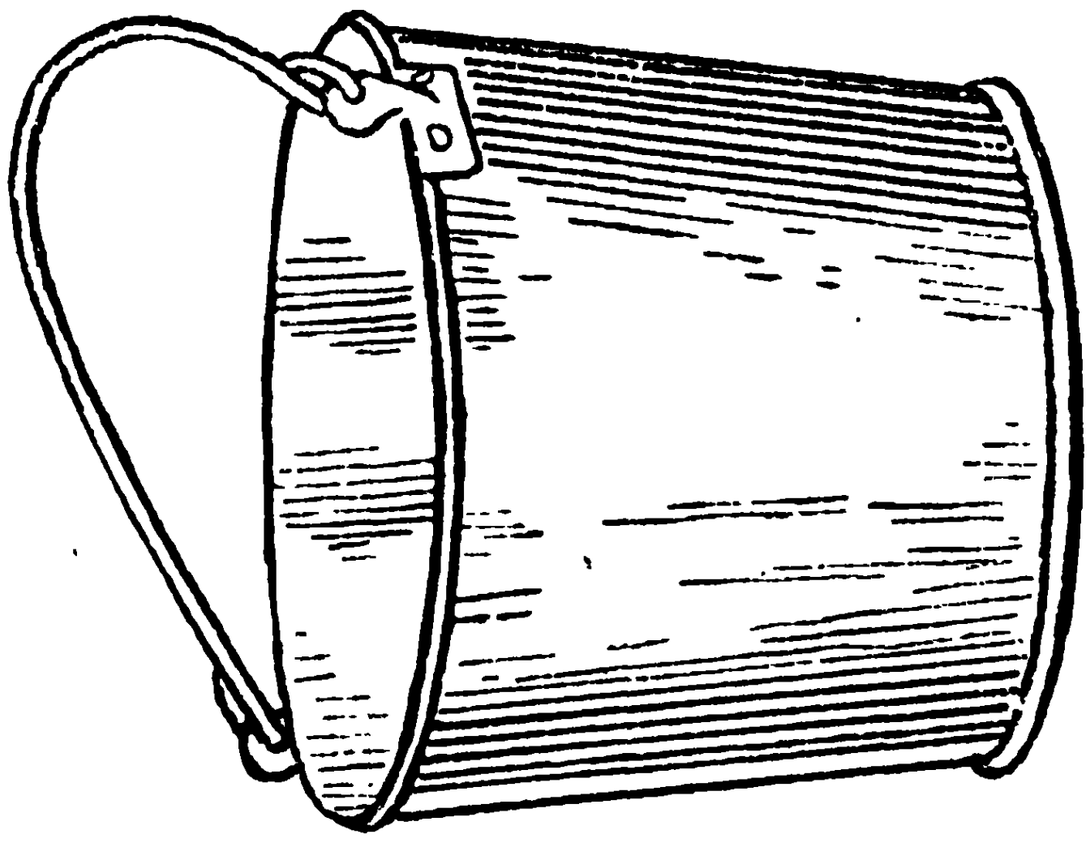


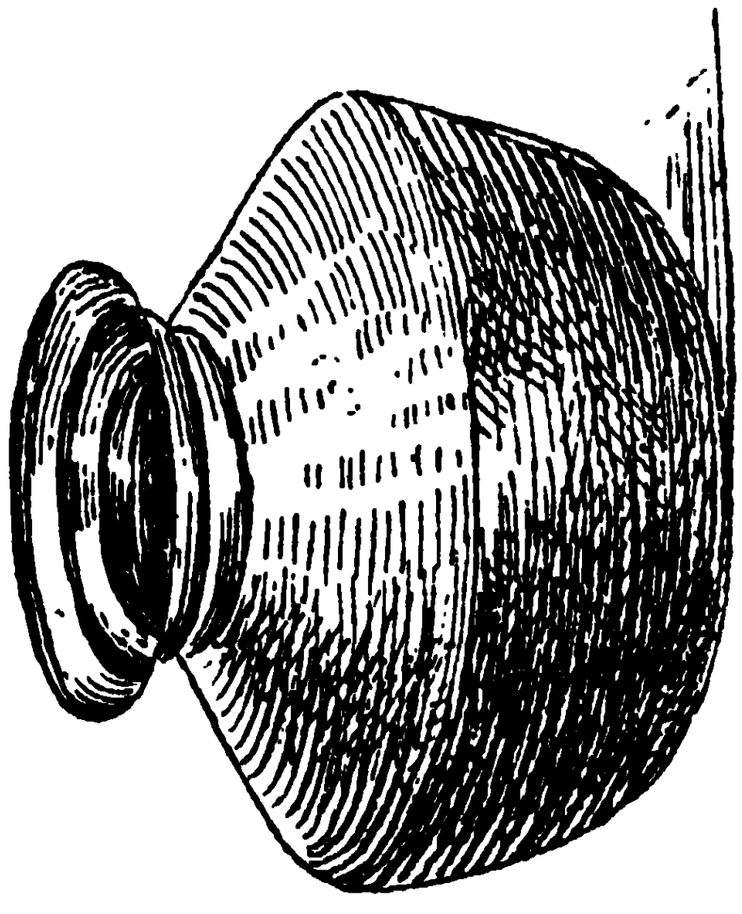
FIG. 10 SANITARY MILKING VESSELS.
WITH A DOME-SHAPED TOP.
FITTED WITH A FILTER CLOTH.

milkers should keep their nails short, both for the sake of cleanliness and to prevent injuries from scratches.

The cow is a very sensitive animal. She likes quietitude and regular routine. Any change of milkers especially for those with a rough touch is disliked and even resented by the animal ; and the probability is that the cow roughly handled by the strangers will become restive and ' hold ' her milk



BUCKET.

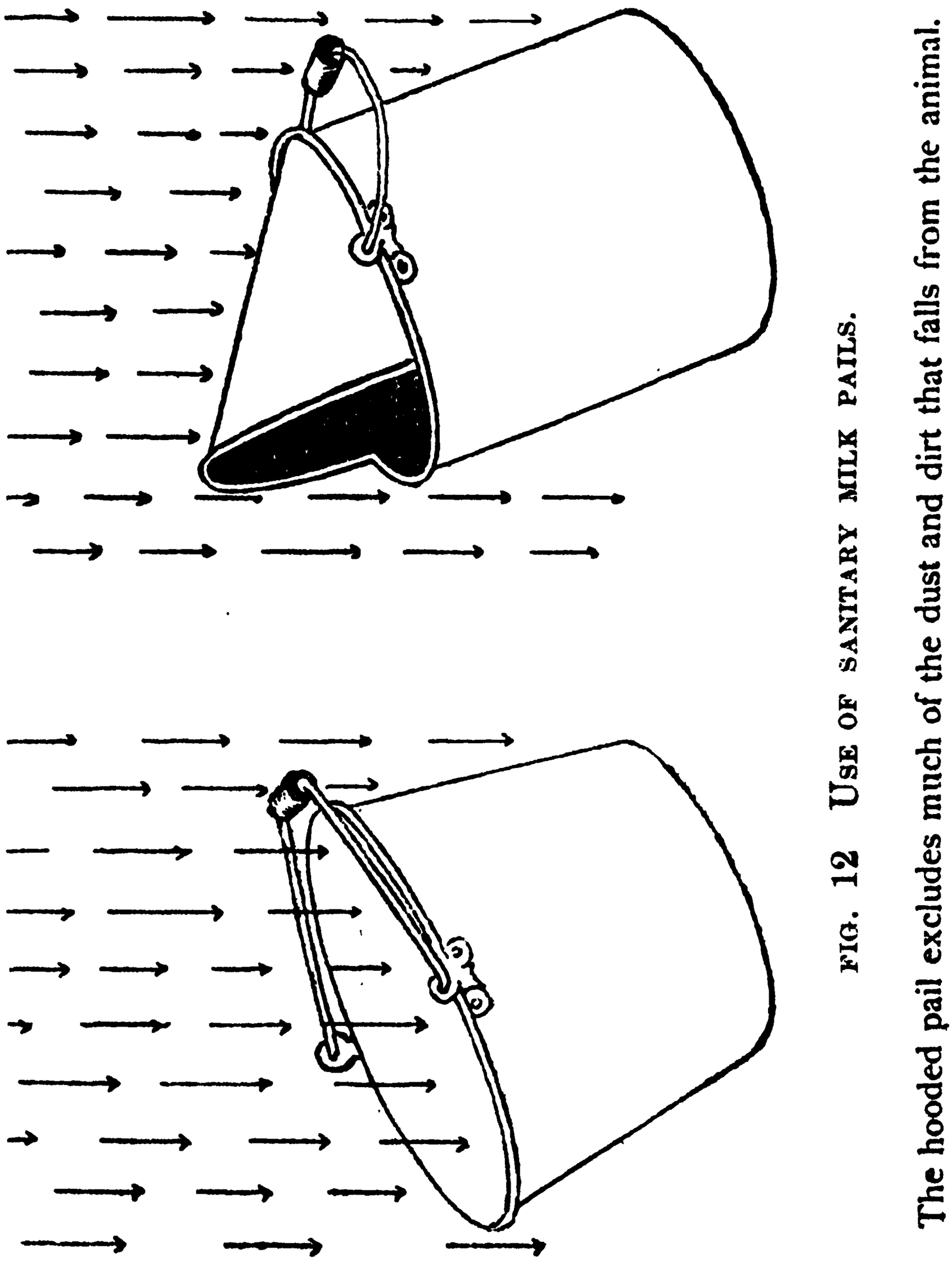


WALTOHI.

FIG. 11 MILKING VESSELS USED CHIEFLY IN INDIA.

back. As a rule, the same milker should always milk the same animals.

In England the cow is milked from the right side but in India the left side is usually taken for milking, and it has been termed the 'milking side.' This is preferred for two reasons; firstly, because it is customary to



USE OF SANITARY MILK PAILS.

FIG. 12.—The hooded pail excludes much of the dust and dirt that falls from the animal.

approach all the larger domesticated animals by their left side — it being most convenient for us, and secondly, because most men are right handed, the right hand being stronger can be most conveniently used to draw milk out of the hinder teats which are difficult to reach due to their position between the hind legs. Whichever side is adopted and considered convenient, the same should always be used with the same animal.

The order of milking the various teats differs. Milking from the same side is said to induce development of the side first milked. It is because the half of the udder milked first is worked with fresh strength and the quarters subsequently milked are not emptied so well due to the tiresomeness of the milker, and therefore they develop less perfectly. Teats may be milked cross-wise, or preferably, the forequarters together and the hind quarters together. Teats appearing most distended may be milked first.

The milk must be squeezed and not dragged out of the teats. The first few streams of milk from each quarter must always be discarded so as to remove the bacteria which have gained access and collected in the passage of the teats between each milking. According to the experiments of Dr. Schultz it appears that the first drawn milk contains about 1,360,000 micro-organisms per cubic inch, while that drawn afterwards is sterile. Trout* using the first three to five streams as the fore-milk found an average of 3,900 bacteria per c. c. The remainder of the milk showed a count of 890

*Trout, G. M., 1929. Michigan Agr. Exp. Sta., ii No. 4, 172

bacteria per c. c. only. Freudenreich* found that the fore-milk averaged 6,000 bacteria per c. c., the middle-milk 1,341 and the strippings 769. Again, Orla-Jensen † secured milk in sterile tubes after washing the udder and teats and found that the fore-milk from four quarters contained 16,000 bacteria per c. c., the middle-milk 480 and strippings 360. Copeland and Olsen‡ determined that the fore-milk contained 5,989 bacteria per c. c., the middle-milk 577 and the strippings 415.

The actual operation of milking may be performed in two ways: *stripping* and *full-hand milking*. Stripping (Fig. 13) consists in firmly seizing the teat at its base between the front of the thumb and the fore-finger, and drawing them down the entire length of the teat, pressing it simultaneously to cause the milk to flow down in a stream. This action is repeated by quickly taking the hand to the base of the teat again. Both hands may be used, each holding a different teat and working alternately. The two nearest are milked first and then the two farthest. Full-hand milking (Fig. 14), on the other hand, is done by grasping the teat with the whole hand, and pressing it against the palm with the fingers. By maintaining a quick succession of alternate compressions and relaxations the alternate streams of milk from the two teats sound like one continuous stream. Full-hand milking removes milk quicker than stripping because of no loss of time in changing the position of the hands. Cows with large

*Von Freudenreich. 1904. Centrl. f. Bakt., 2 abt., xiii, 281.
†Orla-Jensen. 1921. Dairy Bacteriology, p. 21.
‡Copeland & Olsen T. M. 1929 S. Dakota Agri. Sta. Bul. 218

FIG. 13. STRIPPING.

FIG. 14. FULL-HAND MILKING.

