THE MODERN HOMESTEAD

ITS ARRANGEMENT AND CONSTRUCTION

BY

RICHARD HENDERSON

THE ESTATE LIBRARY SERIES.

THE MODERN HOMESTEAD.

BY PERMISSION, THIS BOOK IS

DEDICATED TO

HIS GRACE THE DUKE OF PORTLAND,

WHOSE ESTATES,

BOTH IN ENGLAND AND SCOTLAND,

LIKE THOSE OF MANY OTHER LANDOWNERS,

ARE CHARACTERISED BY

WELL-APPOINTED AND EFFICIENT HOMESTEADS.

THE MODERN HOMESTEAD:

ITS ARRANGEMENT AND CONSTRUCTION.

BY

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THE ESTATE LIBRARY SERIES.

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INTRODUCTORY NOTE.

THERE is need—and in many cases there is room—for greater economy in providing the buildings necessary for agricultural holdings. At the present day neither the owner nor the occupier of land can afford to spend money lavishly or thoughtlessly in any form of farm equipment. The time for lordly estate or farm management has gone past, probably never to return. Even when the strictest economy is observed it is no easy matter for landowners or farmers to draw from land anything like a reasonable return for their capital employed upon it. With these significant circumstances in view, one all the more heartily welcomes the appearance of such a work as Mr. Henderson offers to the public in the volume entitled "The Modern Homestead."

For the preparation of this volume Mr. Henderson has exceptional qualifications. His tastes, training and experience have all combined to fit him for such an undertaking. He is familiar with the numerous types of homesteads to be seen upon present-day farms, and has made it his business to study their peculiar features, their weak points, and their strong. He has had extensive and varied practical experience both in the erection of new homesteads and in the repairing and remodelling of old. Armed with this knowledge and guided by a clear and commendable conception of the principles which should be uppermost in the minds of modern farm architects, he set himself to the preparation of a work which cannot fail to be of great service both to owners and occupiers of land.

An outstanding feature in "The Modern Homestead" is its consistent and thoroughly wholesome inculcation of the principle of the strictest and soundest economy. Unnecessary or unremunerative outlay of money is carefully guarded against at every point. A minimum expenditure, consistent with efficiency, is an object which Mr. Henderson has kept constantly in view. Economy in labour is another point of prime importance in the designing of farm homesteads, and to this also Mr. Henderson has given careful attention.

The author is a skilful draughtsman and has done well to make free use of this accomplishment. The many excellent sketches and plans it contains enhances greatly the practical usefulness of the book.

JAMES MACDONALD.

PREFACE.

It is undeniable that much inconvenience results to agriculture in general on account of the want of system displayed throughout the country in the arrangement of farm buildings. Besides this inconvenience, which means increased labour to the occupiers, there is often discomfort to the animals to be reckoned with; and sometimes in addition there is direct loss to the proprietors in the erection of buildings for which there is no need. The reason of this is not far to seek. Trained architects are seldom called upon in connection with farm buildings, and when they are, their want of touch with rural matters leads them astray. Indeed, they are usually the greatest sinners in the way we refer to. Failing their assistance, the property manager takes the matter in hand himself. In the majority of cases, however, he has not had the training or undergone the experience requisite to enable him to do the work satisfactorily. He may have a subordinate whose duty it is to attend to the buildings on the estate, but as a rule that official will have acquired his skill from an architect, and like the latter, will not be fully in sympathy with agricultural subjects. There are of course architects well qualified to deal with estate work, no matter how elementary to the profession it may happen to be. There are also estate agents possessed of the double qualification of intimacy with the requirements of farms and a knowledge of building that is needed in the planner of efficient farm homesteads. And where estates have employment for clerks of works some of these are well fitted to identify themselves with the special requirements of country life, and to leave their mark for the good of the district in which their duties lie. But these only serve to prove the case we started with—that, taking the country as a whole, there are few farm homesteads to be met with that approach perfection in their own peculiar line. The generality of them point to a want of aim in their arrangement, and a disregard of simple sanitary laws. Agent, occupier, and country tradesman seem all to have had a hand in the promiscuous adding of house to house or building to building and the jamming of shedding into every available corner, or the leaning it against any clear wall space.

It is only right to consult the occupier with regard to any accommodation that is about to be provided at the homestead. The buildings will be there, however, long after he has gone over to the majority; therefore it is advisable to keep this in view when arranging for their erection. Many tenants may have to make use of the homestead, but it can serve only one farm. What may come up to the notions of one tenant may not to any of the others. It follows, then, that it is hardly possible to make the original set of buildings suitable to the purposes, either real or fancied, of a series of tenants, and that each change of occupancy implies alterations and additions to the available housing. Still, where the necessary skill is forthcoming a good deal can be done towards minimising these periodical outlays in answer to the wishes of fresh lessees. There is a type of homestead or farm-steading that is peculiar to each of the different agricultural districts of Great Britain. If this be carefully noted and followed out when a new place is about to be established, there is less chance of many calls being made for future alterations on a homestead so arranged than with one that has evolved on no fixed principle. In Scotland, for instance, there are but three leading types of homesteads—that of the arable land on the east side of the country, that of the dairying tracts on the west, and that peculiar to the sheep farm proper. We may find each of them blended with one or other of the remaining pair according to circumstances, but these three are easily capable of differentiation. To begin with, therefore, if one keeps close to the single characteristic type of his district, or to the admixture of the pair that may otherwise apply, he is not far from the mark. A homestead erected on these lines lends itself easy of adaptation to the limited demand for change in arrangement that is likely ever to arise. It is possible even to lay down a single type that is capable of including the strictly arable-farm one of the east coast—the Caithness "square," the "toon" of the north-east, the "mains" of the Lothians, and the "onstead" of the Border Counties and Northumberland—and the one devoted specially to dairying.

But these are matters that we shall seek to demonstrate as the body of our work proceeds. Our present object is to lend a helping hand to those who are in search of guidance on questions of the kind. A lead in this respect is not as yet readily available. The branch of architecture involved therein is, as we have said, usually so intermittent in its calls on the professional exponent of the art as to be hardly worth his while to devote full attention thereto. And the layman who has had opportunity to master the subject seldom will take to print to enlighten his less experienced fellows. There are not awanting in this connection, as in other departments, instructors who have more of the fluency of the ready writer than the wit of the man of experience to recommend their productions. More stone than bread, however, is generally found in their baskets. We claim to have had rather exceptional opportunities of becoming acquainted with the subject, and in the following pages seek in a plain way to put, more especially, though not solely, young enquirers on the right track for picking up some knowledge of the underlying principles for themselves, so that they may in future be able to act in accordance therewith. The various diagrams relating to the actual work of building construction at the homestead we have purposely made simple and easy, in order that beginners may not be deterred from venturing forward on their own account.

If we succeed in some measure in helping either to lessen or make more efficient the outlay on the part of proprietors, to lessen the too frequent inconvenience and simultaneously reduce the labour bill of occupiers, and at the same time do something towards increased comfort and health of the live stock, we shall have done our little in the furtherance of the interests of the parent industry.

RICHARD HENDERSON.

31*st July*, 1902.

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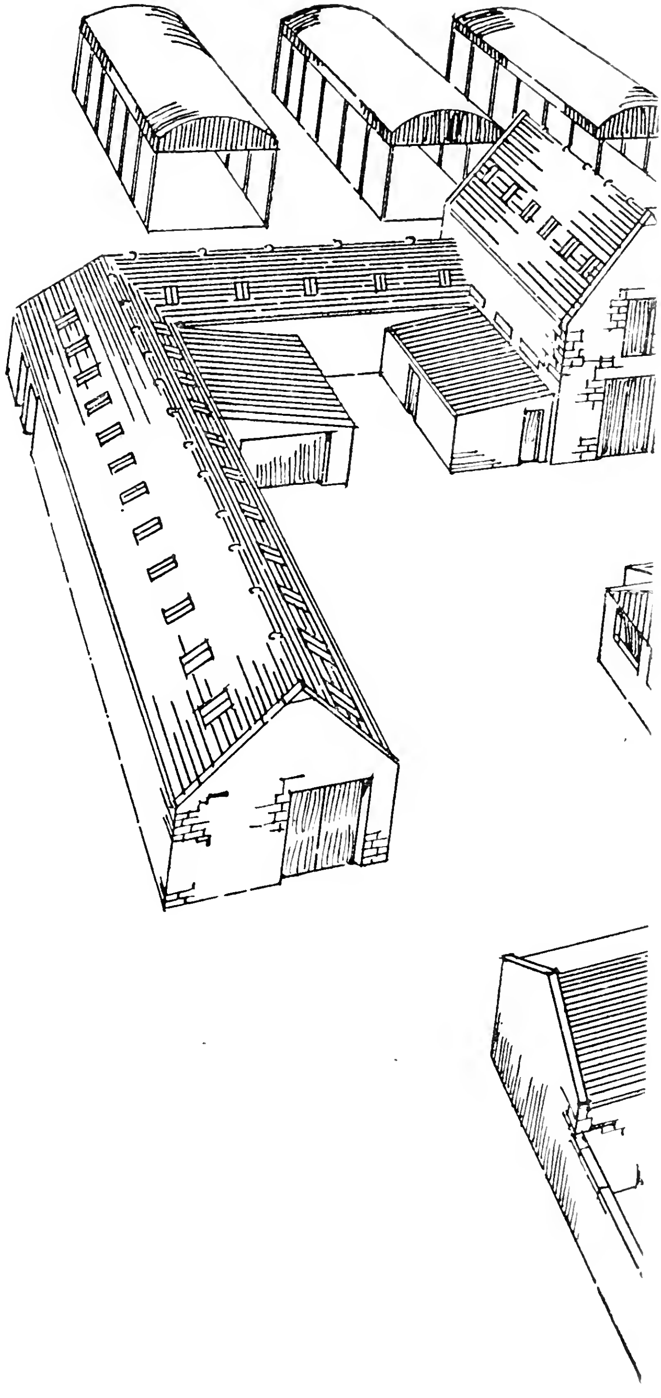
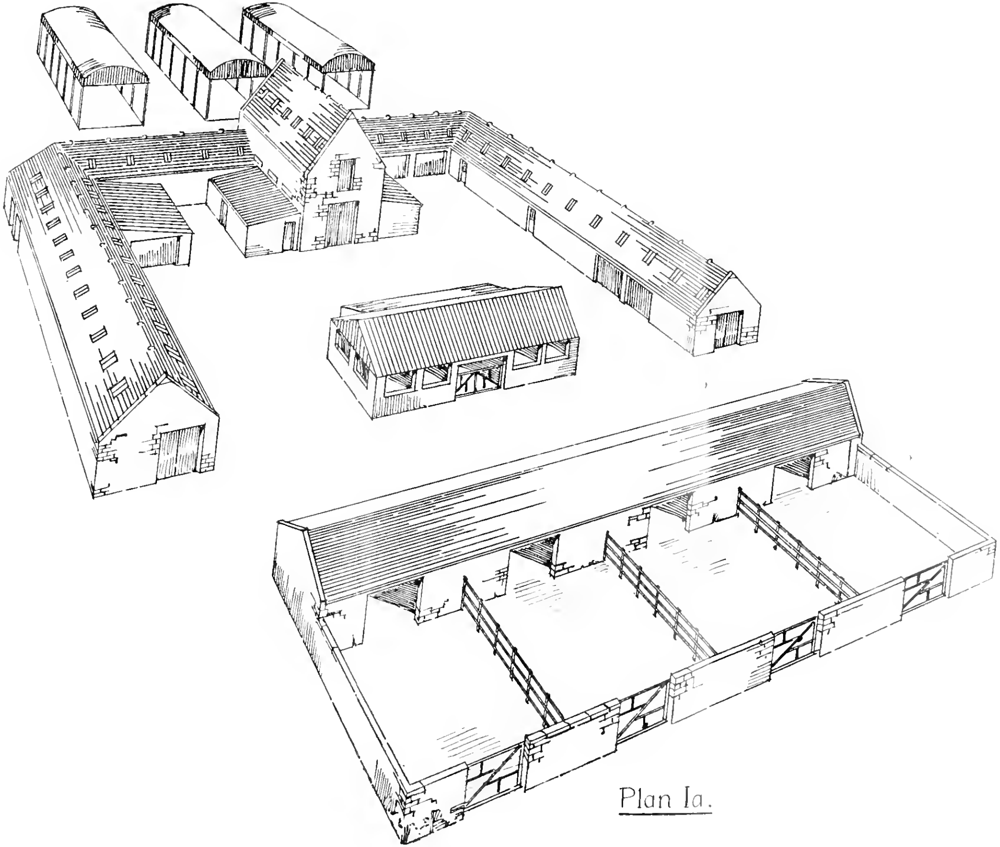
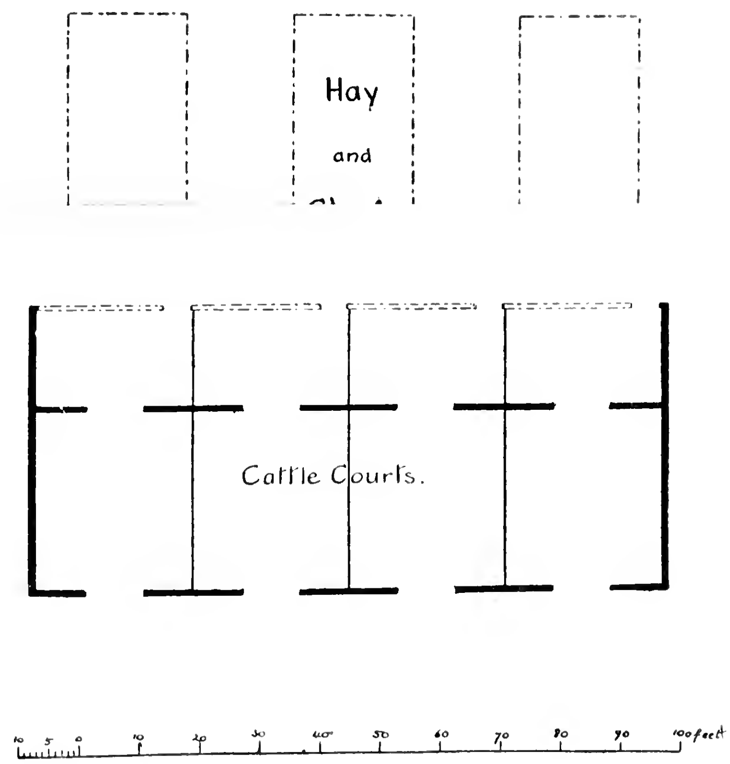