[*To face page 136.*]

teats and buffalo-cows are milked with the full-hand method, but in milking small cows with smaller teats this method does not help much and stripping has got to be adopted. Full-hand milking stimulates the natural sucking of a calf, pressing the teats more or less steadily and equally on all sides, and is preferred. In stripping the teats are pressed unequally and more friction is caused by repeatedly sliding the fingers and thumb up and down the teats more than is necessary. This produces undue irritation of the skin and easily causes sores. It also causes a certain amount of unpleasantness to the milker who has got to lubricate the teats frequently with milk or water. No such expedient is required in the full-hand method. Further, stripping is more painful to the animal and cannot be employed when teats are chapped, cracked, sore or affected with cow-pox. Inspite of these drawbacks when all milk that is available is drawn out by the full-hand method, stripping should be resorted to with a view to milk the animal thoroughly clean of all milk that can possibly be taken out. The last drawn milk is called '*strippings*,' and is found by testing to be richer in fat than the fore-milk. Thus, if an animal is not milked dry and stripped efficiently the richest part of the milk is lost. The milker should imitate the greedy calf which sucks the last drop out of the teats. Thorough milking causes a greater flow of blood to the udder, and it is from the blood that all material for the further development and for forming more milk must be sought. A full udder inhibits further formation of milk, whilst emptying the udder well promotes milk yield.

The ordinary method of stripping the animals at

desirable to milk with dry hands. Moistening the teats or fingers with the first few drops of milk or water to facilitate the milking operation is a pernicious habit and should never be allowed. It only results in washing the hands in milk, because the moisture with which the hands are wet will cause the bacteria on the milker's hands or on the outside of the teats to run down and get mixed up with the milk.

Many people hold that wet-hand milking is the natural method of milking, because it imitates the action of the calf in suckling. On a closer scrutiny this has been proved not to hold good. The calf does strip and pull the teats but retains them practically in one position, giving the udder an occasional push upwards. Apart from that, one must bear in mind that judging from an economical point of view, the natural plan may not be the best. Improvement in any branch of science is not necessarily measured by the degree of tenacity to which one clings to natural plans, but rather by the degree of our improvement on Nature. The calf is a wet milker for the very obvious reason that it has no choice of systems. Clean milking is imperative and this can be accomplished affectively with the dry hands.

Wet-hand milking very soon makes the teats look harsh and dry, and later, chaps, cracks and sores make their appearance which prove to be very troublesome and painful to the animal. When cracks and sores have formed the affected teat, after milking, should be steeped in a cupful of a weak solution of lysol or any other antiseptic lotion and then dried with a clean cloth. Thereafter, the part should

be smeared with carbolised vaseline. Zinc ointment to which a few drops of carbolic acid have been added also serves the purpose well. Stripping should not be allowed in such cases ; it aggravates the trouble.

In our country practically every milker is habituated to wet-hand milking. He wets his hands, causes the fingers to drip when milking and not infrequently dips his fingers into the milk in the vessels, thus contaminating the whole milk badly. This is a dirty practice. Under such conditions it is no wonder to find cows in large numbers suffering from manifold udder and teat troubles. From statistics obtained from the Outdoor Clinique of the Punjab Veterinary College, Lahore, the author has found that out of 874 female bovines treated during the year 1925, no less than 151 or 17·5 per cent. nearly were victims of teat and udder affections. This is mostly due to wet-hand milking, keeping irregular hours, objectionable and incorrect methods, incomplete milking and bad management of milch cattle.

Milking should be done regularly at the same hours each day. Cow is a creature of habit and her udder works steadily and regularly. Irregularity in milking hours disturbs the animal's yield. If continued it is also believed to exert a harmful influence on the work of the cow during her entire period of lactation, the evil becoming gradually and increasingly more prominent and finally closing the milking period earlier than it would have closed, had the milking been done regularly every day in the week.

appetizing food. Moreover, the longer the milker takes to draw out milk, the more are the chances of the animal becoming restive. An expert milker, who does the job quickly, getting a ' head ' on the bucket, so to say, gets a greater amount of milk and richer in fat than a novice.

Dr. Crowther in 1904 found a remarkable difference in the milk yield of cows when milked by an expert and a novice. One cow, on the days she was milked by an expert, gave on an average 11·3 lbs. per day, but when milked by a novice she averaged only 9·4 lbs. per day. The average proportion of fat obtained by the expert was 4·2 per cent. against 2·5 per cent. by the novice. In later experiments he found the great importance of quick milking against slow milking. In one experiment he found that by quick milking 10 per cent. more milk and 30 per cent. more fat were obtained.

Cows possess a highly developed nervous organisation, and a complete harmony between the milker and the cow is necessary. They should be handled with tenderness and good judgment. Gentleness encourages milk secretion ; roughness shocks the nerves and the reflex impairs secretion. If the animal is troublesome, naturally unaccommodating and kicks and knocks, no amount of swearing at her, abusing or striking will ever make her any better. The best in such cases is to be gentle and kind. Milking affords a certain amount of pleasure to the animal and she will soon learn to be quiet and docile.

Some cows are ' hard ' to milk and would require great exertion on the part of the milker to remove

the whole of the milk, while others would 'let down' copiously even with the gentlest handling and before the pail can be got under them. Cows are frequently hard to milk at their first calving, but usually improve with judicious milking or suckling the calf. The udder of a gentle cow and the one that lets down easily generally possesses a soft and pliable skin covered with short, fine silky hair, whilst that of a 'hard' one possesses a rough and thick skin, tough like tanned leather. In some cows the teat openings are abnormally small and such animals are often hard to milk. Hard milking may, in general, be considered as an abnormality, and in most instances it is the result of infection, injury or growth on the lining membrane of the teat canal, near the orifice or the part up above close to the udder. In such cases expert veterinary advice should be sought. Undue surgical interference by quacks like Gawallas or Gujjars should be discouraged. They frequently push in quills of feathers or dirty reeds to widen up the duct and remove blockage. No attention is paid to asepsis or antisepsis. As a result, the animal's most useful part of the body is badly spoiled for future work.

In milking, the teats should not be drawn beyond their natural length. For a 'wet-hand' milker, milking seems an impossibility if the teats are not drawn and stretched. This unnecessary stretching of the teats has been described by a famous farmer as 'rather like the action which a thief would make when stealing the milk from the cow.' A 'dry-hand' milker does not need it, and once the dry-hand plan is learnt it is found to be much the easier of the two. For the sake of cleanliness also it is

the close of milking may with advantage be replaced by the so-called method of 'after-milking' or 'clean milking,' introduced in dairy economy by Hegelund, a Danish veterinarian. The method has been proved to be of great value in developing the milk yield of the cows, in increasing the fat content of milk and in preventing mastitis (inflammation of the udder) during the early period of lactation. In this the udder is thoroughly emptied by stimulating the secretion by massage. The method has been adopted as a routine method of after-milking by some of the most progressive dairies in Denmark and America with useful results, and is worthy of trial in India also.

The manipulations of the udder in the Hegelund's method of milking may be described as follows, assuming that the milking side is chosen to be the left side of the animal :—

First Manipulation.—The left quarters of the udder are pressed against each other with the right hand on the hind quarter, and the left hand in front on the left fore quarter, the thumbs being placed on the outside of the udder and the fingers in the division between the two halves of the udder. In the case of a large udder only one quarter is grasped at one time. The hands are then pressed towards each other and simultaneously pushed upwards toward the animal's body. This exerts a massaging action on the udder and stimulates the secretion of milk. This manipulation is repeated three times and then is followed by milking out the quarters. The manipulation is repeated again until no more milk is obtained. The right quarters are then treated in a similar manner.

Second Manipulation.—In this the fore quarters are milked each by itself by placing one hand on the outside of the quarter, with fingers spread and the other in the division between the two fore quarters. The hands are then pressed against each other and the teat milked. The hind quarters are milked by placing a hand on the outside of each quarter in such a way that the fingers are turned upwards with the thumb just in front of the hind quarter. The hands grasp the quarter and are lifted and then lowered to draw the milk. This is repeated until no more milk is obtained.

Third Manipulation.—The fore teats are loosely grasped with the hands and the quarters lifted with a push towards the body of the animal. This manipulation imitates the buttings of a calf while suckling, and the glands are shaken, so to say, by being pressed between the hands and the abdominal wall. After three such pushes the milk is drawn. The hind quarters are treated in the same manner until no more milk is obtained.

The only disadvantage of this method is that it requires additional labour and time, but a correct and appropriate handling of the udder is ensured together with holding down the milkers to thorough work.

Milking should be done fast. A cow will give more milk when milked rapidly than when she is milked slowly. It is during the process of milking that a greater part of milk is secreted. This is said to be due to the stimulation produced by the action of milking. The action is very similar to the formation of saliva in the mouth from the stimulation of the gland by some savoury smell, taste or

After the milking is finished the animal should be patted in a soothing way and a few kind words uttered to her.

The common practice is to milk animals twice daily. The period between morning and evening milking should be as nearly of the same length as possible, *viz.*, an interval of twelve hours should be left between each milking. In the case of very heavy milkers and where records are required, probably an extra milking would be needed. It is thought that milking a cow three times daily or more frequently stimulates the udder to increased activity, and the yield becomes correspondingly more. But the stamina, digestive possibilities and increased milk yield in an animal are limited, and in the interests of preserving milch cows in good breeding condition and sound health, it may be said that no more than two milkings are necessary except in the case of a few very high type animals. Allowing the udder to become unduly distended with milk, on the other hand, by failing to milk, is a cruel and dangerous practice. It may lead to inflammation of the udder, and often results in the loss of one or two quarters. It may also prove fatal in a few cases.