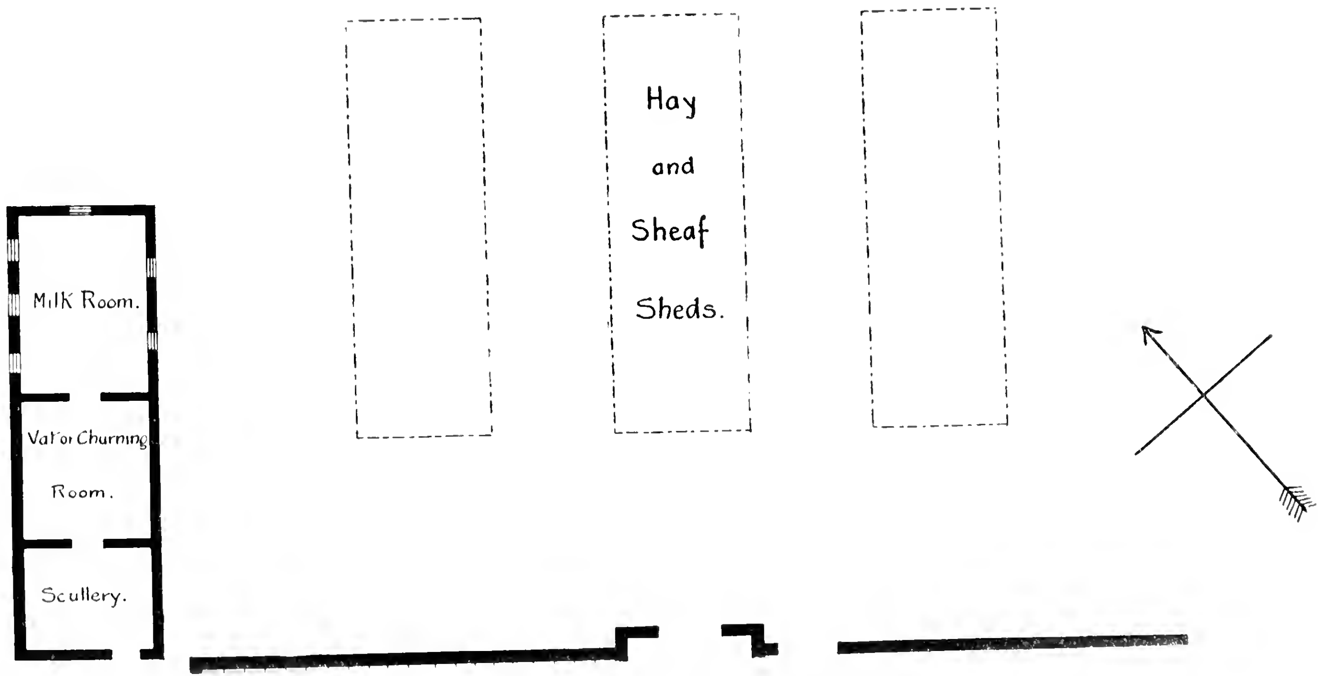


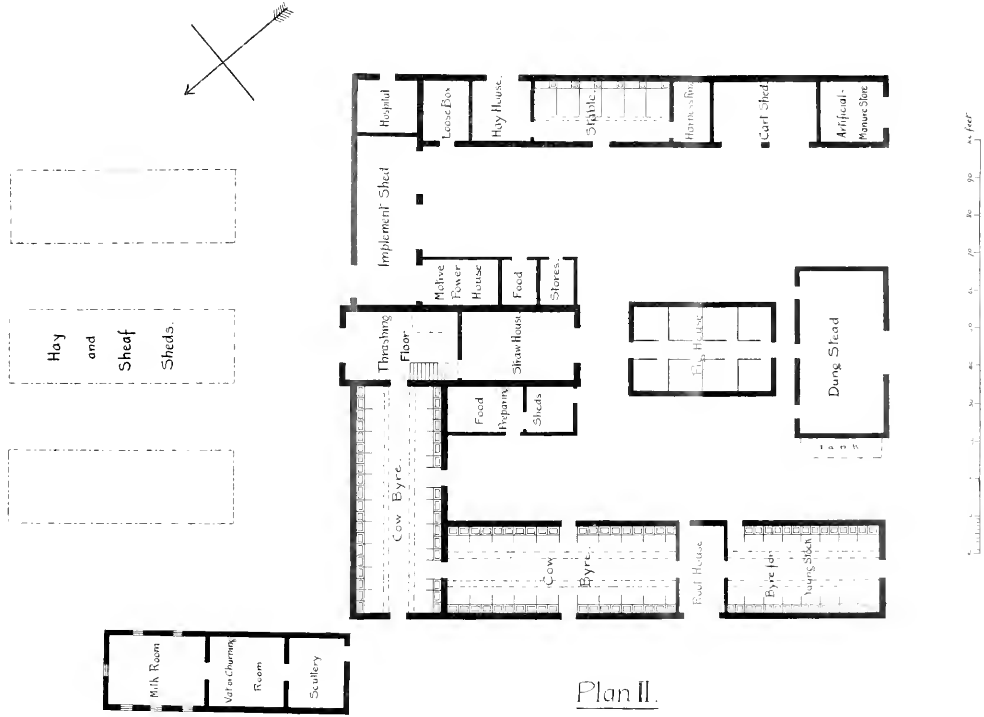
Plan Ia.


Hay
and
Cattle Courts.
10 5 0 10 20 30 40 50 60 70 80 90 100 feet


Hospital
Loose Box
Hay House
Stable
Harness Rm
Cart Shed
Artificial-Manure Store
Implement Shed
Motive Power House
Food
Stores
Thrashing Floor
Straw House
Food Preparing
Sheds
Byre
Root Shed
Cattle Boxes
Root Shed
Pig House
Dung Stead
Cattle Courts
Hay and Sheaf Sheds

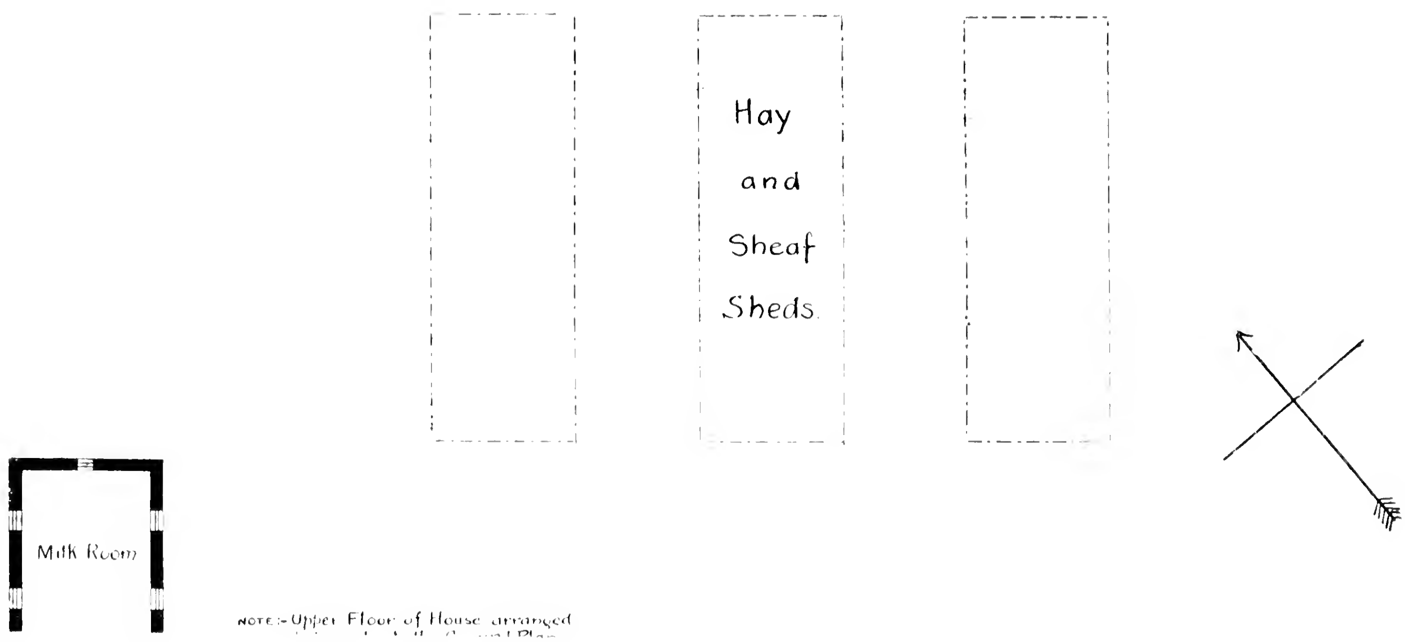
Plan I.


Milk Room.
Vat or Churning Room.
Scullery.
Hay and Sheaf Sheds.



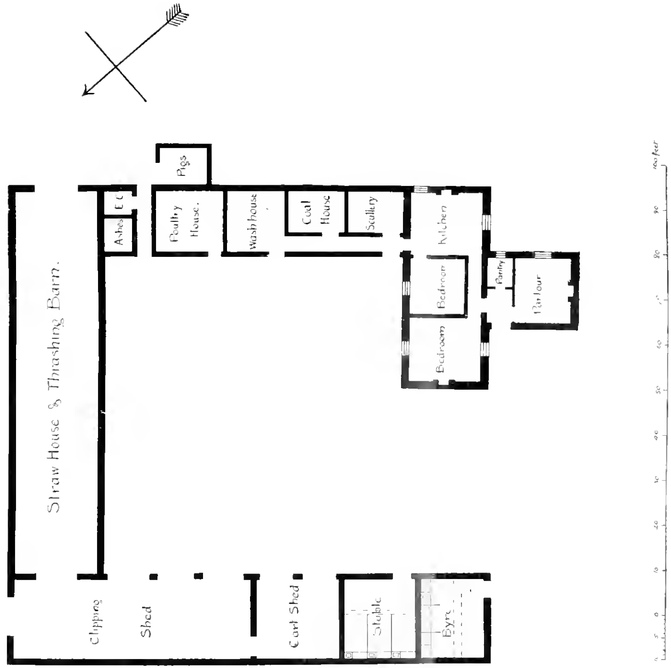
Hospital
Loose Box
Hay House.
Stable.
Harness Rm.
Cart Shed
Artificial-Manure Store
Implement Shed
Motive Power House
Food
Stores.
Hay and Sheaf Sheds.
Thrashing Floor
Straw House
Pig House
Dung Stead
Tank
Food Preparing
Sheds
Cow Byre.
Cow Byre.
Root House
Byre for Young Stock
Milk Room
Vat or Churning Room
Scullery
feet

Plan II.