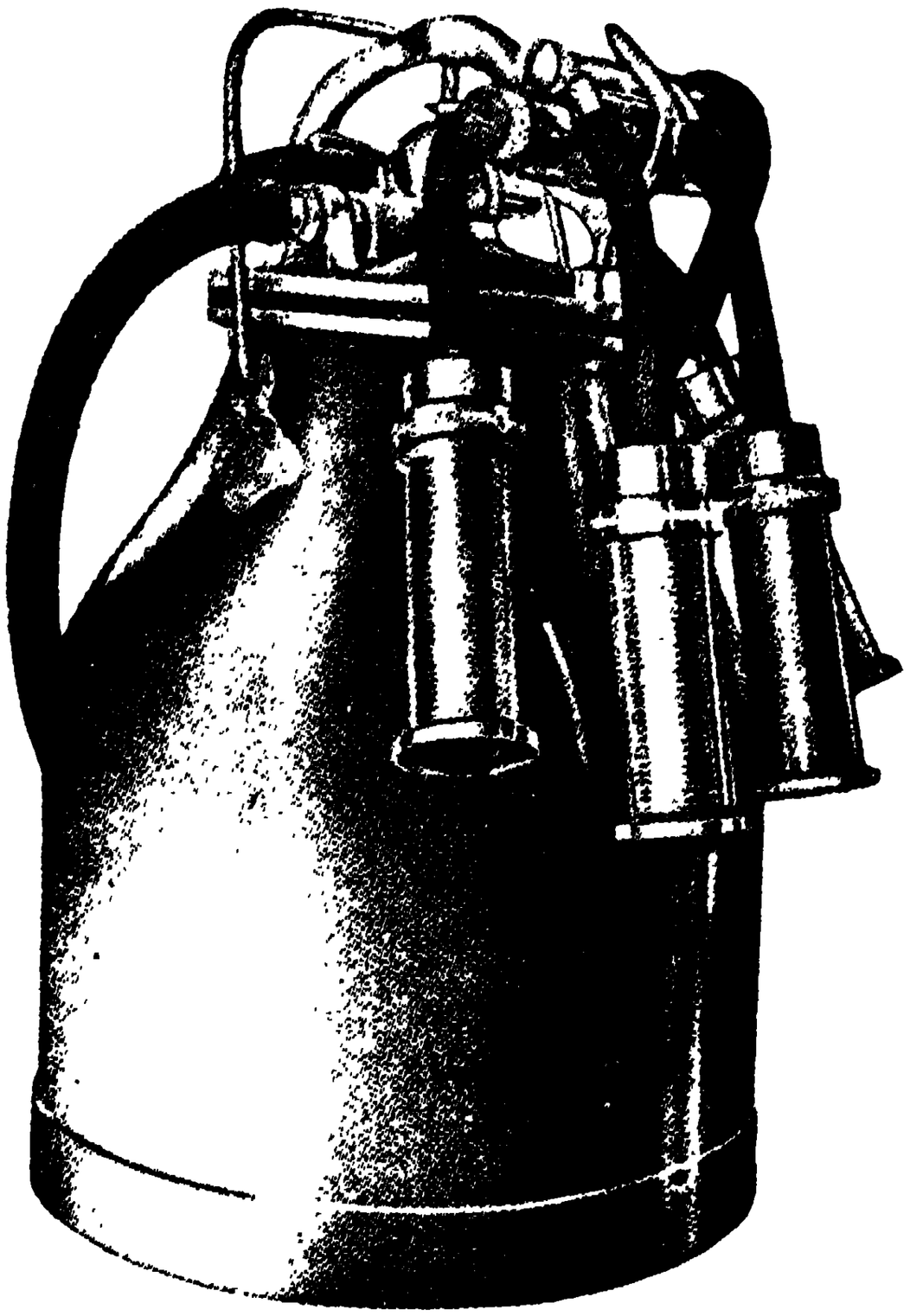
* * * *

4. Milking Machines.

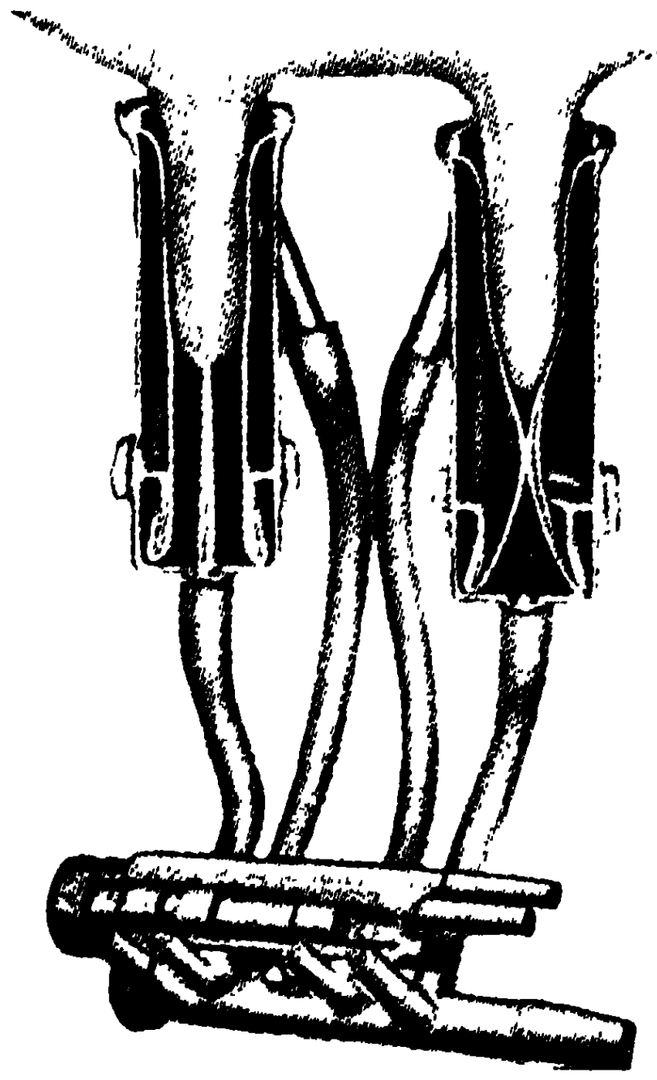
Milking Machines* (Fig. 15) are quite recently introduced in farm economy and in the West they have attracted much attention. Most of these

The chief types of making machines are :—The Wallace, The Alfa-Laval, The Lawrence-Kennedy, The Lister, The Amo, The Gane, The Vaccar, etc., etc.

Fig. 15.



THE ALFA-LAVAL MILKING UNIT.



TEAT-CUPS.

o face page 114.

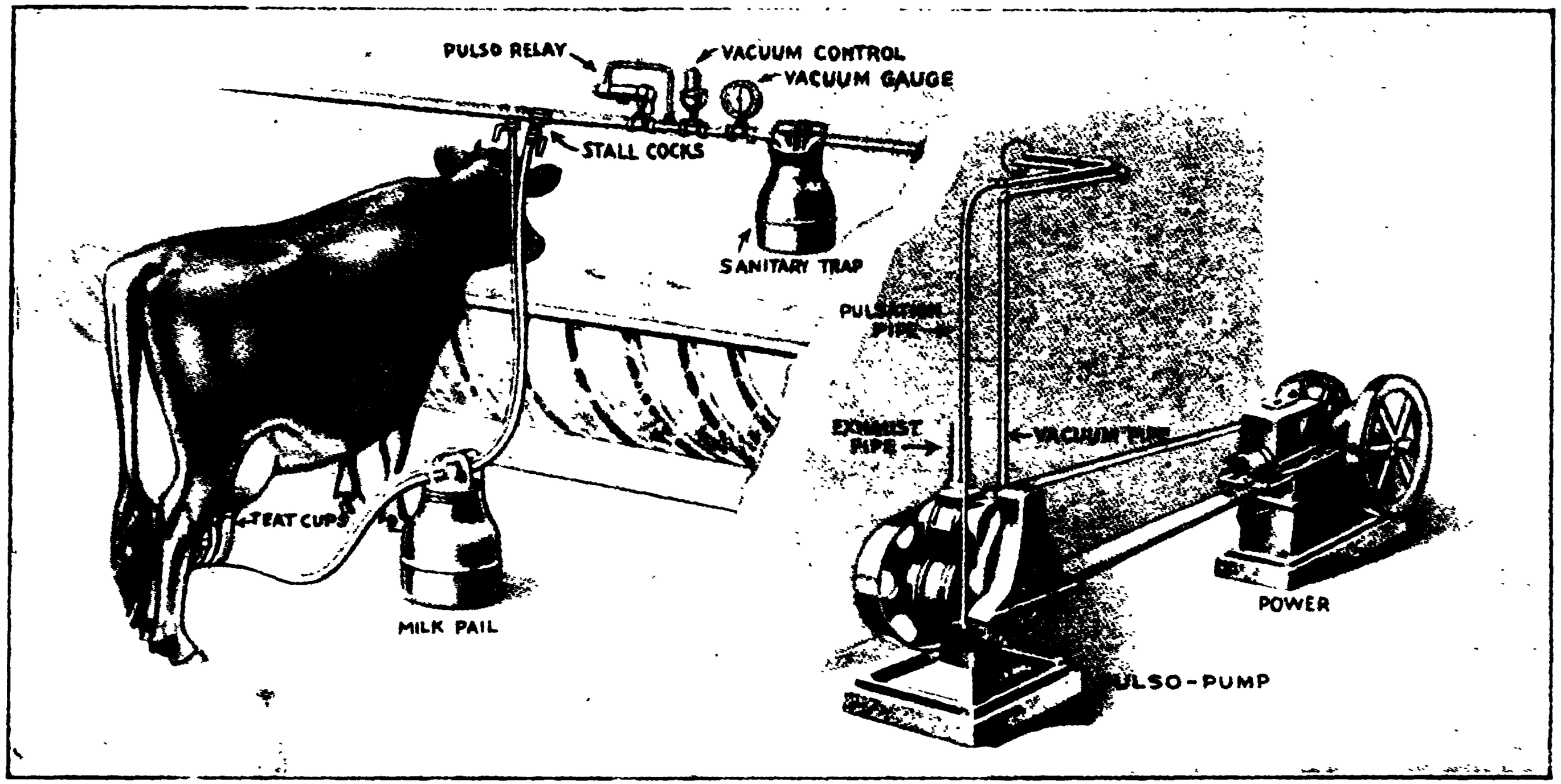


FIG. 16. THE ALFA-LAVAL INSTALLATION.

To face page 145]

machines work by intermittent suction, thus imitating more or less the sucking of the calf. The chief advantages claimed by the exponents of these machines are that the diseases of the udder and teats are greatly reduced, milk is obtained clean and wholesome, and that the labour is reduced and relieved of the irksome work of hand-milking to a certain extent. Many conflicting views are held as to the superiority between machine-milking and hand-milking. A short description of the Alfa-Laval Milking Machine, however, is given to understand the principles underlying the working of these machines.

The Alfa-Laval Milker claims to reproduce the natural process by which the calf sucks its mother's milk by the combined action of pressure of its tongue against the teats and the suckling action of the mouth.

The following are the parts of the installation. (Fig. 16) :—

The pulso-pump which is of the horizontal rotary type without any valves produces the necessary vacuum and creates the pulse for massaging the teats by the pulso-maker fixed on to the end of the pump. There are two pipe lines, one being smaller than the other. The larger of the two conveys the steady vacuum whilst the smaller one, called the pulso-pipe, conveys the pulsations. Due to the regular speed of the pump the pulsations created and transmitted to the teat cups are also fixed and regular, such that the pulsations cause the milking to be carried out at a correct rate. The

machinery is also fitted with vacuum gauge and controller pulso-relay and sanitary trap. Milking machine itself consists of the milk pail with its cover holding about 18 quarts, 4 teat cups with a pulse-distributor and milk claw and tubes for the transmission of air and milk. The teat cups are made of bronze, corrugated on the outside and nickel plated. The inner surface is made of very smooth rubber liner which is non-adhesive to milk and will not crack. The liners are about the only parts of the machine which require renewal at intervals.

Electric milking apparatus* has also recently come into practice in England, and a great saving in the cost of production is claimed by the use of this equipment.

* * * *

5. Milk Records.

An annual milk record is really the history of the work of an animal during twelve months, and serves as a pointer to profitable production and profitable breeding. The essential feature of milk recording is the determination of the milk yield of each cow in the herd. Immediately after milking, each cow's yield is accurately recorded in a proper register and the total yield estimated after a year. The weighing of milk by a suitable spring balance (Fig. 17), of which many patterns can be obtained, is a ready and certain means to this end.

*Mr. F. Swarbrick, Borough Electrical Engineer, Basingstocke, installed in August 1925 an electric milking apparatus on the farm of Mr. Tom Bowden, Sherborne, St. John, where 64 dairy cattle are milked daily in one and a quarter hours with the current consumption of electric motor of 2·475 units. Only one man and three lads are required to do the whole work.

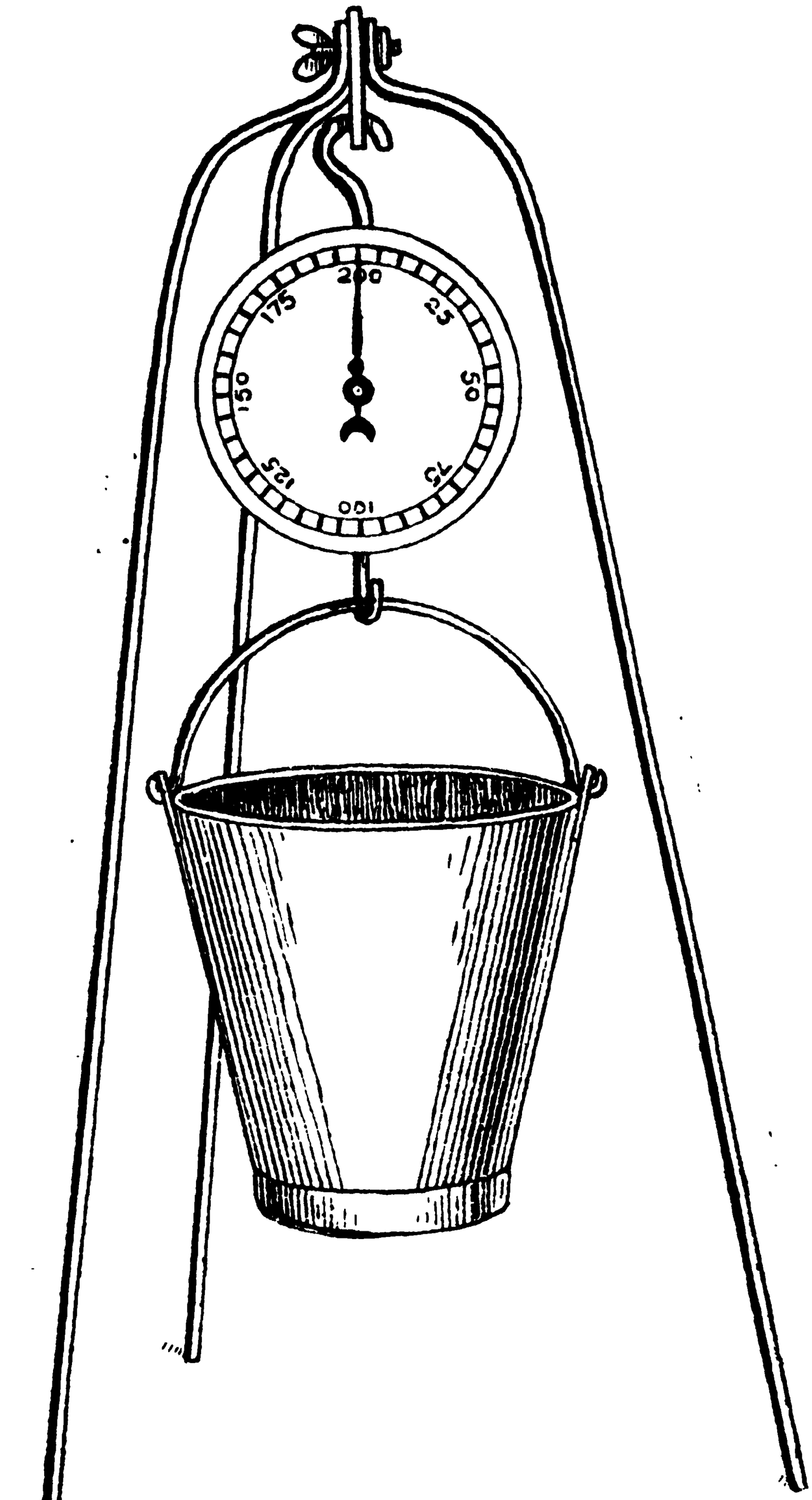


FIG. 17 SPRING BALANCE.

It may be set on a tripod in a convenient place, and as each cow is milked, the milking pail is hung on the handle of the machine when the index hand records the total weight. From this the weight of of the pail is deducted and accurate weight of the milk entered in the register.

Since the adoption of this system of milk recording in the Western countries many leaks in the economy and management of dairies have been stopped and wonderful improvements achieved. From the economic standpoint, however, no milk recording scheme should be considered complete unless it includes the determination of the total yield of butter-fat in addition to that of milk. This necessity is easily recognised when we consider that the value of milk depends upon its composition as is the case in cheese and butter-making. Leaving that aside, where milk is sold irrespective of its composition, subject to the legal minimum requirements, it is also advisable to know its content of fat for the simple reason that, other things being equal, the cost of producing one maund of 5 per cent. milk would obviously be higher than that of an equal quantity of 3 per cent. milk.

There is no doubt about the fact that keeping of milk records of individual animals and testing for butter-fat involves more labour and expense. Realising that the people in India are yet too backward in education to grasp the usefulness of the practical application of scientific achievements, and keeping in view the existing low standard of Indian dairies, perhaps it would be generally expedient in the initial stages to aim only at the recording of milk yield weekly. When such a scheme is found

to be firmly established and its advantages realised further steps for testing of butter-fat and keeping of feeding records can be adopted. Some people are of opinion that fort-nightly or monthly weighings afford a fair guide to the yield, but it has been found not to be sufficiently accurate to be of real value. They do not enable one to detect sufficiently quickly, if at all, when a cow is ill, to gauge readily and accurately the effect which alterations in food have on the yield of milk; and they afford a bigger margin of error in calculating the records than when weighings are made daily or weekly. In England the Ministry of Agriculture prescribes weekly weighings unless it is desired to take records daily.

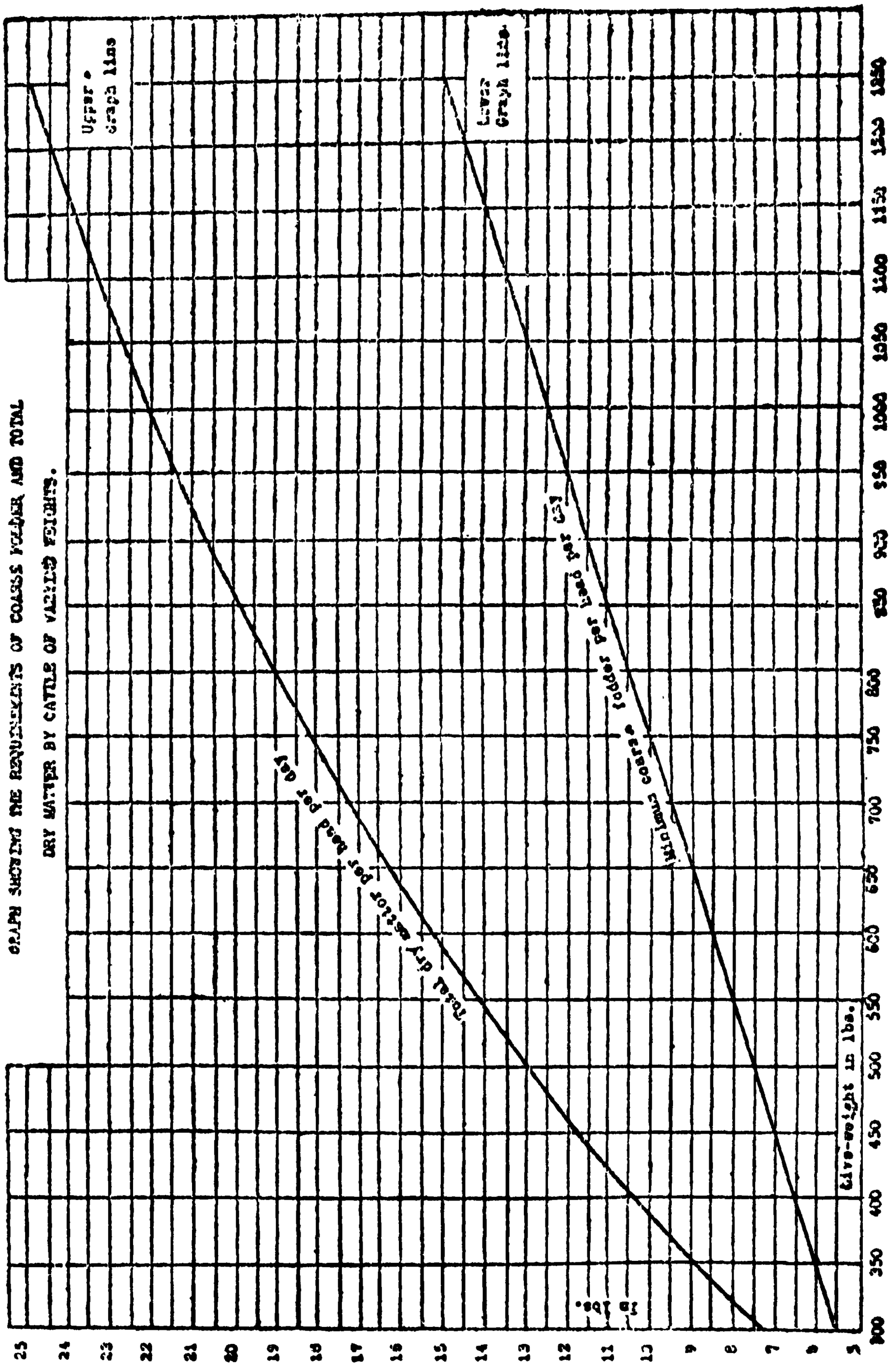
The chief advantages of milk recording are that the average milk yield of the cows in a herd is increased by the elimination of the poorest milkers, and the phenomenal producers that have a breeding value beyond that of the value of actual milk yield can be located. By the removal from the herd of the poorest milkers and by using the phenomenal ones as the foundation for future development of the herd, a double improvement can be accomplished, and better prices realised for the bulls, cows and calves that are bred for sale. These better prices are a direct consequence of the high milk yields of the dams and the good milking pedigrees of the sires. Underlying the system is the proved fact that cows capable of giving high yields of milk as well as bulls bred from such cows are able to transmit this character, in a greater or less degree, to their progeny; and without the help of milk records the milking capacities of cows in a herd cannot be accurately estimated.

Keeping of milch cattle purely for home necessities or for dairy work is fundamentally an economic problem. The two main essentials of a dairy cow are ability to produce economically and the ability to produce other cows that will do the same thing. The more civilised Westerner recognises this economic situation and reaps the benefits. The position of cattle industry in India, on the other hand, is curious. An overwhelming majority of the population of the country holds the cow in extreme veneration and love purely on sentimental grounds, and owing to this the elimination of useless animals is rendered an impossibility. The result is that many millions of cattle are economically unprofitable, and mean a heavy drain on the resources of people. On a rough estimate there are about 15,000,000 cattle which are useless and of no value whatever. If the life of these animals in taken at 5 years, and the value of food consumed by each at Rs. 10 per annum, the total money spent apparently without any profit would amount to Rs. 750,000,000 annually. This a very conservative estimate but is enough to demonstrate the cause of proverty of Indian people. Useless animals consume the food that is needed for useful animals. It is not the cow here that is keeping the people, but the people are keeping her, whereas its reverse should be the case. India's vital industry is agriculture and the cattle constitute an integral portion of the wealth in it. Every attempt which can be analysed and proved on economic and scientific lines to be useful for the development of the cattle industry of the country should be tried, and no other fantastical and antiquated scheme launched. Re-

cently some of the Government Breeding Farms and Dairies have been started which are doing extremely well, but what is more especially needed is that the people should be educated and initiated into the useful systems by the help of vigorous propaganda work. It is the ignorant class of people who own a bulk of the cattle population and deserve consideration.

APPENDICES.

Appendix I.


Upper Graph line
Lower Graph line
Live-weight in lbs.
Maintenance coarse fodder
Total dry matter per head per day
Total dry matter per 100 lbs. live-weight per day
Maintenance coarse fodder per head per day
GRAPH SHOWING THE REQUIREMENTS OF COARSE FODDER AND TOTAL DRY MATTER BY CATTLE OF VARIOUS WEIGHTS.

Names of Foods.			In 100 parts.						Authority.
Indian.	English.	Botanical.	Water.	Proteins.	Carbohy-drates.	Fat.	Crude fibre.	Ash.	
1	2	3	4	5	6	7	8	9	10
Table 1. Straws:									
Nar Gundum (Prali)	Wheat Straw	Triticum vulgare	8·93	2·98	41·02	1·18	31·64	14·25	Clouston, D., Agri. Res. Inst. Pusa. Bull. No. 150. 1923.
Chawal prali	Rice straw	Oryza sativa	10·01	3·09	39·38	1·21	29·88	16·43	Ditto.
Juar	Dry Juar	Sorghum vulgare	12·68	4·20	34·55	1·09	38·88	9·10	Ditto.
Turi, Bhoosa	Wheat chaff	Triticum vulgare	5·71	1·72	44·40	0·72	39·87	7·58	Lander, P.E., Mem. Agri. Ind. Chem. Series. Vol. VII, No. 4, 1924.
Jai, Jawi	Oat straw	Avena sativa	9·88	3·00	41·31	1·97	30·13	13·23	Leather, J. W., Agri. Ledger, Vol. X, No. 7, 1903.
Ragi	Ragi straw	Eleusine coracana	9·88	2·19	45·24	2·37	28·22	12·10	Ditto.

Bajra	Bullrush millet	Pennisetum typhoideum	7·07	1·94	43·99	1·33	37·63	8·04	Ditto.
Arhar bhusa	Pigeonpea chaff	Cajanus indica	8·81	11·01	44·67	4·40	19·23	11·87	Ditto.
Channa bhusa	Gram chaff	Cicer arietinum	8·41	3·65	45·86	2·27	26·71	13·11	Ditto.
Khesari bhusa	Khesari chaff.	Lathyrus sativus	8·59	9·50	44·21	3·96	19·97	13·77	Ditto.
Urd bhusa	Urd chaff	Phaseolus mungo	15·96	11·19	39·14	1·70	17·08	14·93	Ditto.
Mung bhusa	Mung chaff	Phaseolus radiatus	13·30	10·88	40·35	2·52	18·66	14·29	Ditto.
Mattar bhusa	Pea chaff	Pisum sativum	8·57	10·84	42·63	3·02	20·81	15·62	Ditto.
Kulthi bhusa	Horsegram chaff	Dolichos uniflorus	5·60	5·25	49·66	2·63	28·01	8·85	Ditto.
Lobea bhusa	Lablab chaff	Dolichos lablab	9·92	13·39	43·03	3·72	16·17	13·78	Ditto.
Jau bhusa	Barley straw	Hordeum vulgare	12·07	7·81	39·99	1·38	24·56	14·19	Ditto.
Rai bhusa	Mustard straw	Brassica juncea	13·50	1·94	41·10	1·64	32·79	9·03	Sen, J. N., Agri. Res. Inst. Pusa. Bull. 70, 1917.
Massar bhusa	Lentil straw	Lens esculenta	10·23	4·37	50·03	1·80	21·36	12·21	Ditto.

1	2	3	4	5	6	7	8	9	10
Table 2. Hays:									
Sukha ghas	Hay	Mixed grasses	8·24	3·30	43·99	1·52	32·54	10·41	Clouston, D., Agri. Res. Inst. Pusa, Bull. No. 150, 1923.
Berseem	Egyptian clover hay	Trifolium alexandrinum	6·01	12·14	46·24	2·63	22·03	10·95	Ditto.
Lusan	Lucerne hay	Medicago sativa	6·04	15·20	43·30	2·02	23·83	9·56	Ditto.
Sukha ghas (Jullundur)	Jullundur hay	Mixed	7·40	3·25	43·74	0·92	37·14	7·55	Lander, P. E., Mem. Agri. Ind. Chem. Ser. Vol. IX. No. 7.
Sukha ghas (Jutogh)	Jutogh hay	Mixed	6·44	3·50	45·05	1·31	36·84	6·86	Ditto.
Sukha ghas (Sialkot)	Sialkot hay	Mixed	9·26	4·38	41·25	0·88	35·06	9·15	Ditto.
Jai sukhi	Oaten hay	Avena sativa	3·36	5·69	48·64	1·84	33·94	6·53	Ditto.
Teff ghas	Teff hay (Cawnpore)	Teff tseddia	6·95	4·06	51·43	2·01	29·35	6·20	Clarke & Burt, Agri. Jour. Ind., Vol. XII. 1916, p. 202.
Shaftal	Shaftal hay	Trifolium rusupinatum	15·86	14·10	39·98	2·19	13·80	14·07	Sen. J. Agri. Journ. Ind. Vol. XIII. 1917, p. 34.

Juar sukhi	Millets dry hay	Andropogon sorghum	6·14	2·89	58·42	0·89	25·37	6·29	Clouston, D., & Plymen, F.J. Agri. Journ. Ind. Vol. XV. 1920, p. 380.
Gini ghas	Guinea grass hay	Panicum jumentorum	8·02	9·03	28·63	1·68	40·54	12·10	Brown, W. R., Agri. Journ. Ind. Vol. XIX, 1923, p. 33.
Sarson sukhi	Dried sarson	Brassica campestris	10·00	13·00	30·16	3·05	20·41	23·38	Sen, J. N., Agri. Res. Inst. Pusa, Bull. No. 70, 1917.
Table 3. Food grains:									
Bajra	Bullrush millet	Pennisetum typhoideum	11·30	10·40	71·50	3·50	1·50	2·00	Church, A. H., Food Grains of India, 1886.
Makai	Maize	Zea mays	12·30	9·50	70·70	3·60	2·00	1·70	Ditto.
Chawal	Rice	Oryza sativa	12·80	7·30	78·20	0·60	0·40	0·60	Ditto.
Jawar (Jawari)	Great millet	Sorghum vulgare	12·50	9·30	72·30	2·00	2·20	1·70	Ditto.
Jawi	Oats	Avena sativa	12·70	10·10	56·00	2·30	16·60	2·30	Ditto.
Ragi	Ragi (husked)	Eleusine coracana	13·20	7·30	73·20	1·50	2·50	2·30	Ditto.
Ragi	Ragi (whole)	Eleusine coracana	12·50	5·90	74·60	0·80	3·60	2·60	Ditto.