Hay and Sheaf Sheds.
Milk Room
NOTE:-Upper Floor of House arranged


Hospital
Loose Box
Hay House
Stable
Harness Room
Cart Shed
Artificial Manure Store
Implement Shed
Motive Power House
Food
Stores
Thrashing Floor
Straw House
Pig House
Dung Stead
Tank
Cake & Meal Store
Food Preparing Sheds
Hay and Sheaf Sheds
Open Root Pit
Cow Byre
Heifer Byre
Dwelling House
Milk Room
Scullery
100 feet

Plan III


Pigs
E C
Ashes
Poultry House.
Wash house
Coal House
Scullery
Kitchen
Pantry
Parlour
Bedroom
Bedroom
Straw House & Thrashing Barn.
Clipping Shed
Cart Shed
Stable
Byre
100 feet

Plan IV.

THE MODERN HOMESTEAD.

CHAPTER I.

The Essentials of a Good Homestead.

Interests affected in its erection.

The interests involved in the planning and erection of a farm homestead or steading are threefold, affecting as they do landlord and tenant and the domesticated animals. On the proprietor's behalf, one has to take care that the set of buildings is in keeping with the requirements of the holding. The same, of course, holds good with the tenant. If the housing does not enable him unrestrictedly to make the most out of the farm something is wrong. And concurrently with these runs the welfare of the animals whose accommodation is provided for. It goes without saying that if they are not comfortable a full return cannot be expected from them.

Landlord's interest.

As regards the landlord's interests, the first principle involved is to guard against the erection of what is not absolutely necessary to the profitable working of the farm. Building is an expensive item in the estate accounts, and requires a tight hand over it. It ought always to be well done; but it can be simple as well as thorough. The second leading principle is the arrangement or grouping of the respective houses in such a way that the purpose of each can be slightly modified at any time to meet the demands of prospective tenants. When this is done much unnecessary intermittent outlay in alterations and additions is obviated. Some system is then being followed, and an occasional improvement may easily be effected either without sacrificing work already completed or marring the symmetry of the whole. In this direction, more than any other, perhaps, does the special skill of the estate manager reveal itself.

Tenant's interest.

Up to this point the interests of landlord and tenant are nearly identical. So long as it answers the end, the tenant is pleased with something that is strong and substantial and that calls seldom for repair. He can hardly, however, be expected to have an eye towards the adaptive character of the homestead, such as it is natural to look for in the proprietor. Provided the place meets the wants of the tenant in possession, he is content with things as they are. How it may affect his successors in the premises is not his business. What he is most concerned about is the suitability of the housing to his method of working the farm. This implies that the steading can be used by the tenant at the least expenditure of labour practicable under the circumstances that apply to places of the kind. Further, that it be fitted to accommodate his stock, whether live or dead—both animals and implements—without detriment to either.

The interests of the two almost identical.

The interests of landlord and tenant thus being almost alike in the matter of homestead accommodation, and those of the tenant and his stock being wholly so, it therefore comes about that the interests of the three are not very antagonistic. What room for difference there is lies between the first-mentioned two. It goes no farther either than the occupier, in some cases, seeking for more accommodation than the landlord thinks fit to burden the farm with. It may sound strange in some ears to use the word "burden" in this connection. But what direct return is ever available for outlay on the buildings proper of the farm? Does the efficient nature of the steading ever induce the offerer for the lease of a farm to allow an extra shilling per acre therefor? We have heard theorists say that such is the case, but we never came across it on the part of the rent-paying farmer. It cuts the other way occasionally, as some of us can tell from experience; at least, it affords a certain class of offerer an opening to belittle the advantages of a farm possessed of a well-appointed set of buildings (these implying, as he will maintain, much cost in upkeep) if negotiations necessitate interviews between parties. We do not wish to infer that the farm is as valuable when the steading is unserviceable and out of repair as when it is in good order and well adapted to the development of the place. All the same, it must be apparent to any one that in a business of this nature there is ample room for the exercise of the maxim that induces efficiency with economy.

Economy in Building never to be pressed at the expense of Efficiency.

We would not unduly press economy—never, at any rate, at the expense of efficiency. Nor would we be too conservative on the point of accommodation. On the contrary, we are inclined to think that custom deals rather hardly with the tenant in this respect. The conditions under which agriculture is prosecuted have changed very much in recent years, and are likely to keep changing. Labour is so much dearer now that it has to be economised in every shape and form. Farm implements are now more costly than they used to be, and proper storage room must be afforded them at the steading. And every opportunity should be given to the tenant to enable him to secure his crops as quickly and as cheaply as possible.

Shedding should be at the service of his crops as well as his animals. When labourers were plentiful and easy to pay, the storing of hay and corn in ricks was looked upon as the one method available; but now, when harvesters are in some places hardly to be met with, the farmer who has neither hay nor sheaf shed at his disposal is at times sadly handicapped in the ingathering of his crops. He is able with the help of mowers, tedders, and self-binders, to face the difficulty of severing them from the ground: but when it comes to the time of carrying them home and ricking them in the stackyard, he is often at his wits' end how to overcome the work. He is obliged sometimes to build a range of stacks in the newly-reaped cornfields, which seems always to us a slovenly proceeding. In fact, the ricking of hay and corn at the steading, other than in sheds of some sort, will, in our opinion, soon be seen at none but those farms that are held from and by the least enterprising landlords and tenants. Affairs may be hardly ripe yet for that state of matters, but we are inclined to think that it will soon take place. Already tenants are frequently provided with shedding of the nature referred to on payment of interest on the outlay involved; seldom, however, to the full extent that the circumstances of the farm warrant. The demand for accommodation of this kind is growing, however, and before very long we may expect to see provision being as freely made for the housing of hay and corn crops as for the cattle, and equally a matter of course.

In what manner our Homesteads might have developed had the Reaping Machine evolved on certain lines.

We often picture to ourselves the changes there would have been at our homesteads had the reaping machine evolved on the line of securing the ears of grain irrespective of the straw. Had it, for instance, developed into something after the description of the Australian stripper, what a saving would have resulted to agriculture generally. Were it practicable to make sure of the ears first and afterwards to deal with the straw as occasion offered, British agriculture would be completely revolutionised. To begin with, the range of barn buildings, usually the biggest about the steading, could then be cut down considerably. Thrashing would, under these conditions, be a comparatively simple operation. At present every sheaf, every straw indeed, has to be beaten unmercifully in order that grain and stalk may be effectually separated. Much power, a good deal of machinery, and roomy buildings are required for the operation. How different it would be had the farmer the ears of corn alone to deal with in this way. A tithe of the motive power would be sufficient. Thrashing would then be done by a rubbing instead of a beating motion, and, considering the difference in bulk of the matter to be handled, the sheaf-loft, a good deal of the machinery space, and much of the granary room could be dispensed with. The operation of separating the grain from the ear and husk would be about as simple as that of chaffing or chopping hay and straw, or of bruising oats. It would, in fact, require less expenditure of force than either, and might be done in a space as circumscribed as generally is allotted to one or the other. The donkey-engine could be substituted for the one of many horse-power. In these, as in some other directions which will occur to the mind of him who is at home in such matters, would building be saved. There would, of course, have to be storage room of some kind for the ears of corn, but rough shedding would suffice—some sort of building that would allow the wind to whistle through while it stopped the advent of rain, would do. On the other hand, much less granary accommodation would be called for. The grain would keep better in the ear than when detached therefrom, and the separation of the two being so easy, and so capable of quick performance, that operation would be delayed until the grain was actually wanted.

The advantages of such a system as we refer to, could it be instituted, would, however favourable they might be to the proprietor, be even more marked in the case of the farmer himself. His labour bill would, it is needless to say, be very much lessened. He is at all times at the mercy of the elements. But under the conditions we are presuming he would, at any rate during harvest season, be comparatively easy in mind on that point. Not having to wait on the straw until he could make sure of the ear, he could then laugh at the weather, as it were. At present, should it be unfavourable, he is obliged to wait on patiently until the straw has become sufficiently seasoned to admit of its keeping in bulk, while all the time, it may be, the grain is daily decreasing in value. Were the straw by itself it would matter little or nothing what sort of weather it had to face. It would be seasoned in time. It could be seasoned, too, and much quicker, without having recourse to the slow and troublesome process of binding it into sheaves, and placing these on end in small groups, as is customary. It could be left lying as it fell behind the mower. If not likely to season as it lay, a round of the tedder would put it out of danger. Afterwards, were a baler at disposal, how handy it would be could the straw, thus tidily put together, be stored in a shed until required. What was to be used as litter for live stock would, of course, be dealt with more summarily. It could simply be carted to the steading and be piled up in shed, or be packed together in long ricks. In the meantime the ears of corn, safely housed, would be seasoning under the most favourable circumstances.

How different, we repeat, is all this from the prevailing method of harvesting our grain crops! We have to undertake the laborious operation of severing the crops from the ground and tying them into small bundles as we proceed, taking care to keep the ears at one end of the sheaf. Of recent years this work has, indeed, been considerably lightened. Since the days of the sickle much improvement has certainly been made in harvesting appliances. First came the manual-delivery reaper, next the self-delivery, followed later by the self-binder. Each of these was a most decided advancement on its predecessors. But still the advancement was in the contrary direction to what we would have had it go. And while we are enabled to reap more readily than before, the advantage is gained somewhat at the expense of the "winning" of the corn. Machine-cut corn packs closer together than either sickle or scythe-cut corn, and machine-bound corn closer still. We get it cut and tied much quicker, but then, packed more regularly and tighter than before, the straw takes longer to dry. What a blessing it would be therefore to agriculture could we fall upon a feasible method whereby we could separate the ear from the straw, carrying the former away to the steading at once out of all risk of damage from exposure, and leaving the latter by itself to mature at leisure! It can stand what the other cannot. As things go neither gets a proper chance. The grain has to wait on the straw; and lest the grain suffer too much the straw has often to be taken before it is ready, with the consequence of heated ricks and damage to straw and corn alike.

It may not be practicable for us to adopt the "stripper" method of harvesting grain. Our corn crops are usually too much knocked about for them to be on their feet at harvest time; and to comb out a tangled mass of laid corn would be a hopeless job. The separation of the two parts of the plant might be attained by a modification of the self-binder, under which, instead of binding the bunches of corn, it decapitated them, afterwards shaking out and releasing the straw, but retaining the ears. These, the machine that can tie up corn could no doubt be modified to secure in bags and deliver at stated intervals. Our corn crops are heavier than those grown on the continents either of Europe or America, or in Australasia, where the self-binder and the stripper consequently work easier in the thinner and more upstanding stuff. If not possible for us, however, to retrograde in the way of thinner and much shorter crops, it is open to us, as instance the results obtained by the Messrs. Garton, to help matters by paying attention to the selection of varieties of corn of medium length, but stout enough in straw to carry its head erect until delivered over to the reaper.

Such a departure from the existing methods of procedure would, of course, necessitate the erection of more shedding accommodation at the steading. As we have indicated, storage room would be required for the loose ears. These would keep securely in considerable bulk, and the grain improve all the time. The several grains would be kept apart, and air, if allowed access all round, could freely circulate throughout the mass. A shed after the nature of an ordinary hay-barn, but with a wood floor raised a little from the ground, and the sides and ends enclosed with some perforated material, such as fine-meshed wire net, and protected from rain by means of louvre boards, would answer admirably. Provision would also have to be made for keeping the straw secure. Seasoned loose, it would more than ever be needful of house-room of some kind at the steading. It is bad enough when the sheaves have to be secured by themselves in the absence of sheds, but much more labour would be required when loose, or even trussed, straw had to be handled. But even had much extra shedding, of the kind spoken of, to be put up, buildings of that nature are not necessarily very costly. They would prove to the proprietor a favourable set-off against the more expensive group that at present embraces the thrashing-barn and granaries. These we do not mean to infer would, under the change of circumstances we have been assuming, be altogether dispensed with. They would, however, be considerably curtailed, so much so indeed as to clearly outweigh any outlay on extra shedding. Besides, we are inclined to maintain that there is already too little shedding of the kind at the farm steading. We advocate roofage for both corn and hay. Had the farmer abundance of this, harvest labour and anxiety would both be lessened. And had he further ease from these in the way we have been seeking to point out, his lot would be vastly improved. We have been digressing a little, perhaps, and that, too, on the very eve of our work. But our end in view being the furthering of rural economy, and the better organisation of labour being apparently one of the most vital present-day aids to agriculture, we need offer no excuse. This, in fact, with a care over the proprietor's interests, will be our keynote all through.

Next to economy and efficiency in the erection of the Homestead comes the Easy Staffing of the place.