1	2	3	4	5	6	7	8	9	10
Food Grains —contd.									
Gundum, Kanak	Wheat	Triticum vulgare	12·50	13·50	68·40	1·20	2·70	1·70	Ditto.
Jau	Barley (husked)	Hordeum vulgare	12·50	11·50	70·00	1·30	2·60	2·10	Ditto.
Jau	Barley (whole)	Hordeum vulgare	12·39	6·62	71·55	1·85	4·16	2·38	Leather, J. W., Agri. Ledger, Vol. X, 1903, No. 7.
Binole	Cotton-seed	Gossypium herbaceum	9·82	17·31	31·15	18·65	19·01	4·04	Ditto.
Alsi	Linseed	Linum usitatissimum	5·80	17·91	26·12	40·31	5·27	4·53	Ditto.
Torea	Rape seed	Brassica napus	6·69	18·29	23·18	39·46	5·24	7·13	Ditto.
Rai	Mustard	Brassica juncea	7·68	19·14	24·10	38·26	5·48	5·34	Ditto.
Sarson	Colza	Brassica campestris	7·21	20·09	22·04	41·82	4·47	4·35	Ditto.
Kusum	Safflower	Carthamus tinctorius	6·22	13·38	22·93	25·88	27·67	2·76	Ditto.
Safed til	Gingelly	Sesamum indicum	4·73	19·32	15·28	49·13	4·21	7·32	Ditto.

Kulthi	Horse gram	Dolichos uniflorus	8·82	18·18	62·29	00·80	4·13	5·76	Ditto.
Kala til	Niger seed	Guizotia abyssinica	8·43	19·25	11·49	41·14	12·10	5·46	Sen, J. N., Agri. Res. Inst. Pusa, Bull. No. 70. 1917.
Channa	Gram (husked)	Cicer arietinum	11·50	21·70	59·00	4·20	1·00	2·60	Church, A. H., Food Grains of India. 1886.
Channa	Gram, with husk	Cicer arietinum	11·20	19·50	53·80	4·60	7·80	3·10	Ditto.
Guar	Guar beans	Cyamopsis psoralioides	11·80	29·80	46·20	1·40	7·70	3·10	Ditto.
Khesari	Vetchling	Lathyrus sativa	10·10	31·90	53·90	0·90	...	3·20	Ditto.
Mattar	Pea (husked)	Pisum sativum	11·80	28·20	55·00	1·50	1·00	2·50	Ditto.
Mattar	Pea (unhusked)	Pisum sativum	12·50	23·60	54·50	1·30	5·70	2·40	Ditto.
Massur	Lentil (husked)	Lens esculenta	11·80	25·10	58·40	1·30	1·20	2·20	Ditto.
Massur	Lentil with husk	Lens esculenta	11·70	24·90	56·00	1·50	3·60	2·30	Ditto.
Soya	Soya bean	Glycine soja	11·00	35·30	26·00	8·90	4·20	4·60	Ditto.
Mash	Green and blackgram	Phaseolus mungo	10·80	22·20	54·10	2·70	5·80	4·40	Ditto.

1	2	3	4	5	6	7	8	9	10
Food Grains —contd.									
Moth	Moth bean	Phaseolus aconitifolius	11·20	23·80	56·60	0·60	4·20	3·60	Ditto.
Rawan (husked)	Catiang bean	Vigna catiang	12·50	24·10	56·80	1·30	1·80	3·50	Ditto.
Sem, lobea	Lablab bean	Dolichos lablab	12·10	24·40	57·80	1·50	1·20	3·00	Ditto.
Arhar	Pigeonpea	Cajanus indicus	10·50	22·30	60·90	2·10	1·20	3·00	Ditto.
Table 4 Roots:									
Gajar	Carrots	Daucus carota	88·30	1·20	8·00	0·20	1·10	1·20	Henry & Morrison, 'Feeds & Feeding.' 1917.
Shalgham	Turnips	Brassica rapa	90·50	1·40	5·90	0·20	1·10	0·90	Ditto.
Alu	Potatoes	Solanum tuberosum	78·80	2·20	17·40	0·10	0·40	1·10	Ditto.

Table 5 Green Fooders:									
Jai, Jawi	Green oats	Avena sativa	83·51	0·94	9·00	0·37	3·99	2·19	Leather, J. W., Agri. Ledger, Vol. X. 1903, No. 7.
Ragi	Green Ragi	Eleusine coracana	80·83	1·94	7·85	0·48	5·38	3·52	Ditto.
Jau	Green barley	Hordeum vulgare	79·62	2·46	8·20	0·45	6·54	2·69	Ditto.
Khasil, Kanak	Green wheat	Triticum vulgare	82·65	1·87	7·56	0·40	5·07	2·45	Ditto.
Makai hari	Green maize	Zea mays	88·92	1·13	4·64	0·31	3·11	1·88	Ditto.
Moth hare	Green moth	Phaseolus aconitifolius	74·70	3·20	12·00	0·89	4·99	4·22	Ditto.
Sarson hari	Green sarson	Brassica campestris	86·13	2·00	4·64	0·47	3·14	3·62	Ditto.
Kangni hari	Italian millet	Setaria italica	76·79	2·08	10·08	0·54	6·37	4·14	Ditto.
Senji	Melilot	Melilotus indica	84·40	2·69	6·16	0·36	4·13	2·26	Ditto.
Juar	Indian or great millet	Sorghum vulgare (cut green)	69·76	0·55	14·74	...	11·90	3·05	Leather, J. W., Agri., Ledger, Vol. VIII. 1901, No. 10.

1	2	3	4	5	6	7	8	9	10
Juar	Indian or great millet	S. vulgare (cut ripe)	67·02	0·64	16·42	...	12·78	3·14	Ditto.
Lusan	Lucerne, alfalfa	Medicago sativa	75·00	4·05	11·53	0·54	6·34	2·51	Coluston. D, Agri. Res. Inst., Pusa. Bull. No. 150. 1923.
Berseem	Egyptian clover	Trifolium alexandrinum	81·66	3·22	8·26	0·51	4·00	2·38	Ditto.
Palwan	Marvel grass (Before	Andropogon annulatus flowering)	69·90	2·14	13·46	1·60	9·20	3·70	Burns, W., Agri. Journ. India, Vol. X. 1915, p. 291.
Palwan	(In flower)	Do.	69·53	2·24	16·30	1·70	11·59	3·74	Ditto.
Palwan	(In seed)	Do.	65·40	2·00	12·81	1·72	14·26	3·81	Ditto.
Shisham patte	Shisham leaves	Dalbergia sisso	71·51	5·11	13·68	1·13	5·59	2·98	Lander, P. E., Mem. Dept. Agr. Ind. Chem. Ser. Vol. VII. No. 4.
Thohar	Cactus	Opuntia elatior	92·65	0·31	4·37	0·22	0·85	5·13	Horn, E. W., Agri. Journ. India Vol. X. 1914, p, 190.
Gini ghas	Guinea grass	Panicum jumentorum	63·38	1·88	19·36	0·84	8·79	5·75	Leather, J. W., Agri. Ledger. Vol. XIII, 1901, No. 10.
Ghas	Mixed grass	(Immature)	70·30	5·10	13·80	1·50	6·30	3·00	Henry & Morrison, 'Feeds & Feeding.' 1917.

Ghas *	(haying stage)	...	69·20	3·00	14·10	1·30	10·60	1·80	Ditto.
Gobhi	Cabbage	Brassica oleracea	91·10	2·20	4·70	0·30	0·90	0·80	Ditto.
Patte gajar	Carrot leaves	...	81·80	3·40	7·10	0·90	2·50	4·30	Wood, T. B., Rations for Live Stock. 1922.
Patte shalgham	Turnip leaves	...	88·40	2·20	5·30	0·50	1·50	2·10	Ditto.
Table 6.									
Products :									
Khal binole	Cottonseed cake (undecorticated)		10·23	18·97	38·38	3·97	22·93	5·52	Clouston, D., Agri. Res. Inst., Pusa, Bull. No. 150. 1923.
Khal binole	Cottonseed cake (decorticated)		7·63	34·80	31·06	12·54	6·18	7·79	Ditto.
Mungphali khal	Groundnut cake		7·38	52·85	25·01	4·92	3·62	6·12	Ditto.
Tilli cake	Nigerseed cake		5·35	40·84	25·44	11·35	5·18	11·84	Ditto.
Alsi khal	Linseed cake		5·05	34·34	36·24	10·15	7·87	6·35	Ditto.
...	Jawar meal		12·31	7·60	73·82	2·59	1·66	2·02	Ditto.
Khal Rai	Mustard cake		12·92	23·69	28·81	16·64	10·58	7·36	Annett, H. E., Agri. Journ. India, Vol. VII, 1912, p. 103.
Nariyal khal	Cocoanut cake		7·72	13·62	44·57	16·53	12·45	5·11	Leather, J. W., Agri. Ledger, Vol. X. No 7, 1903.
Kusum khal	Safflower cake		12·00	16·91	41·48	3·78	19·40	6·43	Ditto.
Makai silage	Maize silage		81·87	0·77	9·44	0·21	5·50	2·21	Ditto

Appendix II.—(*continued.*)

1	2	4	5	6	7	8	9	10
Jawar silage	Sorghum silage	60·52	1·89	21·37	0·65	11·29	4·28	Ditto.
Torea khal	Rape cake	10·38	30·06	33·77	9·53	...	...	Ghare, B.K., 'Manual of Dairy Farming'. 1928, p. 294.
...	Cottonseed meal	8·32	5·84	50·17	4·60	...	...	Ditto.
Taramira khal	Rocket cake	9·44	36·00	28·48	8·83	6·86	10·39	Sen. J. N., Agri. Res. Inst., Pusa. Bull. No. 70. 1917.
Till khal	Gingelly cake	6·96	37·31	29·80	8·08	3·67	14·19	Ditto.
Surajmukhi khal	Sunflower cake	8·38	18·02	57·87	7·35	1·96	6·42	Ditto.
Khali	Mixed rape and cotton cake	9·79	26·50	40·07	8·21	10·86	4·57	Ditto.
Khali	Mixed groundnut and Niger cake	7·32	42·06	25·42	9·12	8·19	7·89	Ditto.
Jau meal	Barley meal	10·64	13·48	70·27	2·42	1·07	2·12	Ditto.
Jawi pholak	Oat husks	11·46	2·62	43·57	0·75	35·70	5·90	Ditto.
Ganna	Sugarcane fodder	31·85	1·01	37·76	1·03	21·56	6·79	Ditto.
Rab, sira	Molasses	11·29	1·52	65·84	0·00	14·78	6·57	Ditto.
Chokar, Chan Bura	Wheat bran	8·17	12·75	59·38	3·54	11·19	4·97	Lander, P. E., Mem. Agri. Dept., India. Chem. Ser. Vol. IX, 1928. No. 7.
Chawal chokar	Rice bran	8·21	5·72	34·25	8·31	25·18	18·34	Leather, J. W., Agri. Ledger. Vol. X. No. 7. 1903.

Dhan pholak	Paddy husks	8·58	3·85	34·75	2·54	29·24	21·03	Ditto.
Phol, chhillar	Gram husks	9·73	2·95	26·59	0·20	46·77	3·88	Clouston, D., Agri. Res. Inst. Ind., Bull No. 150. 1923.
Gur	Crude sugar (solid light yellow)	4·88	...	85·43	...	...	1·08	Swadi, T. S., Agri Journ. India Vol. XIV. 1919. p. 435.
Gur	Crude sugar (Sticky, semisolid, dark to red)	7·66	...	82·54	...	...	1·54	Ditto.
...	Dry Brewer's grains	10·00	18·00	46·00	6·00	15·00	4·00	Linton's Veterinary Dietetics & Animal Nutrition, p. 385.
Dudh gai	Whole cow's milk	87·00	3·50	4·80	3·50	...	0·80	Ditto. p. 387.
Mohwa dudh	Skimmed milk	90·00	3·50	4·80	0·80	...	0·80	Ditto.
Makai chokar	Maize bran	11·80	8·40	62·00	4·20	11·70	1·90	Wood, T. B., 'Rations for Live Stock.' 1922.

Appendix II.—(*concld.*)

Appendix. III.

The figures in this Appendix in columns 5, 6, 7 and 8 are entirely borrowed from Western authorities, since results of digestibility tests of the various Indian food-stuffs are not available in the country. Column 9 in the tables in this Appendix gives the authority for the figures and the following is the key to the abbreviations used.