It may have been gathered, then, that next to economy and efficiency in the erection thereof, the great matter to be kept in view, when grouping together the buildings of the homestead, is the easy staffing of the place—the rendering it capable of being worked at the least expense in labour. It is not difficult to lay down rules in this connection. The observance of these is, however, quite a different affair. When it comes to putting them in practice, hardly two cases are to be met with that are on identical lines. We may in many instances manage to follow out one or two of the leading ideas bearing upon the arrangement of the buildings. As a rule, however, the more subsidiary of these have to accommodate themselves to the circumstances of the site. More especially is this true when we have an old set of buildings to deal with. This, we need hardly say, is of commoner occurrence than the erection of the homestead anew. Besides being obliged to conform to the exigencies of the site, we are in these cases held in check by the position of the main buildings relative to the steading as a whole. The skill of the planner of farm steadings comes out more prominently in the re-arranging and improving of old sets of buildings than in the erection of completely new places. The fundamental laws that govern a good steading can be easily observed in the erection of a new one: but in the altering of an old one these have to be modified in various ways as circumstances will admit.

What these laws are may be put as the placing of the straw-house in as central a place as possible for the serving of the live stock. Next to this comes the placing of the dungstead, or manure-pit, in an equally central position as regards the buildings that have to be regularly cleared of soiled litter. The principal labour at the steading consists in these two operations—supplying the animals with straw and the removal of their droppings, together with the straw they have messed. When matters, therefore, have been adjusted so as to make the accomplishment of these aims as convenient as possible, a considerable reduction of labour has been attained. When, in addition to these facilities towards the economy of labour, it is possible to place the hay-barn, the turnip-house, the cake and meal store, and the food-preparing shed equally handy for the purposes they are there to serve, little more can be done in the way of conserving the tenant's interests. The little there is lies in constructing the buildings in such a manner that they are easily kept in repair, and at the same time making them conducive to the health of the live stock housed therein. Constructing the buildings plainly, but substantially, ensures the former condition, and attention to the elementary laws of sanitation provides for the latter.

There is no necessity for spending more money in the erection of the homestead than is absolutely needful. We do not, however, advocate the pushing of economy to the verge of ugliness in all that pertains to the steading. The buildings may be plain and serviceable, and yet not altogether objectionable from an artistic point of view. Neither, on the other hand, would we sacrifice utility and economy for the sake of appearance. A little money judiciously spent will take away the bareness, if nothing else, from the harshest place of the kind. But first of all let us arrange the houses in such a manner that each one separately, and as a part of the whole group, will serve its end at the least outlay of labour. Following on this we have to make sure that the animals proposed to be confined within the buildings will have the opportunity of being comfortable as well as healthy. Then we must see to their erection for the least amount of money without sacrificing either efficiency or permanency. After that, or at any rate after the probable cost of that has been arrived at, comes in what those who control the purse are willing to spend gratuitously in improving the appearance of the countryside, or at least toning down somewhat the too frequent ugliness of these excrescences on the landscape.

On Plan I. we give the ground plan of a steading which will serve to illustrate the principles of the saving of labour which we have been referring to. It is one after the type characteristic chiefly of North Country arable farming. As we shall see further on, it is capable of adaptation to suit the varying practices of other parts, whether of rearing or fattening live stock or a combination of both. The plan shows the range of barn buildings—the thrashing-floor and straw-barn with granary above—situated with one end convenient to the stackyard, and the other projecting far enough into the courtyard to be handy for the delivery of straw to both cattle and horses. The manure-pit occupies, it will be seen, an equally convenient position at the opposite end of the steading. The sheaves are thus handed in at the north side to be stripped of their grain, after which the straw is passed on to both byre and stable, eventually to find its way, in one shape or another, from these places to the manure heap. Each place is in turn brought within easy reach of the other, and time and labour, both of which are suggestive of money, are in this way economised.

Plan I. (for the Corn-growing and Cattle-feeding Farm).

The rickyard we have represented by a range of shedding supposed to be capable of holding the average annual corn crop of the farm. These sheds are separated from the sheaf-barn by the breadth of a road only. The sheaves can be carted directly into the barn and be tipped up on the floor, or it can be so contrived by laying a series of tram-rails that they can be delivered at the feeding board of the thrashing mill in hand trolleys. No horse is needed under a system of this kind. A woman or a boy can fill, wheel, and discharge a trolley by her or himself; and two, or three at the outside, of these wheeled conveyances are ample under ordinary circumstances to keep the mill going. The sheaves are not always so handy to reach, however, but that it is advisable to have the services of a youth in helping to load the trolleys. Or by means of a travelling endless band the sheaves may be carried direct from shed to mill-board.

Built against the part of the barn that projects into the courtyard on one side is the engine-house, whether steam or vaporised oil be the power employed to drive the mill, and at the other the food-preparing sheds, where pulping, corn bruising, cake crushing, and allied operations go on. And at right angles to this range are produced on the south-east side the implement shed and places connected therewith, and on the north-west side the cow-byre and any other house there is room for in the same row. Down the west side of the square is led the housing of the cattle, whether in the shape of loose boxes or byres, or a combination thereof. On the opposite side we have placed the stables, cart-shed, and other accommodation of the kind. Placed in the centre of the open side of the courtyard is the dungstead, leaving ample space in which to pass by it at each side. Room for the pigs is found against the back wall of the building. The dungstead is alongside the main road to the homestead, and in consequence its contents are all the more easily discharged. At the other side of the road we have the open courts for cattle—the curtains, hammels, and so on, as they are variously termed. A hayshed might be placed parallel to the outer wall of the east side of the square, handy to the stable, and then we have done.

It affords a suitable type for British Farming generally.

This affords a good typical farm homestead where British agriculture is concerned. We do not claim perfection for it. We maintain, however, that it is on the right lines for conforming with the principles we started upon, and few, we think, will dispute the correctness of them. If nothing more, it gives a lead that way which many, after hearing us out to the end, may be glad to follow. There is no crowding anywhere; and fresh air and sunlight are allowed free play. As we proceed we shall point out the simplicity of its structure, and how few repairs it requires to keep it abreast of the ordinary tear and wear of the affair as a whole. It will be admitted, we have no doubt, that it is a place that can be easily manned. Some are loud in the praises of homesteads either partially or entirely covered in. Our preference always lay for such a one as we are setting forth. Each building gets a fair chance of sun and air, both of which are conducive to the welfare of building material and animal life alike, and there is a large yard in which animals have freedom to frisk and romp in or to show themselves to the advantage of their owners. There they can be let loose to drink their fill or be made to show their paces without let or hindrance. Farm fires are a source of loss even to the fully insured business-like tenant, and every one is anxious to nip them in the bud. An outbreak of fire once fairly started makes sad work with a covered-in steading. There is no keeping it within bounds once the flames obtain the mastery. But at the open place we represent fire may under many circumstances rage uninterruptedly at one part of the steading until it burns itself out without causing hurt to other parts. And as regards initial cost, the subsequent cost of upkeep, and the general duration of the establishment itself, which of the two has the advantage is capable of proof without much demonstration. A flash of one's own brain is sufficient to clear up doubt on these points. The slater and the plumber are bound to be frequent visitors to the homestead that is roofed over.

It is not of course in every position that a place so planned can be carried out to the full. All depends on the site that may be at disposal. Many things have to be taken into account in deciding upon the site of the homestead. Generally speaking, more foresight is shown in the selection of the site than in the arrangement of the buildings it has been set apart for. This is, more than likely, due to the fact that the matter of placing the steading with a view to its being convenient to the requirements of the farm comes more directly home to the agricultural mind than does the more technical work of grouping the houses to the best advantage. The one appeals to the general intelligence of those who have to do with country affairs; the other is more in the province of the man who can narrow his ideas and exercise the patience and painstaking necessary to deal with details.

Conditions that govern Choice of Site of the Farm Homestead.

Convenience with regard to the farm in all its parts is the first consideration bearing on a choice of a proper site for the homestead. There are, however, many countervailing circumstances bearing thereon that are apt to be overlooked. A plentiful as well as efficient water supply has to be kept in view when the site of a homestead is in question. And the counterpart to this in the form of a ready way of getting rid of sewage has also to be borne in mind. The frequent behests of the sanitary officer of these times on matters of water supply and defective drainage emphasise that these points have too often been overlooked in the past. Easy access to some good through road and proximity to a railway station are also important points in this connection. So, too, is the availability of a good head of water as a source of motive power at the steading. A plentiful supply of water power at the farm is an immense advantage to the tenant. Where it is available no expensive engine has to be there to lock up capital in. Neither is there the constant expense for fuel and attendance connected therewith to be faced.

A head of water means more or less irregularity in the outline or configuration of the ground, a condition which is against the finding of many situations otherwise suitable that would give the amount of fairly level ground on which to build our suggested homestead. As represented it is supposed to be on ground almost level from west to east, but with a slight "hang" or slope from north to south. This admits of the floors in each range being nearly all kept on the one respective rake or incline. When we come to deal with ground of irregular outline a certain amount of latitude can be given by extra building and making up of the surface where this is necessary. Taking the north-east side first, so long as we get the byre and barn floors to a mutual level it is easy to deal with the remainder of the row should the ground be either above or below that on the other side of the barn. It can either be made up or be excavated as circumstances require. If the former, extra building to a corresponding height is a necessity. It may happen, of course, that the ground on the opposite side is that requiring to be altered. Down both the long sides of the rectangle it is evident that it is practicable to build on ground with a gentle slope. Where the cattle are located the continuous floor is laid with a run corresponding to the ground outside. At the other side the stable floor is of necessity kept level longwise and with it, in order to prevent the inconvenience of steps, the hay-house at one end and the harness-room at the other. But these three places together do not occupy so much of the row as to give trouble in this respect. The loose box at one side of them and the cart-shed at the other readily adapt themselves to the adjustment of the floor levels of that row to the rake of the courtyard surface. All artificial levelling means, however, extra cost—that of altering the surface and the extra building which this implies at some part or other of the different blocks.

The principal point to be kept in mind is to have a site that will admit of an easy slope from barn to byre and stable, continued from these to the dungstead. The produce consumed at the homestead and the waste and spent materials resulting therefrom are all coming this way, and it is easier to bring them down hill than to carry them up. It is the natural way, too, for the drainage matters, whether from the interior of houses, from the housetops or from the courtyard—all should pass to the end where the spent material finds exit. The clean provender comes in at the head, and as it serves its end is passed on to the foot: and with it should go waste water and sewage; not necessarily together these two, however, but the one to be let loose and the other retained.

The leading features of Plan I.

From the elevations delineated on Plan IA. (which is sufficiently representative of the two succeeding plans we give to allow us to dispense with repetitions amended to the slight modifications they imply) it may be readily grasped how simple are the roof lines we suggest. The simpler these, the cheaper in construction, the more effective in purpose, and the easier kept in order will they be. The fewer breaks and joints therein the less risk will there be of rain finding an entrance.

The walls are not high, nine feet to wallhead being in one-storeyed places about the limit we care to reach. This in byre and stable, if both are open to the roof, as we think they ought always to be, gives headroom and to spare within. If this be granted it is waste to carry the walls higher. We would have no animals housed in a building with floor overhead. Where two storeys are in one house the height of the lower one from floor to floor should never be less than nine feet, as before. But we show none of the buildings having two storeys excepting the thrashing-floor with the granary above. Here nine feet of headroom is too little for the kind of work that goes on. It is advisable to have room enough to enable a cart to be tipped up, and also to allow a goodly pile of sheaves being packed within, should this be at any time thought an advisable proceeding.

Some would prefer the granary to be over the straw-barn instead of the sheaf-loft, while others again would have it extend over both from end to end of the barn range. It is best, therefore, to make the range so that the lofting or granary space could be laid over all or part as circumstances at the time of erection or at later dates might make justifiable demand.

The foregoing is a homestead typical, we have said, of the requirements of the well-managed arable farm. Setting aside the cattle accommodation in the meantime, the other buildings are, as shown, suited to any part of the country. It might be necessary, in order to meet fully the wants of a horse-breeding district, to provide one or two extra loose boxes about the place. There might in that case be one taken off the implement-shed, and what is marked as the artificial manure store might also be sacrificed to the same interest. Rather than this, however, it would be better to erect a range of these, of more perishable material than stone and lime, at some convenient place handy to the other buildings. Even in a district where horse-breeding predominates it is not every farmer thereabouts that goes into the business very extensively. When, therefore, a real demand for several of these arises, it is better to provide a few supplementary to the steading than to turn other buildings away from the well-defined objects of their own. Now that increasing capital is being invested in labour-saving implements, it is but right that serviceable keeping-places be set apart for them. Further, it is due to the farmer who spends much money on artificial manures that he is provided with a proper place in which these can be housed and mixed, or otherwise dealt with. True, it is only for a month or two in the year that artificial manures are in evidence at the steading, but during the other months there are plenty of useful purposes other than sheltering animals to which it can be turned to account by the "managing" farmer.