H. & M.	Henry & Morrison—from the digestion trials reported by the State Experiment Stations and the United States Department of Agriculture, as given in their book 'Feeds & Feeding', 1917.
K.	Kellner—as given in the March, 1926 issue of 'Farm Feeding' by Dr. Charles Crowther.
L.	Linton—as calculated from his book 'Animal Nutrition and Veterinary Dietetics', 1927.
M.	Mentzel & Lengerke's Landwirtschaftliche Kalender, 1914, as given in Henry & Morrison's book (Feed & Feeding), 1917.
Lind.	Lindsay—from Massachusetts (Hatch) Experiment Station Report for 1911, as given in Henry & Morrison's book 'Feeds & Feeding', 1917.
W.	Wood—as calculated from his pamphlet on 'Rations for Livestock,' 1922
(Note)	Figures in column 4 are arrived at by subtracting figures given in column headed water (4) in Appendix II from 100.

Appendix III Average Digestibility of the Common Indian Foods.

No.	Names of the Food.		Total dry matter per cent.	Average digesitbility per cent.				Authority.
	Vernacular.	English.		Proteins.	*Carbohydrates.* Soluble.	*Carbohydrates.* Crude fibre.	Fat.	
1	2	3	4	5	6	7	8	9
	Table I.—Straws:							
1	Gundum ki prali.	Wheat straw.	91.07	23	37	50	31	M.
2	Dhan ki prali.	Rice straw.	89.99	22	46	59	23	H. & M.
3	Juar.	Juar straw.	87.32	35	47	...	32	W.
4	Turi, bhoosa.	Wheat chaff.	94.29	43	51	60	43	Combined.
5	Jai sukhi	Oat Straw.	90.12	28	51	60	39	H. & M.
6	Missa bhoosa.	Gram straw.	91.59	...	...	...	...	...
7	Jau ki prali.	Barley straw.	87·93	25	53	54	39	M.
8	Matter bhoosa	Pea bhoosa.	91.43	50	68	...	55	K.

Appendix III.—(*Contd.*)

1	2	3	4	5	6	7	8	9
	Table II.—Hays :							
1	Sukha ghas.	Hay (mixed).	91.76	50	59	55	49	M.
2	Berseem sukhi.	Clover hay.	93.99	54	64	...	53	K.
3	Lusan sukhi.	Lucerne hay.	93.96	64	62	...	33	L.
4	Jawi sukhi	Oaten hay.	96.64	54	56	52	61	H. & M.
5	Shaftal sukhi	Shaftal hay.	84.14	80	69	...	66	L.
6	Juar sukhi.	Dry Juar hay.	93.86	38	63	61	65	H. & M.
7	Gini ghas sukha.	Guinea grass dried.	91.98	57	62	62	50	Lind.
	Table III.—Food Grains :							
1	Bajra.	Bullrush millet.	88.70	59	84	41	80	H. & M.
2	Makai, Makki.	Maize.	87.70	75	95	...	90	K.
3	Chawal.	Rice.	87.20	67	91	26	82	H. & M.
4	Jawar, Jawari	Great Millet.	87.50	70	90	...	75	L.
5	Jawi, Jai.	Oats.	87.30	78	81	35	87	H. & M.
6	Gundum, Kanak.	Wheat.	87.50	85	90	...	65	K.
7	Jau.	Barley.	87.50	70	90	...	90	K.
8	Binole.	Cottonseed.	90.18	68	50	76	87	H. & M.
9	Alsi.	Linseed.	94.20	90	55	...	85	K.
10	Torea.	Rape seed.	93.31	80	77	...	95	L.
11	Safed Til.	Gingelly. Sesame.	95.27	90	53.3	...	95	L.

12	Channa.	Gram.	88.80	80	94.3	...	75	L.
13	Mattar.	Peas.	88.20	86	92	...	80	K.
14	Massur.	Lentil.	88.20	82	93	...	50	L.
15	Soya.	Soya bean.	89.00	85	64	...	88.8	L.
	Table IV.—Roots :							
1	Gajar.	Carrots.	11.70	76	94	100	100	Lind.
2	Shalgham.	Turnips.	16.60	73	92	51	...	M.
3	Alu.	Potatoes.	21.20	51	90	...	...	M.
	Table V.—Green Fodders :							
1	Jawi, Jai.	Green oats.	16.49	73	63	55	70	H. & M.
2	Jau hare.	Green barley.	20.38	71	72	59	56	H. & M.
3	Khasil. Kanak.	Green wheat.	17.35	70	75	...	60	K.
4	Makai hare.	Green maize.	11.08	66	71	65	86	Lind.
5	Moth hare.	Green moth.	25.30	70	75	...	60	K.
6	Sarson hari.	Green sarson.	13.87	70	75	...	60	K.
7	Juar hari.	Millets (green).	30.24	44	73	55	64	Lind.
8	Juar pakki.	Millets (ripe).	32.98	47	75	62	70	Lind.
9	Senji.	Melilot.	15.60	70	75	...	60	K.
10	Lusan.	Lucerne.	25.00	74	72	42	38	H. & M.

1	2	3	4	5	6	7	8	9
11	Berseem.	Egyptian clover.	18.37	77	74	56	66	H. & M.
12	Patte Gajar.	Carrot leaves.	18.20	65	66	56	55	W.
13	Patte Shalgham.	Turnip leaves.	11.60	68	80	53	40	W.
14	Gobhi.	Cabbage.	8.90	86	99	100	56	Lind.
15	Ghas.	Mixed grasses (immature).	29.70	70	75	66	62	M.
16	Ghas.	(Haying stage).	30.80	56	61	62	46	M.
17	Gini ghas.	Guinea grass.	36.62	70	75	...	60	K.
18	Thohar.	Cactus. (Prickly pear).	7.35	50	81	47	68	H. & M.
	Table VI.—Products.							
1	Khal binole.	Cottonseed cake (Undecorticated).	89.77	75	50	...	95	K.
2	Khal binole.	Cottonseed cake (Decorticated).	92.37	85	70	...	95	K.
3	Mungphali Khal.	Groundnut cake.	92.62	90	85	...	90	K.
4	Tilli Khal.	Nigerseed cake.	94.65	85	87	...	50	L.
5	Khal Alsi.	Linseed cake.	94.95	85	80	...	90	K.

6	Rai Khal.	Mustard cake.	87.08	...	...	...	...	...
7	Nariyal khal.	Cocoanut cake.	92.28	90	87	23	100	H. & M.
8	Torea Khal.	Rape Cake.	89.62	76	75	...	75	L.
9	Till Khal.	Gingelly cake.	93.04	90	57	...	91	L.
10	Chokar.	Wheat bran.	91.83	78	72	31	68	H. & M.
11	Chhan makki.	Maize bran.	88.20	60	80	71	80	H. & M.
12	Phhak chawal.	Rice bran.	91.79	65	79	25	77	H. & M.
13	Phholak Dhan.	Paddy husks.	91.42	10	35	1	67	M.
14	Phhol Jawi.	Oat husks.	88.54	50	53	60	77	H. & M.
15	Phhol channe.	Gram husks.	90.27	...	...	...	...	...
16	Rab, Sira.	Mollasses.	88.71	33	89	...	...	L.
17	Makki silage.	Maize silage.	18.13	100	75	...	30	L.
18	Juar silage.	Sorghum silage.	39.48	..	64	58	56	Lind.
19	Brewer's Grains.	(Dry).	90.00	72	60	...	100	L.
20	Dudh Gai.	Cow's milk.	13.00	94	100	...	100	L.
21	Mohwa dudh	Skimmed milk.	10.00	94	100	...	100	L.

Appendix III.—(*concld.*)

Appendix IV.

Average Digestible Nutrients in Indian Foodstuffs.

No.	Names of the Food-stuff.		Digestible Nutrients in 100 parts.		
	Vernacular	English	Proteins	Carbo-hydrates	Fat.
1	2	3	4	5	6
	Straws :				
1	Gundum ki prali	Wheat straw	0·685	30·997	0·366
2	Dhan ki prali	Rice straw	0·679	35·744	0·278
3	Juar	Juar straw	1·480	16·200	0·340
4	Turi, Bhoosa	Wheat chaff	0·739	46·566	0·309
5	Jai Sukhi	Oat straw	0·840	39·146	0·768
6	Jau ki prali	Barley straw	1·952	30·772	0·551
7	Mattar bhoosa	Pea bhoosa	5·420	28·988	1·661
	Hays :				
1	Sukha ghas	Hay (Mixed)	1·650	43·851	0·744
2	Berseem sukhi	Clover hay	6·555	29·593	1·393

3	Lusan sukhi	Lucerne hay	9·770	26·870	0·670
4	Jawi, Jai sukhi	Oaten hay	3·070	44·887	1·120
5	Shaftal sukhi	Shaftal hay	11·280	27·800	1·460
6	Juar sukhi	Dry Juar hay	1·090	52·280	0·570
7	Gini ghas sukha	Guinea grass hay	5·140	42·885	0·840
	Food Grains:				
1	Bajra	Bullrush millet	6·136	60·675	2·640
2	Makai, Makki	Maize	7·125	67·165	3·240
3	Chawal	Rice	4·891	71·264	0·492
4	Jawar, jawaree	Great millet	6·510	64·820	1·500
5	Jawi, Jai	Oats	7·878	51·170	2·001
6	Gundum, Kanak	Wheat	11·476	61·560	0·780
7	Jau	Barley	8·050	63·000	1·170
8	Binole	Cottonseed	11·770	30·022	16·220
9	Alsi	Linseed	16·119	14·366	34·263
10	Torea	Rape seed	14·630	18·020	37·700
11	Safed til	Gingelly, Sesame	17·388	8·150	47·030
12	Channa	Grams	15·600	50·700	3·450
13	Mattar	Peas	24·252	50·600	1·200
14	Massur	Lentil	20·730	54·300	0·600
15	Soya	Soya bean	30·100	16·700	7·900

Appendix IV.—*Contd.*

1	2	3	4	5	6
	Roots and Tubers:				
1	Gajar	Carrots	0·914	8·600	0·200
2	Shalgham	Turnips	1·000	6·000	0·200
3	Alu	Potatoes	1·100	15·800	0·100
	Green Fodders:				
1	Jai hari, Jawi	Green Oats	0·680	7·865	0·259
2	Jau hare	Green barley	1·740	9·763	0·250
3	Khasil, kanak	Green wheat	1·309	5·670	0·240
4	Makai hari	Green maize	0·740	5·316	0·260
5	Moth hare	Green moth	2·240	9·000	0·534
6	Sarson hari	Green sarson	1·400	3·480	0·282
7	Juar hari	Millet (cut green)	0·242	17·305	...
8	Juar hari	Millet (cut ripe)	0·300	20·239	...
9	Senji	Melilot	1·883	4·620	0·216
10	Lusan	Lucerne	3·290	10·964	0·205
11	Berseem	Egyptian clover	2·470	8·352	0·330
12	Patte gajar	Carrot leaves	2·200	6·100	0·500
13	Patte shalgham	Turnip leaves	1·500	5·000	0·200
14	Gobhi	Cabbage	1·900	5·600	0·200
15	Ghas	Mixed grasses (Immature)	3·600	14·500	0·900

16	Ghas	Mixed grasses (Haying stage)	1·700	15·200	0·600
17	Gini ghas	Guinea grass	1·316	14·520	0·504
18	Thohar	Cactus (prickly pear)	0·155	3·939	0·140
	Products and Concentrates :				
1	Khal binole	Cottonseed cake (Undecorticated)	14·227	19·190	3·771
2	Khal binole	Cotton seed cake (Decorticated)	29·580	21·742	11·913
3	Mungphali khal	Groundnut cake	47·565	21·258	4·428
4	Till khal (kali)	Nigerseed cake	34·650	22·100	5·670
5	Khal alsi	Linseed cake	29·189	28·992	9·135
6	Nariyal khal	Cocoanut cake	12·258	41·639	16·530
7	Torea khal	Rape seed cake	22·940	25·420	7·140
8	Till khal (safed)	Gingelly cake	33·910	17·000	7·400
9	Chokar, Chhan	Wheat bran	9·945	46·222	2·407
10	Chhan makki	Maize bran	5·040	57·907	3·360
11	Phhak Chawal	Rice bran	3·724	33·352	6·398
12	Phholak dhan	Paddy husks	0·385	12·454	1·701
13	Rab, Sira	Mollases	0·500	58·580	...
14	Phholak jawi	Oat husks	1·310	44·512	0·577
15	Makki silage	Maize silage	0·770	7·080	0·063
16	Juar silage	Sorghum silage	...	20·225	0·364
17	...	Brewers grains	13·000	28·000	6·000
18	Dudh gai	Cow's milk	3·300	4·800	3·500
19	Mohwa dudh	Skimmed milk	3·300	4·800	0·800

Appendix V

Table showing requirements of digestible nutrients for maintenance purposes by cattle of varying weights.