More granary room might be required in one district than another, but the 60 feet by 18 feet or 60 feet by 20 feet floorage available in the barn range, if taken advantage of to the full, implies a considerable storage area. The straw-barn as marked off might, indeed, be small enough for the requirements of some districts, especially such as those where it is common to see an endless web transporting the straw, and alongside a foot-bridge or rail for allowing the attendant to pass to and fro and deliver the straw from side to side and fill up the house in a regular manner. Were this to be practised, there would not be head-room left if we ran a loft over the straw-house. At a pinch, however, there is the implement-shed to have recourse to. There are no live stock in it, and granary accommodation could be provided by adding half a storey thereto. It would hardly do not to carry the granary the full length of this range, but running a loft over the hospital would not be a great infringement of our rule never to house animals in buildings not open to the roof. Standing at a corner, the hospital could easily be well ventilated, although it did happen to be under the granary. But there is nothing to hinder the enlargement of the barn range both in length and breadth to suit the requirements of any farm, and thus keep the granary within the bounds of its own department.

The stable, with hay-house communicating at one end and the harness-room at the other, would come up to the requirements of any district; and so without doubt would the adjoining cart-shed. The dunghill, too, would be equally accommodating, as also would the pigsty abutting thereupon.

Coming now to the housing space for the cattle, while the parts of the homestead we have just been dealing with are capable, as we have planned them, of almost universal adoption so far as Britain is concerned, it is very different with this division of the buildings. In the extreme North of Scotland, for instance, the arable farmers work almost wholly with store cattle, rearing these to a certain age, on attaining which they are disposed of to be fattened by farmers more favourably situated as regards weather. In the north-east counties the rearing and fattening of cattle are more or less combined. Further south, again—in Fife, the Lothians, and the Border counties—the rearing of cattle is almost dispensed with, the "stores," or young, raw animals, being imported for the purpose of getting finished off or being manufactured into beef. This is not all, however, for while the north country beef producers tie up their fattening animals, those further south mostly lodge the animals in open sheds, with courts attached. Usually a few loose boxes are set apart as well. At some places there are many courts and few loose boxes: at others the latter predominate. From this it may be implied that, taking the country at large, there is more diversity in the arrangement of the part of the steading set aside for cattle than occurs in all the rest put together. Even in the one department of beef preparing there is much disparity in the matter of housing the cattle during their enforced spell of gluttony.

The "custom of the country" has as much to do with this variance in the quartering of stock being made ready for the butcher as anything else we are aware of. In fact, we can think of nothing else bearing on this, unless it be the amount of straw available. That, however, could only affect the choice of open courts if balanced against the other two. The tied-up animal will spoil or tread down as much straw as the one confined in a loose box; therefore there is little between the two in that respect. It is easy to understand that the treatment in this respect of growing stock will naturally be different from that of animals kept for the laying on of beef; and that the treatment of cows will differ from either. But why in one district fattening animals should be tied up by the neck like milch cows, and in another they should have comparative liberty in loose boxes, while not far from either we come to where it is customary to give them the freedom of open courts, it is difficult to tell, unless it be due to what we have suggested. And the custom of any particular district has, we suspect, originated in the class of buildings at the disposal of the farmers thereof at the time they took up this branch of their industry. It is not so very long since the art of fattening cattle at the homestead sprung into universal practice in the best agricultural districts of our country. Until root crops became a fixed part of our rotations, and artificial feeding stuffs followed later on, it was impossible to adopt the system. There was little except hay and straw then available as winter food for cattle. There were the various grains at disposal, of course, but oats and beans, dry of themselves, need to be qualified with much pulpy food ere they can be turned to useful account by the domesticated ruminant. It was hard to keep on until the following spring a modicum of the flesh gained by the animal during the grazing season.

A few cattle could, no doubt, by the aid of cooked messes of one kind or another, be advantageously tided over the lean season of winter and early spring at nearly every farm. The cows are an instance in point. There cannot have been many, however, at the ordinary kind of homesteads. But the manner in which these few were then housed would unquestionably govern the after method of so disposing of the increased number of winter-fed cattle. Custom dies hard, and the mixture of method we speak of still prevails. There must be one system better than another, one would think. If so, it is reasonable to maintain that the one under which the animals are most comfortable is the best. It can hardly be that according to which the "beasts" are tied by the neck and obliged to stick to almost one position, whether standing or lying. Never at liberty to use its tongue, either as a counter-irritant or as an aid to toilet making, and at no time free to assume any sort of position in accordance with ease or inclination, an ox or a heifer so situated cannot be said to be under conditions of the most comfortable nature. Confined in a loose box, it can lie where and how it likes, and it can use either tongue or foot when any part itches. And if unable to reach the spot with these organs, there are the walls and rails that border the box to rub against. Somewhat similar are the conditions of its confinement in the open court. It is apter there to have masterful companions and to feel changes of weather, but it gets more air and has the chance now and again of basking in the sun's rays. The best of the three for placing the animal under circumstances most likely to make it grow fat is unquestionably the loose box, where distractions are limited, the air is warm, hunger is unknown and repletion encouraged, and a soft bed is ever at hand.

There is but the one plan adopted in housing the cow. She has to be tied by the neck in a line with others, her head against the wall, or against a breastwork of boards if there be a feeding passage in front of the row, and her hind feet at the edge of the "grip" or channel which collects the droppings. This allows her, in accordance with the breed she is of, from 7 feet to 7 feet 6 inches from head to tail, and all the breadth she has in the rank is from 3 feet to 3 feet 6 inches. This is the limit of her bed. In it she has both to lie and stand. On foot she cannot edge to the right or to the left without encroaching on her neighbour's room, and laid down she has to content herself with almost one position. There is no tossing to and fro and stretching limbs in bed with her. Jammed up thus in line, she can neither stretch nor lick herself, nor can she satisfy much of her mild curiosity as to what is going on around her. But had she more elbow-room, she would mess her bed and annoy her neighbours in her endeavours to see better round about. Were her head-gear looser, she would soon have her tail where her head ought to be. As it is, the present close packing has to be supplemented by short barricades (the travises), so as to stiffen up the row. She knows no better, however, and gets along somehow.

Taking the cows into account, our provisional plan allows for all three methods of lodging the animals. We pillory only the cows, however, and that because there is no other method practicable, bad in theory though it be. We have given space for twenty. That may be too many for some farms. Where it happened so, the spare stalls could be occupied with fattening heifers. We next provide a range of loose boxes for cattle, each capable of holding two at least. And separated from these by the breadth of the road that passes the low end of the homestead we have planned a series of open courts. This affords a fair variety of cattle accommodation suited to the wants of the different classes and ages of stock. The young, as well as their good-natured seniors, could have the run of the courts, while the more quarrelsome or excitable were placed under the more pacific influences of the loose box.

We have shown no part as being specially set aside for calves. But the loose box or two nearest to the cow-house or byre would always be at their service. If these could not be spared, then it would not be difficult to locate a shed somewhere within handy reach of the byre.

How the Plan might be modified.

Here, then, we repeat, is a homestead which we consider is typical of the requirements of the British farmer of arable land, easily capable, as we have laid it down on the plan, of adaptation either to the varieties we find in that class of farming or to the different-sized farms which it may include. With little or no modification, except enlargement as needful, it will meet the wants of such advanced farmers as those of Berwick and Roxburgh, of the Lothians and Fife, Forfar, Aberdeen, Banff, Moray, Inverness, and Easter Ross and Cromarty. And as regards Caithness, where the stores are housed similarly to their dams, all that is requisite to make it equally suitable in that stormy part is to fit up the easterly range as a byre instead of a set of loose boxes, and dispense with the open courts, should they in the circumstances be deemed superfluous. It is a type, moreover, for which we lay claim to capability of being worked at a minimum outlay of labour, and of being erected at a comparatively small outlay in money.

Plan II. (for the partly-Dairy Farm).

And, still sticking to the North, very little alteration, as shown on Plan II., is needed to make it equally suitable to the big dairy farms of Galloway and Dumfries, where dairying and arable farming are combined. The homestead could remain as it is, with the exception that room be made for more cows, and that dairy offices be provided. From forty to a hundred cows are kept on the average farm of this class, usually sublet to a middleman called "the bower." The extra accommodation for cows could be met by making the byre a double one, which would then admit of forty being housed therein to start with. As much of the loose-box range as necessity called for could be similarly dealt with, and the remainder be set aside for the younger stock.

Shelter for an increased number of pigs would now become a necessity. A good place for this might be where the open courts are: or, better perhaps, the pig-houses might be, as we show them, in one at right angles to the dunghill up the centre of the yard. This would block up the court a little, and go to divide it into two. But a division of this kind at a place where, so to speak, there are two interests concerned—the bower at one side taken up with the welfare of the cows, and the tillers of the soil at the other—is rather an advantage than otherwise. Where we have drawn them on the plan they are within easy reach at one end of straw-barn and cooking-shed, and of the dungstead at the other. An underground earthenware pipe would serve to convey the whey from the dairy to some convenient part of the pig-house.

The site we choose for the dairy buildings keeps them well away from the tainted air that proceeds from the cooking-shed, the pig-houses, and the dunghill; and while we thus keep them thoroughly isolated in this respect, they are at the same time quite convenient to the byres. It is but a step from byre to dairy offices, yet the one is quite cut off from the other so far as the odours prevalent in the byre are capable of affecting the delicate work that goes on in the dairy. Moreover, these offices are in their right place at the cold corner of the homestead.

At the farm where the cows are hired to a bower, the tenant requires an odd place in which to keep a cow or two for his own household wants, and perhaps accommodation for a pig or two as well. This he likes to be entirely away from the bower's department. It can be got without much trouble somewhere at his own side of the steading; or near to the farmhouse, especially if the establishment is of any importance, might be the proper place for it. There would need to be a two-stalled stable and gighouse beside the farmhouse at any rate, and the lot would go together.

Plan III. (for the Dairy Farm proper).

Coming to the dairy farm proper, such as prevails in Ayrshire, Renfrew, Bute, and parts of Lanark, and is occasionally found in some districts near to these, we are face to face with an entirely different class of homestead. The dwelling-house forms part of the block. The farms are small, and the tenants and their families do the big share of the work, and naturally prefer to live close to the seat of operations. The housewife likes, indeed, to be within earshot of her charges even by night, so that either she or her husband can attend at once when sounds of distress are heard. It is satisfactory to her also to know that her husband, when rising frequently in the night time to attend to some ailing animal, or to note the condition of some one of them under suspicion, is not unduly exposed to the night air when scant of garment. And in those instances where the "grey mare is the better horse" and trusts but little to deputy in times of emergency, it is well, too, that such exemplary individuals are not put to too much risk in the same way. The health officer and his subordinates, the sanitary inspectors, are generally bitter against house and byre being in such direct communication, and not altogether without cause either. It is better policy, however, to ameliorate as far as possible rather than to break down completely an arrangement that has served its end so well in the past, and helped to make the people we are referring to the best managers of dairy cattle in our own country, if not, indeed, the world over. It is not difficult to arrange matters in such a way that the owners of the animals are in close touch with them, and yet sufficiently isolated therefrom as to transgress the laws of sanitation but slightly.

On Plan III. we show, as we have said, a place suitable for a dairy farm characteristic of the districts we have referred to. We still stick to the fundamental law we started with—that of keeping the straw-barn and dunghill within easy reach of the live stock, seeking in this way to minimise as far as possible the labour of attending to the animals. As we remarked at the beginning of this chapter, most of the work connected therewith is the carrying of fodder to them and the subsequent removal of their soiled litter and excrement, consequently the easier we can make the carrying out of these operations the better for all concerned. The art of reducing labour at the homestead is, in fact, the placing of the live stock quarters in close touch on the one hand with the commissariat department, and on the other with the refuse depôt.

We keep the part of the steading east of the barn range much as before, because the needs of the arable farmer are much the same in all our respective districts. It is at the other side where we come to mark off the peculiarities of the Scottish dairy farmer.

We place the house at the north-east corner so that it may be handy both to the byre and the dairy offices. We keep it clear of the barn by introducing the small one-storeyed storehouse between the two. It might be practicable to have had house and barn joined to each other, but we prefer the arrangement given on the plan.

The cattle accommodation takes up the west wing of the steading, following out much the same arrangement as we give on Plan II. It is cut off from the house by means of the open passage shown on the plan. The currents of air are likely to be always tending from one end to the other of this passage, carrying with them both the odours that are apt to issue from the byre door at one side and the smells following on cooking that emanate from the kitchen at the other. Both are in addition effectually cut off from the dairy offices in so far as tainted air is concerned by placing these buildings in the manner indicated.

Dungstead and pig-houses we also incline to place in accordance with the arrangement on Plan II.

Both in this and the preceding instance some calf pens would be essential. In this, part of the space allotted to food preparation might be spared for the purpose. In the other, the root house might be taken if an open root store, as on Plan III., were substituted.

It is necessary that ample accommodation for poultry be provided in this instance. Something of the kind is of course needed at the other types of homestead, but not very often in the proportion found necessary on the smaller dairy farm. Poultry-keeping is a fruitful source of income to the dairy farmer's wife, because she is favourably situated for looking after the birds, and it is but right that she gets the chance of developing this branch industry to the limit of her powers. It is a shame that the poultry are to be found so often stowed away in a loft in the byre. The cows are thereby robbed of their already scrimp enough air-space, and the poultry placed under very adverse circumstances as regards pure air and cleanly surroundings. There is often no proper way of access for women folk reaching the loft, and after more or less scrambling the floor has been gained, it is only towards the centre of the place that one can stand upright. Under these circumstances it is hardly likely that much attention can be paid to the periodical cleaning out of the place. It is enough to overtake the egg-collecting without in addition having to stir up latent dust and smells in a general turn-over of the place. The hens are kept warm in winter, which is to their benefit if accompanied with even fairly fresh air; but this condition is entirely wanting when they are perched among the spent and vapour-laden air of the cow-house. And in summer, on account of their house being so close to the slates and little if any means of ventilation being left in the roof, the condition of the air within is sometimes really shocking.

Something better than this ought, we maintain, to be at the disposal of the thrifty housewife. Such a condition exists because nothing better is placed to her hand. Give her suitable houses to start with, and the backward state of poultry management that characterises our agriculture generally will begin to improve. The sanitary inspector, where he can, is gradually interfering for good in this respect, but the matter might be rectified without waiting for his suggestions. What is given must further be convenient to the dwelling-house—somewhere adjoining the rickyard, perhaps. On the arable farm, what of this kind of accommodation we provide will for convenience be near to the farm kitchen, somewhere beside the small byre and stable. There is less need, however, of providing in this way for the requirements of the bigger farmer. If he condescends to poultry-keeping, and has a taste that way, he will no doubt have movable houses for the majority of his feathered friends, so that he can both keep the separate breeds apart and give any of them a change of ground as he thinks fit.

Plan IV. (for the Sheep Farm).

There remains now the sheep farm pure and simple to attend to. What is needed here is hardly worth a plan to itself, and might be delineated as we go into detail over other matters in the following chapters. All the same we will do by it as with the others. What is really wanted on the moorland or hill farm, however, is, in fact, more or less of a miniature steading, and may as well be depicted in company with the others. Setting aside the farmhouse and the shepherd's cottage, what may be looked for at the place are the barns, a stable, and a cart-shed, room for a few cows and some young cattle, a pig-house, and plenty of shedding. The latter is wanted both for the temporary storage of wool, and for the handling of sheep on the great occasions of smearing or dipping, clipping, and the separation of the lambs from the ewes, and ought accordingly to be made inter-communicable. And in connection with the sheds there must be suitable pens or "fanks" in which to classify the sheep and retain them, as may be desired. When the steading is of any size, both a corn and a hay-shed are useful adjuncts thereto. They enable the respective crops to be easily and expeditiously made safe for the winter; and to be able to abstract a few sheaves from the one or a bundle or two from the other without having to break into a rick of either, and thus make it vulnerable to the next high wind, is a great boon at a place of the kind.

The farm may be so large that one gathering-place is not sufficient to serve the different "hirsels" or separate "gangs" of sheep. In that instance supplementary fanks and sheds must be put up at the most convenient places, besides the cottages of the more outlying shepherds, perhaps. Sheds and barns to any very appreciable extent can hardly, however, be called for at many of these isolated places.

On Plan IV. we have, therefore, laid down the arrangement of a miniature homestead, typical of the wants of the class of farm it refers to—the simplest, yet to us the most interesting homestead of all—the one that calls to memory the pleasant pastoral sounds connected with the sheep-walk, as well as those associated with the lonely moor. It brings us in mind of the annual gathering of the flocks, whether to dress or wean the lambs, or to shear or dip their dams. And we hear in the one connection in endless medley the shouts of the men and the laughter of the girls, the yapping of the dogs, the thick "baa" of the ewes, and the tremulous bleating of their offspring; and in the other the wail of the whaup, the bumming of the snipe, and the "kuck-kuck" of the grouse.

We have now exhausted the list we led off with, and it remains to go closer into detail. To do this the more thoroughly our idea is to discuss separately the several buildings that make up the homestead, paying close attention to the fittings and other peculiarities of each as we go along. In that way we would seek to make matters clear, and help to spread a sound knowledge of this branch of rural economy.

First, however, there are fundamental points common to each of the buildings—the walls and roofs for instance—which, for the sake of learners principally, we propose to take up at this stage and have done with, in order to steer clear, as far as we can, of unnecessary repetition. These subjects will occupy us long, but some acquaintance with them is essential on the part of him who has to do with the arrangement and construction of farm buildings.

CHAPTER II.

THE WALLS.

The Materials for their construction. In the construction of these we are led of necessity in a climate such as ours to make use of materials that are capable of withstanding exposure to sun, rain, and frost. Nature provides us at first hand with stone, a material which in every way answers the purpose. It is impracticable, however, to handle it in bulk and form a building out of it devoid of joint or seam. But our progenitors early discovered that fragments of stone could be built up to form walls of considerable stability. These were at first thick and unwieldy. The workers' tools, if any were then forthcoming, must have been few and of small account, and as likely to harm the handlers as have much effect on the stones. In time, with the growth of intelligence and experience on man's part, he took to the piecing together of handy-sized stones by means of mortar or plastic stuff that would eventually harden more or less and knit all in a piece. Neater walls were thus obtained, their lasting powers being determined by the nature of the mortar used. Mud of a clayey texture—still necessary to the house-building swallow and to the man in embryo (the savage as well as the child)—was the first sort of mortar man turned to account. Nowadays we have mortars that will become as hard as the stones they are set to bind together. Walls constructed of building stone and a mortar of this class, if properly put together, are more efficient than if they were cut out of solid stone, could such a thing be done.

Stone. Stone of one kind or another is readily met with in most districts of the British Isles. In some it is too far underground to be readily available. Where this happens recourse is had to brick, which is simply artificial stone. The situations devoid of building stone are happily those that are generally well supplied with brick-forming clay. This, mixed with a due proportion of sand in order to form a slight flux, is formed into bricks which are roasted in kilns and thus rendered as hard and impervious to moisture as stone. In no part of our country, therefore, have we far to go for material, whether it be stone or brick, with which to erect the walls of our various buildings. And in this way it occurs that the nature of the walls of a homestead take after the geological formation indicated by the outcropping rocks of the neighbourhood, or it may be by the absence of any such. Here we come across one built of whinstone that has either been quarried or found in boulders; there one of granite similarly obtained; another we pass constructed of freestone. Further afield we may come upon one the walls of which are of limestone, and by-and-by, as we proceed, find another where brick alone has been used. These different types tell plainly the nature of the crust of the earth around their respective sites.

So far as efficiency goes it matters little what kind of stone is used in the construction of the buildings. One is as good as another, provided of course that it be a good specimen of its class. Generally speaking, the stone from stratified rocks such as our various sandstones succumbs sooner to weather than granite, whin, and stones of a similar nature do; but it is a very poor stone indeed that cannot be turned to useful purpose in farm buildings. No such sharp, well-defined corners are looked for in these that one expects in a dwelling-house or town building. All the same we do not advocate the use of poor stone in this connection. It is, however, bad management fetching either brick or stone from a distance, if the available stone of the immediate neighbourhood, though perhaps not so good as either, is capable of being formed into a good wall. The dry-stone dykes or walls of any district give one a good idea of the weather-resisting quaiities of the easiest obtained stones of the country-side. Stone gets well tested in these erections: consequently when we meet with an oldish dyke the stones composing which are still comparatively sharp on the edge and not much crumbled on face, it may safely be taken for granted that stone of the same kind is quite good enough with which to serve the builder at the homestead.

Although the various kinds of stone found in agricultural districts are much on a level as regards efficiency, they vary considerably in matters such as texture, density, their form of cleavage or fracture (how they split up into pieces that can be manipulated first by the quarrymen and next by the mason), and so on. Stratified rock, be it sandstone, limestone, or shaly stuff, or any of the innumerable gradations and admixtures of these, can as a rule be readily quarried along the natural bedding planes of the rock. At one time horizontal, these, as the result of the subsequent crumpling and twisting, are now found running in all directions corresponding with the degree of disturbance the respective strata have undergone. The primary rocks, those composing the ribs of our sphere, such as granite and the early ones laid thereon that have now lost trace of their origin, as well as the intrusive rocks, whin, trap, and allied kinds, those that have been thrust up through the sedimentary rocks of later time, are more homogeneous in bulk. The first-mentioned contain many flaws or lines of easy fracture, while the others have few weaknesses of that nature. The one quarries out in longish blocks or in cubes, but the other gives way to the labourer only in jagged junks of irregular fracture. Every time the steady deposit of rock-forming material in the sedimentary rocks has been temporarily checked or been entirely replaced by some other one, a fresh bed or easily-defined joint represents the change. These joints between and among the several beds afford a ready line of separation between the respective beds, or, when such occur, between the different layers of single beds, of which quarrymen are able to avail themselves. But nothing of the kind is there to help them in their attacks upon the real framework of mother earth. Some of the sedimentary rocks are further rendered easy of upbreak by means of frequent fractures along the short plane of the stratification, that is, at right angles to their bedding, caused by crumpling and contortions of the earth's crust as it adapted itself to varying strains during the cooling and lessening bulk of the globe. This and other causes have in many places similarly reduced the primary rocks to a more or less shattered condition, and, if nothing else, given quarrymen a clean-cut side or sole to work from and so render his labour easier, or, at any rate, more symmetrical in its development.

Brick, Wood, and Iron.

Failing available stone, brickwork takes its place. This, when of good quality, is about as permanent as good stonework. Wood is but a makeshift as a wall-forming material at the homestead. Galvanised iron is hardly so serviceable. Wood, if kept clear of the ground and put together in such a way that moisture can freely drip from it and air have liberty to play on it, will indeed last a considerable time. But the place for galvanised iron, if used at all, is the roof, under which head we shall duly treat of it.

The Dressing given to the Stones.

The stones used in farm buildings are never dressed into symmetrical blocks more or less polished, such as we are accustomed to see in the better class buildings of towns or in country mansions. All they usually receive at the hands of the mason is a chipping off or rough "clour" of sharp edges and corners by means of his single-handed hammer. The great matter to keep in view is to avoid stones of a wedge shape. Every one who thinks must know, this is the worst form anything that has to be laid on or against others can have when stability of the structure is essential. The wedge leads to sliding and outward thrust; but every particle in a theoretically perfect wall presses downwards to the earth's centre within the narrow space defined by the outer and inner faces of the wall. The art of the mason lies, therefore, in his skill in first knocking the stones into suitable shape, and thereafter placing them in position in such a way that they will lie steadily each one as part and parcel of the whole. Each must be able to bear its share of the weight above without flinching. Once the mortar has become hard and stone-like in itself it serves to bind all the different pieces of stone together as one. This we have all seen in the ruins of castles and abbeys. It is a slow natural process, however, and in the meantime the wall, as a patchwork of separate pieces of varying size, has to stand.

It is evident that the nature of the stones available has much to do with arriving at a state of stability of the wall. Flat stones "bed" well because they have little tendency to shift. They bear equally on those beneath and they afford good footing to those above. Others that are all angles act as so many compound or many-sided wedges, neither steady themselves, because lacking in breadth of base, nor of advantage to others adjoining them above and around. Bricks are entirely different in this respect. If laid both level and plumb each one is bound to distribute its own weight as well as the burden it sustains equally at all points of its base. But from their comparatively small and uniform size a brick wall has of necessity a large number of joints, which are all so many weak points in the structure. We shall see as we proceed how the bricklayer counteracts this defect. Meanwhile it will be well to observe the proper sequence and first discuss the foundations of the wall, and next the matter of the mortar that holds the stones or bricks together.

The founding of the Walls.