(*Modified Wolff-Lehmann Standards*)

Body Weight in lbs.	Total dry matter in lbs.	Digestible nutrients in lbs.		
		Protiens	Carbo-hydrates	Fat
A	B	C	D	E
100	3·3	0·138	1·38	0·019
150	4·5	0·184	1·84	00·26
200	5·5	0·227	2·27	0·032
250	6·4	0·265	2·65	0·037
300	7·3	0·300	3·00	0·043
350	8·1	0·325	3·25	0·047
400	8·9	0·368	3·68	0·052
450	9·7	0·400	4·00	0·057
500	10·4	0·431	4·31	0·061
550	11·1	0·460	4·60	0·065
600	11·8	0·489	4·89	0·069
650	12·5	0·518	5·18	0·074
700	13·2	0·545	5·45	0·077
750	13·9	0·573	5·72	0·081
800	14·5	0·598	5·98	0·085
850	15·1	0·624	6·24	0·089
900	15·7	0·650	6·50	0·092
950	16·4	0·675	6·75	0·096
1000	17·0	0·700	7·00	0·100
1050	17·5	0·724	7·24	0·103
1100	18·1	0·748	7·48	0·106
1150	18·7	0·772	7·72	0·110
1200	19·3	0·805	8·05	0·113

Appendix VI. Ration Statement No. 1

Ration Table.—Chintaldevi Cattle Farm, South India.

Class of Animal.	Rice bran.	Groundnut cake.	Ragi or sajja flour.	Horse gram.	Salt.	Mineral Mixture.
	lb.	lb.	lb.	lb.	oz.	oz.
Milch Cows:						
Class A	3	3	1	...	2	1
Class B	2½	2½	1	...	2	1
Class C	2½	2	1	...	2	1
Parturition Cows ...	3	2	...	...	2	...
Dry Cows and Heifers ...	2	2	...	...	1½	1
Calves:						
3 to 6 months ...	1	½	...	...	½	...
6 to 12 months ...	1½	1	...	...	1	½
Special young Bulls ...	1½	2	...	1	2	1
Young Bulls over one year	2	2	...	...	2	1
Breeding Bulls ...	2	3	...	...	2	...
Work animals ...	3	3	...	...	2	...

Class A. ... giving 15 lb. milk per day and over.
Class B. ... giving 10 to 15 lb. milk per day.
Class C. ... giving 10 lb. and less of milk per day.

(Data kindly supplied by the Deputy Director of Agriculture, Livestock, Hosur Farm, on request.)

Appendix VI. Ration Statement No. 2

Agricultural College Dairy Herd, Coimbatore.

Class of Animal.	Groundnut cake	Cottonseed.	Rice bran.	Dholl husks.	Salt.	Wheat bran.	Lime and Bone-meal.*	Remarks.
	lb.	lb.	lb.	lb.	oz.	lb.	oz.	
Milch Cows :								
Daily yield :—								
25 to 30 lb. ...	3½	3	2	3½	2	...	1	*Young Stock :*—
20 to 25 lb. ...	3	2½	2	3	2	...	1	Milk Ration.
15 to 20 lb. ...	2½	2	2	2½	2	...	1	1st. Month—6 to 8lb. whole milk.
10 to 15 lb. ...	2	1½	1½	2	2	...	1	2nd. month to 6th. month.—whole
5 to 10 lb. ...	2	1	1	1½	2	...	1	milk gradually reduced
Below 5 lb. ...	1	1	1	1	2	...	1	and gruel made up of

Cows due to calve in one month.	2	1	1	2	2	...	1		separated milk, ragi flour and linseed meal is substituted.
Dry Cows ...	1	½	½	1	2	...	1		
Breeding Bulls ...	2	1½	1	1½	2	...	1		After 6th. month.—Gruel fed only if separated milk is available.
Young Stock:									
6 to 12 months ...	1	½	½	...	1	1	½		*Gruel Mixture:*—
3 to 6 months ...	½	...	...	...	...	1	½		Separated milk ... 20 to 30 lb.
1 to 3 months ...	½	...	...	...	...	½	½		Ragi flour ... 1 to 1½ lb.
									Linseed meal ... 1 lb.

*Equal parts of fine steamed bone-meal and fine shell lime.

Roughage.—

Milch cows and young stock.....Green stuff all the year round.

Dry cows and Breeding bulls.....Dry fodder, quantity *ad. lib.*

Green roughages consist of cholam, maize, Guinea grass, Elephant grass, lucerne and green grass, etc., according to their availability.

Dry roughages consist of mostly cholam straw, paddy straw and ragi straw.

(Data kindly supplied by the Deputy Director of Agriculture, Livestock, Hosur Cattle Farm, on request.)

Appendix VI.—Ration Statement No. 3

Ration statement of the Imperial Institute of Animal Husbandry & Dairying, Bangalore.

Class of Animal.	Dry fodder. lbs.	Mixed ration. lbs.	Ground-nut cake. lbs.	Wet grains. lbs.	Common salt. ozs.	Linseed cake. lbs.	Bran. lbs.	Barley. lbs.	Gram. lbs.	Whole milk. lbs.	Separated milk. lbs.	Remarks.
Cows 30 lbs. & over ...	18	6	3	12	1	...	2	...	...	...	...	
Cows 25 lbs. to 30 lbs....	18	5	2	12	1	...	2	...	...	...	...	
Cows 20 lbs. to 25 lbs....	18	5	2	12	1	...	1	...	...	...	...	
Cows 15 lbs. to 20 lbs....	18	5	2	12	1	...	...	...	...	...	...	
Cows 10 lbs. to 15 lbs....	18	4	1	8	1	...	...	...	...	...	...	
Cows under 10 lbs. ...	18	3	1	4	1	...	...	...	...	...	...	
Dry cows. ...	18	3	1	...	1	...	...	...	...	...	...	

Cows down calvers ...	18	4	2	...	1	...	...	...	...	...	...			
Young stock 12 months and over	12	3	1	...	1 Also 8 lbs.		Silage	...	...	...	...			
Young stock 6-12 months	6	2	1	...	1	...	...	...	...	...	...			
Calves 4 months to 6 months	6	...	1	...	½	...	1	...	...	...		4		
Calves 3 months to 4 months	4	...	1	...	½	...	1	...	...		1	8		
Calves 6 weeks to 3 mths.	4	...	1	...	½	...	1	...	...		5	5		
Calves 1 month to 6 weeks.	...	...	...	...	...	...	...	...	...		7	3		
Calves birth to 1 month	...	...	...	...	...	...	...	...	...		9	...		
Young stock bulls. ...	12	5	1	...	1,8 lbs silage.		...	...	2	2	...	...		
do. ...	12	4	1	...	1	...	...	...	2	...	...	...		
do. Bullocks ...	12	3	1	...	1	...	...	...	..	...	...	...		
Bullocks. ...	16	5	2	...	1	1	...	...	...	...	...	...		
Buffaloes. ...	18	6	3	12	...	...	...	...	2	...	...	...		
Bulls including buffalo-bulls.	18	5	2	...	1	...	..	...						

Mixture is made up as follows :—
Bran 700 lbs, Linseed cake 300 lbs.
Chenna Bhusa 500 lbs.

Total 1500 lbs.

Scindi cows as above except mixed ration in lieu of oil cake.
Saniwal bulls similar ration as in last item except gram 2 lbs. in lieu of 2 lbs. mixture.
(Data kindly Supplied by Mr. A. Lamb, Superintendent, Imperial Institute of Animal Husbandry & Dairying, Bangalore.)

Appendix VI.—Ration Statement No. 4.

Ration statement of the Co-operative Dairy Farm, Dogachia, for the week ending 15th December 1926.

(Data kindly supplied by Mr. H. C. Verma, I. D. D.)

Serial No.	Classes of animals.	Dry fodder seers.	Mustard cake seers.	Wheat bran seers.	Channa bhusa seers.	Gram seers.	Common salt Chhataks.
1	Bulls	10	1	3	...	2	1
2	Buffaloes—Class I (15 to 20 lbs. milk) ...	10	1¼	2	2	1½	1
3	Buffaloes—Class II (10 to 14 lbs. milk) ...	10	1¼	1½	2	1¼	1
4	Calves—3 to 4 months ...	3	½	½	½	...	½

Appendix VI. Ration Statement No. 5

Ration Table.—Buffalo Breeding Station, Guntur, South India.

Class of Animal.	Rice bran.	Groundnut cake.	Cotton seed	Salt.	Horse gram.	Fish meal.	Bone-meal and lime.	Grass hay.
	lb.	lb.	lb.	oz.	lb.	oz.	oz.	lb.
Milch Buffaloes :								
Class A. ...	3	2	2	1	...	...	3	15
Class B. ...	3	2	1	1	...	...	3	15
Class C. ...	2	1½	1	1	...	...	2	15
Buffaloes due to calve.	2	1½	1	1	...	...	2	...
Heifers over one year.	2	1	1	1	...	...	2	...
Bulls over one year.	2½	1	1	1	1	½	2	15
Breeding Bulls...	3	1½	1	1	1	½	3	15
Calves :								
3 to 6 months.	1	½	...	½	...	...	...	5
6 to 12 months.	2	1	...	1	...	½	½	8

The quantity of bulky fodder has been reduced in some owing to the fact that there is plenty of bite in the reserve.

Dry Buffaloes are not being fed with concentrates owing to the reason cited above.

Class A. ..... yielding 15 lb. of milk or over daily.

Class B. ..... yielding 10 to 15 lb. of milk daily.

Class C. ..... yielding under 10 lb. of milk daily.

(Data kindly supplied by the Deputy Director of Agriculture, Livestock, Hosur Cattle Farm, on request.)

Appendix VI. Ration Statement No.6

Central Cattle Farm, Hosur, South India.

Class of Animal.	Ground nut cake.	Rice bran.	Ragi flour.	Oats crushed.	Bengal gram husks.	Wheat bran.	Horse gram.	Fish meal.	Salt.	Lime & Bonemeal	Green stuff.	Hay.
	lb.	lb.	lb.	lb.	lb.	lb.	lb.	oz.	oz.	oz.	lb.	lb.
Milch Cows :												
Class A. ...	1 1/2	3/4	...	...	3/4	...	...	...	2	...	20 to 30	12
Class B. ...	1	1/2	...	...	1/2	...	...	...	1 1/2	...	20 to 30	12
Class C. ...	...	...	...	.	...	...	...	...	...	...	20 to 30	12
N. P. Class ...	1/2	1/4	...	...	1/4	...	...	...	1 1/2	...	20 to 30	12

Calves ...	½	...	4½ oz.	...	¼	¼	...	...	½	½	15	...
Horses ...	...	...	...	3	...	3	3	...	2	...	40 or	15
Breeding Bulls or Work Cattle.	2	1	...	...	...	1	1	...	2	...	50 or	18
Young Bulls. 2 to 3 years old.	1	1	...	...	...	...	...	2	1	...	30 or	12
Young Bulls Special.	1	1	1	...	...	...	...	2	1	...	30 or	12
Young stock 1 to 2 years.	½	½	8 oz.	...	...	...	...	2	1	½	15 or	5
Dry Cows and heifers in poor condition.	1	1	1	...	...	...	...	...	2 1*	...	30 or	12

*Heifer

Some of the good yielders in Class A cows get in addition to cakes etc., 2 lb of wheat bran each.
The newly calved cows get a pound of treacle in addition, which is usually mixed along with food.
Bulky food for young bulls. special bulls and young stock and dry cows and heifers in poor condition, is cut short when grazing is available.
All these animals have good grazing *ad. lib.* all the year round.

(Data kindly supplied by the Deputy Director of Agriculture. Livestock. Hosur Cattle Farm, South India. on request.)

Appendix VI. Ration Statement No. 7

Ration Statement of the Imperial Cattle Breeding Farm, Karnal, Punjab.

Class of Animal.	Mixture Ration lb.	Charri Silage lb.	Fresh Milk lb.	Separated Milk lb	Bhoosa lb.	Remarks.
1. Cows giving 27 lb. milk.	11	30	...	...	5	
2. Cows giving 18 lb. milk.	8	30	...	...	5	
3. Cows giving 15 lb. milk.	7	30	...	...	5	
4. Cows giving 12 lb. milk.	6	30	...	...	5	Mixture Ration is
5. Cows giving 9 lb. milk.	5	30	...	...	5	made as follows:—
6. Cows giving 6 lb. milk.	4	30	...	...	5	
7. Cows giving 3 lb. milk.	3	30	...	...	5	Gram 186 Mds.17Srs.
8. Milking Buffaloes.	8	30	...	...	5	Bran 332 „ 12 „
9. Dry Stock.	2	30	...	...	5	Barley 87 „ 27 „
10. Calving Stock.	4	30	...	...	5	Rock-salt
11. Bulls.	5	30	...	...	5	14 „ 25 „
12. Bulls on Special Ration.	4	30	...	...	5	Mustard-cake
13. Calves under one month.	½	...	8	...	...	158 „ 29 „
14. Calves 1 to 6 months.	¾	...	4	6	...	
15. Calves 6 months to 1 yr.	1	15	...	...	5	
16. Young stock 1 to 3 years.	2	20	...	...	5	
17. Bullocks.	4	30	...	...	5	

(Data kindly supplied by Mr. F. E. Traynor, Superintendent, Imperial Cattle Breeding Farm, Karnal, Punjab).

Appendix VI.—Ration Statement No. 8

Ration statement in force for the year 1930 at the Willingdon Cattle Farm Malir (Karachi).