In order to make sure of a firm foundation the wall must be based either on rock or on unyielding subsoil. The aim in view is to secure uniform pressure at every part of the foundation. This it is impossible to arrive at absolutely. One cannot make certain that even the bottom of a trench cut down to the rock will be equally firm from end to end. Were we to cut far enough into the rock, provided the same kind held good over the area embraced by the foundations of a building, a close approach to the ideal of equal resistance throughout might be obtained. The architect of farm buildings has to rest content with less, however. He has to be satisfied with a trench cut down to the undisturbed subsoil. And this, if level in bottom, does well enough, and without being very deep. Level it must be, however, else the weight of the wall will be unequally distributed over the foundation, and undue strains will eventually throw it out of shape. There must be no compressible soil that has either been disturbed by recent excavation, or "spoil" that has been deposited on the place between the foundation stones and mother earth—the stuff that has not seen daylight since it was carried hence by natural forces and deposited over the site of our proposed building. Any sort of medium, other than the natural subsoil, be it cultivable soil, "forced" stuff of any kind—soil laid there artificially—moss or similar organic accumulation, must be cleared out "down to the hard" before a satisfactory base for the foundation can be ensured.

Sound boulder clay and firm sand make the best of foundations. But there must be a sufficient thickness of either. If there is merely a seam of one or the other lying upon a bed of yielding matter, of a mossy nature, for instance, only an unstable base can be expected. Given on the other hand a fair depth of boulder clay or well compacted sand, we have at once a bottom of uniform resistance on which to start the rearing of our walls. It is not necessary to go far down in either substance to make sure of a base that practically speaking is fit for any ordinary purpose. Here, in fact, we are nearer the ideal of a trench of unvarying consistency than in almost any other medium.

Concrete in some cases a valuable aid.

Cement concrete is a valuable aid towards strengthening weak foundations or rather in safeguarding against bad results likely to happen from these if treated in the usual manner. The weak points of a foundation betray themseves as the weight gradually begins to increase with the height of the walls. They may not give way until after the completion of the building, but sooner or later they are bound to be found out. The innumerable strains that come into play in a new building before it has fairly settled down to stability give many a thrust and counter-thrust ere each can be merged into the central one of all—gravity. It is generally not till after this has been accomplished that the weaknesses referred to begin to show; and then too late to be remedied at the seat of the evil. There is no getting down then beneath the foundation to make good defective parts. Concrete possesses the good quality of being able to be turned to account in bridging over the inequalities of an inferior kind of foundation. It forms in the foundation trench when properly laid a continuous solid mass from end to end capable of spanning these weak places without yield or break. Thus an irregular base is converted into one steady and solid, on which to erect the fabric of a building. Where mother earth is sound at surface and good big stones are abundant, nothing further is needed. Where, however, these conditions either together or singly are absent, concrete is of great advantage in this connection. In a brick district, too, it may be the cheapest thing to use even under good circumstances as regards subsoil.

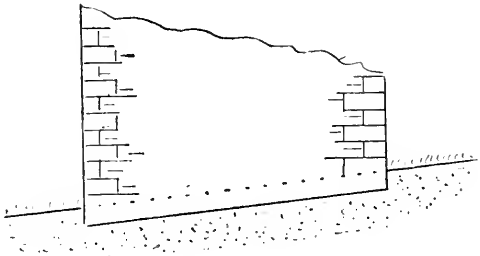


FIG. 1.

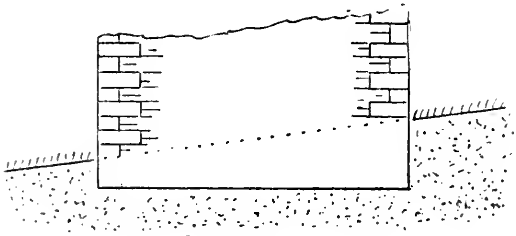


FIG. 2.

The Foundation Trenches.

We have already emphasised the necessity of forming the bottom of the foundation trench as level as possible. A wall built on a foundation with a rake as in Fig. 1 cannot be considered very stable. It may not be practicable to cut the whole length of the trench on one level. Irregularity of the surface may prevent the thing being done. When the trench follows the inclination of the slope it can be done at no point, that is to say, keeping economy in view. It can be done, as Fig. 2 shows, by cutting deeper at the high end of the trench, but if the inclination is quick it can easily be seen what a serious amount of extra building is implied under this manner of working. The same end can be obtained by the easier and simpler method set forth in Fig. 3, which is equally serviceable with that of Fig. 2; and out of question considerably cheaper.

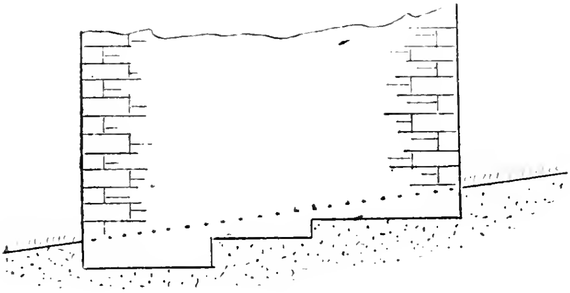


Fig. 3.

Every change in level of the bottom of the foundation trench must be followed up in the same way by one or more steps. If this is not observed there must be unequal distribution of strain in the wall. In a well-built wall the strains are all led into the perpendicular by gravity, and pass down parallel in accordance with the arrows on Figs. 11, 13, 14 and 16, and within the outer and inner faces of the building. But the wall must be plumb and the foundation equal in resistance throughout to allow of this. Whenever the bottom of the trench varies in level, at these points there

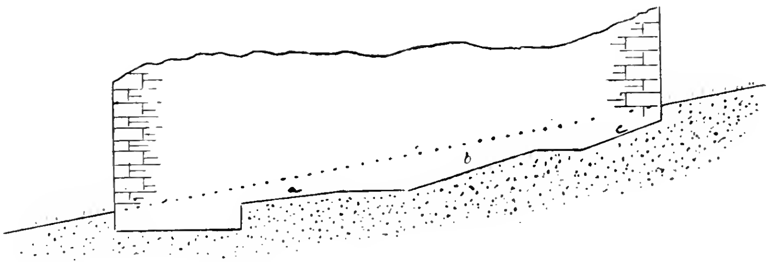


Fig. 4.

is, as Fig. 4 shows, a break in the uniform resistance of the bottom of the trench and a consequent change in the distribution of the weight. At points *a*, *b*, and *c*, the respective portions of wall raised on these are bound to bear to the side which dips lowest and therefore to press against the part of the wall there. Each portion of the wall, however, is supposed to have its own duty meted out to it without having to buttress adjoining parts in addition. Instead of the pieces we are instancing being given a chance to stand strongly up to their work, their foothold is weakened by being placed on an incline down which they would slide were they not arrested by the nearest part on the level.

In Fig. 5, we draw attention to the danger of carrying a foundation that follows the face of rising ground too near the edge thereof. It is a kind of foundation, however, that one is not often brought face to

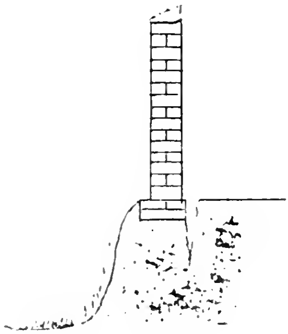


FIG. 5.

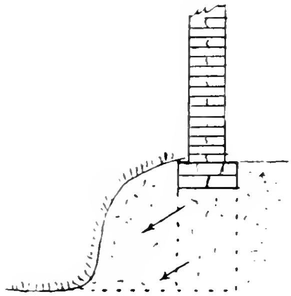


FIG. 6.

face with at the homestead. Still it has sometimes to be encountered, and to be forewarned is generally to be forearmed. In a case of this sort the wall must be kept in from the face beyond the point where the outer side support of the section of soil on which the wall rests comes to be non-effective. There is bound, of course, to be some outward pressure from this section, becoming less as we descend. This is

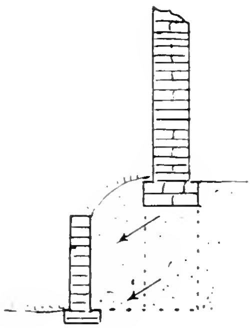


FIG. 7.

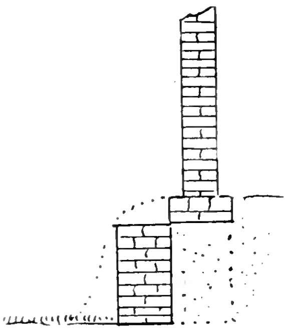


FIG. 8.

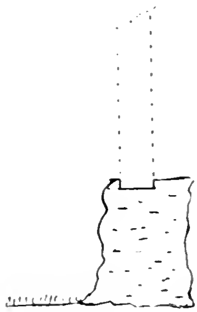


FIG. 9.

represented in Fig. 6. It will not do, therefore, to go so near to the face of the incline as to pass the point where there is too little bulk of soil on that side to counterpoise the outward pressure referred to. If we do the foundation will soon slip to that side and collapse. A retaining wall such as in Fig. 7 will strengthen matters a little, but not much more than results from the good effect of preventing the soil from crumbling away through natural cause or otherwise being disturbed. It will prevent the exposed bank from being eaten back to the dangerous point. Were it made sufficiently thick it would come to take the place of the section of soil that was then wanting to bring the surface to a common level, as ticked in on Fig. 8. Its weight would then prevent its being readily thrust. But to make it so thick would be expensive and add much to the cost of the building. On a bank of firm rock we could come to the edge of the bank, the closeness thereto being governed by the power of the rock to withstand the wear and tear due to weather. Were it strong in this respect we could without danger build on the brink, the one precaution being observed to cut a level foothold for the wall as shown in Fig. 9.

The reason why Walls must be built Plumb.

That a wall to be as perfect as possible must be built plumb is on account of the law of physics that a body, through whose centre of gravity a perpendicular line passes outside the figure formed by the several points on which the body rests when in equilibrium, must have the aid of other support else it will fall. Take for instance a square board, say twelve inches square and an inch thick. Lying on its flat side, as in Fig. 10, the board is in stable equilibrium. So far as itself is concerned it has no tendency to change its position. Its centre of gravity may be taken as lying at the point of intersection of its two diagonals and therefore well within the figure described by the lines joining its outer points of support. In this case the figure is a twelve-inch square with the line through the centre of gravity right in the centre thereof—a condition of perfect stability. But set the board up on edge. It will stand thus, but in a position of unstable equilibrium as compared with its former one. We are nearer the figure of our wall now, and the one may be compared with the other.

FIG. 10.

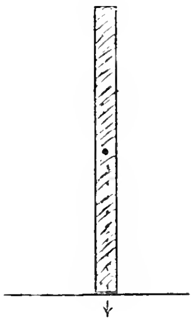


FIG. 11.

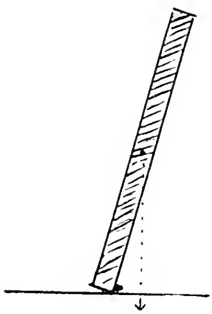


FIG. 12.

Standing on edge on a level surface, as in Fig. 11, the board is consequently plumb, and the vertical line which passes through its centre of gravity falls within the figure defined by the points of its support, this time a figure twelve inches long by an inch broad. Now, however, a very slight cant of the board to one side, in accordance with Fig. 12, throws the vertical line outside of the figure formed by the base, with the effect of its toppling over and lying flat. Flatwise it is in stable equilibrium; on edge it is in a condition of unstable equilibrium. A body at rest with its centre of gravity situated as low as it possibly can be placed is in a state of stable equilibrium. The same still at rest, but with its centre of gravity at the highest point attainable, is in unstable equilibrium, and very little will serve to set it seeking the more stable position. The board when on its side is, as we have said, in stable equilibrium, and not to be shifted easily out of that condition; but on edge it is never, so to speak, easy, and is ever ready to assume the more fixed one. Were the board thinner it would have the greater difficulty to maintain the upright position. And so would it were we to enlarge the board without altering its thickness. In each case we are conducing to the same adverse effect on the stability of the object. In narrowing the base, as in Fig. 13, we are making it the harder for the vertical line through the centre of gravity to keep within the side lines formed by the base. Enlarging the board without adding to the thickness, as in Fig. 14. we are doing the same thing.

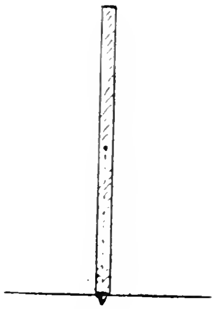


FIG. 13.

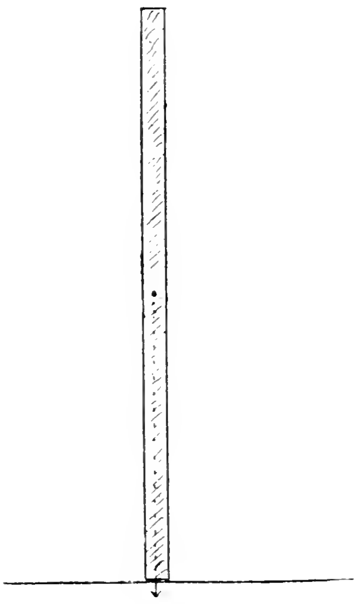


FIG. 14.