	Date.		No. of Milch cows.	Total milk yield after suckling.	Daily Milk average.	Total concentrates to the whole herd.	Ratio of concentrates to milk yield.	Concentrates in lbs.						Roughages in lbs.						
								Wheat Bran.	Gram husk.	Cocoanut cake.	Til cake.	Rape cake.	Salt.	Hay.	Kadbi.	Green Jawari.	Green Maize.	Pulses.	Green Berseem.	Green oats.
			in lbs.	in lbs.	in lbs.	in lbs.														
Hot weather.	March 4th	*	28	366	13-0	175	1: 2-09	85	45	...	45	...	2	140	60	...	...	...	290	670
Monsoon weather.	April 5th	†	27	343	12-7	210	1: 1-63	100	60	...	50	...	2	200	...	...	...	...	2000	...
	May „	‡	25	293½	11-7	200	1: 1-46	100	40	...	60	...	2	300	...	...	700	...	...	...
	June „	‡	24	261	10-8	200	1: 1-3	100	50	...	50	...	2	300	...	...	...	1040	...	...
	July „	‖	25	358	14-2	200	1: 1-79	100	50	...	50	...	2	250	...	1200	...	600	...	...
	August „	¶	28	397	14-1	120	1: 3-3	60	30	...	30	...	2	100	...	300	...	600	...	...
	Sept. „	§	26	336½	12-9	201½	1: 1-68	81¼	51¼	...	69	...	3	...	34	...	1040	...	...	...
	Oct. „	**	26	320	12-3	195½	1: 1-64	86¼	43¼	13	53	...	3	...	60	1000	...	..	..	...
Cold weather.	Nov. „	**	23	308	13-3	165	1: 1-87	85	30	...	30	20	3	100	...	700	500	...	...	...
	Dec. „	**	23	371	16-1	170	1: 2-18	90	30	5	45	...	3¼	300	...	400	...	...	...	110
	Jan. 3rd	**	23	401	17-3	180	1: 2-42	100	20	5	40	...	3¼	250	50	...	...	...	...	1470

*Jungle Grazing on dry grass for 5 hours
† do. Poor Grazing
‡ do. very Poor „
‖ do. some green grazing

§ Jungle grazing on some dry grass.
** do. on dry grass
¶ do. plenty of green „

Appendix VI.—Ration Statement No. 9

Ration statement of the Agricultural College Dairy, Kirkee.

(Table compiled from the data kindly supplied by the Manager, Agricultural College Dairy, Kirkee.)

Animal.	Composition of the Mixture in parts.						Average daily allowance per head in lbs.	Remarks.
	Wheat bran.	Ground nut cake	Tur Chuni*	Cotton seed.	Crushed gram.	Crushed Kulthi.		
Cows—for every 10 lbs. of milk yielded	3	1	1	1	...	...	4·5 to 5	Green fodder like oats, peas, maize, sorghum, etc. is given ad-lib. in addition to the concentrates according to season and availability.
Buffaloes Do Do	3	1	1	2	...	...	5 to 5·5	
Youngstock :					...			
From 1½ months to 3 months ...	W.B.O	...	...	...	...	...	¼	
From 4 months to 6 months ...	4	1	2	...	...	...	½	
From 7 months to 9 months ...	4	1	2	...	...	...	¾	
From 10 months to 12 months ...	4	1	2	...	...	...	1	
From 1 year to 3 years ...	3	1	2	...	...	...	2	
Bulls for light service ...	4	1	1	...	2	...	5 to 6	
Bulls for heavy service ...	4	1	1	...	2	...	6 to 7	
Bullocks (1,000 lbs.) very light work	2	2	...	1	...	2	4	
Bullocks (1,000 lbs.) medium work...	2	2	...	1	...	2	5 to 6	
Bullocks (1,000 lbs.) heavy work ...	2	2	...	1	...	2	6 to 7	
Dry Stock (Cows)	4	1	1	...	...	...	1½	
Dry stock (Buffaloes)	4	1	1	...	...	...	2	
Pregnant animals (advanced) ...	W.B.O	...	...	...	...	...	2	

*Crushed arhar or pigeonpeas (Cajanus indicus.)

W. B. O.—Wheat bran only.

Appendix VII.

Availability of Green Fodders at the Jehangirabad farm, Multan District.

Month.	Names of the green fodders.															Remarks.
	Wheat.	Lucerne.	Turnips.	Oats.	Chiral.	Dry Jawar.	Gram.	Senji.	Methra.	Maize.	Jawar.	Gawara.	Mash.	Moth.	Rawan.	
January.	x	x	x	x	x	x										X This marks availability.
February.	x	x	x	x	x	x	x									
March.	x	x			x	x	x	x	x							
April.		x					x	x	x							
May.		x								x						
June.		x								x						
July.		x								x	x	x				
August.		x								x	x	x				
September.		x								x	x	x				
October.		x								x	x	x	x	x	x	
November.		x					x			x			x	x	x	
December.		x	x	x			x						x			

(By kind permission of Sardar Dost Mohammad Khan, Proprietor, Jehangirabad Farm, Multan District.)

Appendix VIII

Availability of Green Fodders in the Punjab.

No.	Names of Green Fodders.			Seed rate per acre	Method and time of sowing	Time when available in green state	Remarks
	English	Botanical	Vernacular				
1	2	3	4	5	6	7	8
1	Wheat	Triticum vulgare	Kanak, Gundum	24 seers	Sown broadcast, or in lines 9″ apart. From middle of October to end of December.	End of December to the end of March	Should be given cut up and mixed with dry roughages, the proportion being one part of wheat to three parts of dry fodder. Ripened plants are made into straw or *bhoosa*. Can be made into silage.

2	Barley	Hordeum vulgare	Jao	28 to 30 seers	Sown broadcast or in lines 9″ apart. Middle of October to end of December.	End of December to the end of March.	Ditto.
3	Oats	Avena sativa	Jawi	32 seers	Sown broadcast or in lines 9″ apart. Middle of October to the end of December.	From the end of December, plentiful in February and March. Ripens in April.	Should be given cut up and mixed with other roughages.
4	French oats	Ditto.	Ditto.	Ditto.	Ditto.	From February to May.	Should be given cut up and mixed with other roughages. Growth luxuriant and yield high. If cut and dried when grain begins to fill, it forms good hay. Oats supply green fodder at the time of year when it is usually scarce.

1	2	3	4	5	6	7	8
5	Scotch oats	Ditto.	Ditto.	Ditto.	Ditto.	Ditto.	Should be given cut up and mixed with other roughages. Can be made into hay or ripened plants can be made into *bhoosa*.
6	Maize	Zea mays	Makki	12 seers	Broadcast. From March to August.	From June to October.	Should be given cut up Any excess should be made into silage.
7	Bullrush millet	Pennisetum typhoideum	Bajra	2½ seers	Broadcast. May to August depending upon rains.	September, October and part of November.	Ditto.
8	Great millet	Andropogon sorghum	Jowar or Charri	24 seers	Broadcast. For early fodder March to April, otherwise any time in July.	July, August, September to beginning of October.	Should not be given too young. Should be given cut up. Also made into silage.

9	Gram	Cicer arietinum	Channa	15 seers	Broadcast or in lines. Middle of September to end of October.	February and March.	It should be given in small quantity and judiciously, otherwise it is liable to cause tympanites.
10	Lentil	Lens esculentum	Massar	12 to 16 seers	Broadcast or in lines. October and November.	Middle of January to March.	It should only be given in small quantity. It causes tympanites.
12	Mellilot, Indian clover	Mellilotus parviflora	Senji	20 seers	Broadcasted in standing water after irrigating the field. Early October.	February and March.	Excellent fodder for cattle and milch cows, but must be given mixed with *bhoosa* or grasses, otherwise fed alone it causes tympanites. It is also dried for use in time of scarcity.
12	Moth	Phaseolus aconitifolius	Moth	8 seers	Broadcast. Mixed with Jowar and Bajra in June and July.	September and October.	Should be given in small quantities only.

Appendix VIII—(*contd.*)

1	2	3	4	5	6	7	8
13	Lucerne	Medicago sativa	Lusan	4 to 5 seers	Broadcast, in lines or on ridges. October.	Perennial fodder. Gives 8 to 10 cuttings a year.	An excellent fodder for horses, but is not considered suitable for milch cows on account of its heating effects. It should be given in small quantities mixed with other fodders.
14	Shaftal	Trifolium rusupinatum	Shaftal or Shatala	3 to 4 seers	Broadcast. End of September to beginning of October.	Beginning of February to May.	It causes severe tympanites when fed too much and directly after cutting. It should be fed 2 or 3 hours after cutting and mixed with other roughages.
15	Berseem, Egyptian clover	Trifolium alexandrinum	Berseem	15 seers	End of September.	Beginning of December to June.	Can be fed alone, but should preferably be given cut and mixed with other fodders, as it might cause tympanites otherwise.

16	Fenugreek	Trigonella foemum-graecum	Metha	10 seers	October to November.	End of February to middle of April.	Should be given cut up and mixed with other fodders. When fed alone and in large quantities it may cause tympany.
17	Vetch	Cyamopsis psoralioides	Guara	10 seers	April to June.	July, August and September.	It causes tympanites in cattle if fed when ripened. Should be given in small quantity mixed with other roughages.
18	Desi Rape	Brassica campestris	Sarson	2½ seers	Broadcast. October and November.	End of December, January and February.	Given cut and mixed with other fodders.
19	Japan Rape	Ditto.	Ditto.	Ditto.	Early September to November.	End of December January and February.	Yields high. Should be given cut up and mixed with other fodders. Supplies green when it is usually scarce otherwise.

1	2	3	4	5	6	7	8
20	Rocket	Eruca sativa	Tara Mira	Ditto.	October and November.	End of December January and February.	Given to cattle when no other green fodder is available, mixed with other dry roughages.
21	Turnips	Brassica rapa	Shalgham	Ditto.	September and October.	December, January and February.	It gives its own characteristic taste to milk, so should be given in moderate amounts to increase the flow of milk. Better fed after milking.
22	Cabbage	Brassica obracia	Gobhi	Ditto.	Ditto.	Ditto.	Ditto.
23	Sugarcane	Saccharum officinarum	Ganna	Sown vegetatively by canes.	May and June.	Only cane tops are fed in the end of November, December, January and to the middle of February.	Should be given cut up in small pieces.
24	Different grasses	...	Ghas	...	...	August, September and October.	Should be given as much as the animals can eat.

25	Guinea grass	Panicum maximum	Gini ghas	Planted by means of roots. 5000 root-stocks are sufficient to plant an acre.	Can be planted any time from April to August. Rootstocks are stuck in the ground and watered immediately.	Perennial grass, can give 5 or 6 cuttings in a year. Growth is somewhat slack in winter.	It is a nutritious grass; should be fed cut up. Can make good hay and can be turned into silage.
26	Elephant grass	Pennisetum purpureum	Elephant ghas	5000 cuttings from mature stalk or about as much root stocks are sufficient to plant an acre.	Cuttings from mature plants 1½" long with two nodes are stuck in the ground and watered immediately afterwards. Any time from April to August	Perennial grass. Can give 5 to 6 cuttings in a year.	It is a very high yielding grass; can yield as much as 2500 maunds of green fodder in a year. Can be fed green. Its best use is to make it into silage.
27	Sudan grass	Andropogon sorghum	Sudan ghas.	8 to 10 seers in an acre.	Sown broadcast or in lines in the end of March or beginning of April.	From end of May to December. Can give four cuttings on the average.	Can be fed green, made into hay or silage. Stalks are very thin and very little amount of fodder goes waste even when it is fed without cutting.

Appendix IX. Calving Table (Cows).

(For alternate days only.)

Service	Jan.	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	30	31	Jan.
Calving	Oct.	10	12	14	16	18	20	22	24	26	28	30	1	3	5	7	8	9	Nov.
Service	Feb.	1	3	5	7	9	11	13	15	17	19	21	23	25	27	...	...	...	Feb.
Calving	Nov.	10	12	14	16	18	20	22	24	26	28	30	2	4	6	...	...	...	Dec.
Service	March.	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	30	31	March,
Calving	Dec.	8	10	12	14	16	18	20	22	24	26	28	30	1	3	5	6	7	Jan.
Service	April.	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	30	...	April,
Calving	Jan.	8	10	12	14	16	18	20	22	24	26	28	30	1	3	5	6	...	Feb.
Service	May.	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	30	31	May.
Calving	Feb.	7	9	11	13	15	17	19	21	23	25	27	1	3	5	7	8	9	March,
Service	June.	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	30	...	June.
Calving	March	10	12	14	16	18	20	22	24	26	28	30	1	3	5	7	8	...	April,
Service	July	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	30	31	July.
Calving	April	9	11	13	15	17	19	21	23	25	27	29	1	3	5	7	8	9	May.

Service	Aug.	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	30	31	Aug.
Calving	May	10	12	14	16	18	20	22	24	26	28	30	1	3	5	7	8	9	June.
Service	Sept.	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	30	...	Sept.
Calving	June	10	12	14	16	18	20	22	24	26	28	30	2	4	6	8	9	...	July.
Service	Oct.	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	30	31	Oct.
Calving	July	10	12	14	16	18	20	22	24	26	28	30	1	3	5	7	8	9	Aug.
Service	Nov.	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	30	...	Nov.
Calving	Aug.	10	12	14	16	18	20	22	24	26	28	30	1	3	5	7	8	...	Sept.
Service	Dec.	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	30	31	Dec.
Calving	Sept.	9	11	13	15	17	19	21	23	25	27	29	1	3	5	7	8	9	Oct.

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