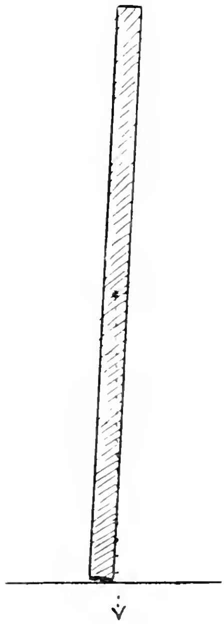


FIG. 15.

We are here again increasing the ratio of the height of centre of gravity to breadth of base. A very slight sway to the side, as in Fig. 15, would now throw the vertical line outside the lines which defined the base, and bring about the fall of the board. As small a force would upset it as would do so in the case of Fig. 13.

The wall comes under the self-same laws. It must first, however, be knit together in all its parts as one continuous fabric. Until this occurs each stone in the building has to be taken on its own merits. It can hardly be said that each piece is a separate mass of matter on which the laws of gravitation are free to work their will. In the course of erection this is so to a considerable extent. But even when the building is at its greenest the individuality of the several stones that compose the same is much curtailed through the adhesive action of the mortar, and the weight of the part of the wall that happens to be above them. These other forces bring an entirely different state of matters into play from what takes place when the stones are left to be dealt with singly and without the interference of other forces than gravitation. Placed together in the wall, one either bears upon or leans against another, and is thus prevented from changing its place, the mortar further tending to prevent separation of the component fragments. It needs little reflection to understand why it is that, notwithstanding such aids to stability as the adhesiveness of the mortar, those stones that are shaped nearest in outline to our assumed board and laid on their face are the least liable to shift, and go to form the strongest wall. They, like the board, are in stable equilibrium, and have no inclination to shift in any direction except steadily downwards. Not only do they lie securely themselves, they help others lying above them to do so; they press equally on the area beneath them, absorbing in themselves any disruptive tendencies that ill-shaped or badly bedded stones immediately overhead are causing. As we shall find, it is customary to stipulate that numbers of stones approaching the shape variously termed "headers," "throughbands," and so on, be distributed throughout the wall as it proceeds.

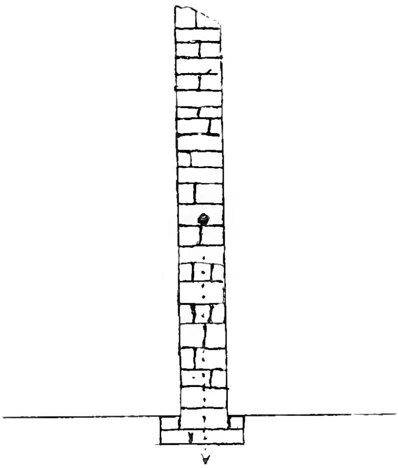


FIG. 16.

Once the mortar has "set," and the wall has become a whole, growing stronger (internally at least) with years, it may be held as analogous to the board aforesaid. Turning then to Fig. 16, and leaving out of account the part of the wall underground, the erection will take no harm; it will not fall, at any rate, until the line, as before, passing down through the centre of gravity of the wall, goes outside the edge of the base of the figure. But in practice the foundation counts—it does at any rate when put together with mortar and made continuous with the wall, and this being usually wider than the wall itself helps the stability of the structure. The centre of gravity is now brought nearer the ground, and the base is widened. A concrete foundation does not tell in this way, because the cement is "set" before building takes place upon it, and therefore, foundation and wall cannot be continuous. And, to a certain extent, a damp course will serve to break the bond of union between wall and foundation. There is not, indeed, much danger of a well-built wall, given fair play, ever swaying over to the falling point. A poorly-built one, it is needless to say, will lighten itself long before the critical point of a good one is reached. How long a good one may keep its feet, even when considerably off the perpendicular, we have the famous example of the leaning tower of Pisa. But we look for nothing but plumb-walls at homesteads. They are rarely so high that any excuse can be advanced for their going to one side.

Ordinary Mortar.

The mortar of every-day use is an intimate mixture of lime and sand made into a thin paste with water. The lime is burnt limestone, the principal natural form of carbonate of lime, or, to speak more technically, calcium carbonate. Roasted in kilns, the carbonic acid or carbon di-oxide is driven off as gas from the limestone by the heat generated, and lime or the oxide of calcium left. In practice the quarried pieces of lime are thrown together with a certain portion of coal into the open limekiln. Provision is made for fire being applied at the bottom of the basin-like building, and for a sufficiency of air to promote combustion being admitted at will. On cooling down, the contents of the kiln are thrown out as lime shells, in a state of purity corresponding to the quality both of the limestone and the coal dealt with, and to the thoroughness of the process. If the limestone prove inferior the proportion of effective shell to the initial stone will be the less; if the coal be indifferent a good deal of unnecessary cinder will be in the shell; and if the process is not thorough the best will not have been made either of limestone or coal, whether one or both be bad.

Its preparation.

Lime shells are known as quicklime. They have great avidity for moisture. Whenever they come in contact with water they absorb it greedily and enter into chemical combination therewith, evincing much heat at the time and crumbling to powder. The mason, on delivery of the shells, at once sends a labourer to attend to them. The labourer arranges them in a heap, surrounding the base with a proper quantity of sand, then pours water over them until they are thoroughly drenched or "slaked," as the term goes. This finished he envelops the heap in sand and allows it to remain undisturbed for some time. It is all the better to be untouched for two or three weeks. In that time all the particles in the heap may get a chance to be moistened, and the whole contents to become well "soured," as the tradesman says.

About two parts of sand to one of lime is considered the standard proportion in making mortar. It is impracticable to heap all this quantity of sand on the shells at the time of slaking. No more than will cover the shells and to some extent retain the moisture is required to begin with. The full allowance of sand is added when the mortar is being prepared for the builder. Preparatory to this, the by this time quite dry contents of the heap are passed through a sieve or riddle which ensures that no hard pieces of matter get into the mortar, then water and additional sand are added and the stuff made ready for use.

The "setting" or hardening of Mortar. The mortar gradually dries and hardens in the wall, binding all, stones and lime, into one solid piece. This takes time, however, according to the circumstances that affect each case. Some take a short time, others a long time. In any case it does not do to scamp the proper bedding and locking together of the stones above referred to, trusting to the mortar to correct the evil. When the latter has reached the stony stage it is then able to hold the weak parts in place, but there flaws would need long as well as careful bolstering ere the mortar were fit for that purpose.

According to theory, the hardening of mortar in the wall is due to the reconversion of the oxide of lime to the carbonate. It absorbs carbonic acid from the atmosphere and reverts to carbonate of lime. This takes a considerable time. The lime dries as it hardens. If subjected to the influence of more moisture than was added when it was being prepared, the natural process of the hardening of the mortar is hindered, and if this be continued too long it will lose the power of "setting." Unlike Portland cement, it will not cohere at all under water. Some of it will dissolve and a larger portion be taken up in solution by the water, the remainder will become disintegrated and be turned into sediment.

The quality of the mortar depends much on the nature of the sand it is made up with, assuming, of course, that the lime is good to start with. It is argued that since there is much silica in sand, this unites with the lime to form silicate of lime. But the chief part taken by sand in the partnership seems to be that the separate grains or particles afford suitable media round which the slowly forming carbonate of lime can crystallise. Each constitutes a nucleus or rallying point for the carbonate as it generates. The cleaner the sand—the freer it is of mud or earthy matter—the more effective the part it plays in mortar. The grittier, too, the better. It is no uncommon thing to find it in the ruins of some ancient castle more after the nature of gravel than sand. There is a happy medium, however. When it is too coarse in grain the resulting mortar is not conducive to close bedding of the stones. But this is of less moment in the country than in the town. In the town square polished stones are much dealt with, and these have to be accommodated with close-textured mortar; and brickwork requires a mortar less gritty than answers for roughish stonework. In towns, or wherever big jobs justify the use of the pug mill for mixing mortar, we find the labourer throwing all manner of stuff into the tub or trough—brickbats, chips of stone of all kinds, sand (earthy and otherwise), and not a little soil at times, and yet turn out the best of mortar. This seems to belie what we have been saying, yet there is bound to be truth in both rather contradictory facts. In the pug mill the miscellaneous contents are subjected to treatment that converts the whole into a mixture more after the nature of a cement than ordinary mortar composed of lime and sand pure and simple.

Here may be a suitable place to warn beginners against the use of sand that has been recently under the influence of sea water in buildings. Such sand is ever absorbent of moisture from the atmosphere, and buildings that contain it are never really dry. It is possible to wash out the salt of sand thus contaminated from a builder's point of view; and sea sand from far above high-water mark is not liable to have much of it in its hold; but it is advisable to keep clear of both when possible.

Portland Cement.

Portland cement is another substance occasionally put to use as mortar—only under special conditions, however. It is not well adapted to the every-day purposes of the builder. It sets too quickly to be effective as mortar for wall-building. In the case of ordinary mortar, for long after the building has been completed the lime will be found comparatively soft and yielding, therefore capable of adaptation to a considerable amount of compression. Matters would be different were Portland cement the mortar that held the stones together. Before many courses were laid the mortar in the first one would be set hard as stone, with the consequence that instead of its being able to pack closely into the internal crevices, holding the stones tighter together as the rising wall increased in weight, it would have to find relief in cracking and splitting. But were it the equal of lime for building with, its price would forbid its general application to the purposes of the mason.

Portland cement is largely taken advantage of at the homestead in the manufacture of concrete for floors. It is of much avail too in the construction of watertight tanks of stone or brick; and in some positions it serves well to point with, and to plaster parts of walls much subjected either to wet or to hard knocks.

It differs from lime in being more complex in composition. In the process of its setting more forces would seem to come into play than are supposed to be concerned in the hardening of lime mortar. We have already mentioned that Portland cement will set as well under water as in any ordinary place elsewhere. In fact, it begins to set of its own accord, and that without the help of sand or other partner of the kind whenever affected by moisture. On this account Portland cement cannot be safely stored in a damp place. Of course, if exposed to rain it will harden right off and become usless as mortar. It can be used either with or without sand as circumstances decide. It is nearly always advisable, however, to mix it with more or less sand. There is not much risk of giving it too much, because, speaking generally, it can carry more than lime is capable of doing.

Lime is the most fully represented body in Portland cement. A certain percentage of clay is also present in the substance. It is not altogether a natural product, although it can be manufactured almost entirely from special kinds of deposit of a more or less rocky description. Unlike the simpler lime, it is ready for the builder as it leaves the hands of the producer.

Arden Lime. Another kind of mortar lying, as regards composition, somewhere half-way between lime and Portland cement is known under the name of Arden lime. It, too, is ready for use when it reaches the builder. Very seldom does Arden lime take the place of ordinary lime in wall-building; it does not at the homestead, at any rate. Pointing is the principal end it serves.

Building Stone Walls. We have now got our stones and mortar, and may proceed to the erection of the walls. The foundations are usually laid six inches or so wider on each side than the walls. This extra width where it finishes at the surface and forms a ledge or shelf at either side is termed the scarcement. Large flat stones make the best material for a foundation. Sometimes these are laid one upon another without the addition of mortar. This we consider is not economical. A more satisfactory basement for the wall will be afforded where all the joints and crevices in the foundation have been toned down by the means of mortar. Where mortar is not too scrimped in application it will take upon itself many of the strains that affect the wall, and in its yielding before these, by pressing into places where tension is slightest, in this way serve as a sort of elastic packing to equalise the pressure throughout the whole. But whatever the kind of stones turned to account in the foundation, and whether we leave scarcements or not, or leave out the lime, we must, without fail, observe what we previously enforced regarding the bottom of the trench. At no part must it be so left that any piece of the wall, not even a running foot of it, can have other than a straight down pressure—parallel with the plumb-line. The matters of the class of stones, and that of mortar, are not of such vital importance as this one—that the wall must, over the whole area of its foundation, press down at right angles to the bottom of the trench, and this it cannot do unless, to begin with, the latter be everywhere strictly horizontal.

Rubble work.

The walls of farm buildings where of stone are built after the style known as random rubble work. The stones are taken as they come and fitted together in the manner they are likely to lie most conformably one with the other. There is no exact squaring of corners observed previous to the stones being laid near at hand to the builder. The builder and hewer are one and the same person at this style of work. Before starting to build at any time he first overhauls the stones, selecting the best for the outer face of the wall, and laying them to one side. Each of these must have one smoothish face to present to the world. If no suitable face is already on the stone one must be given it. This is accomplished by means of hammer and chisel or hammer alone in accordance with the texture of the stone. At the same time, the sharpest of the corners are knocked off, and what of the edge surrounding the face that requires it is dressed back at right angles to the same, the part behind being brought into conformity therewith. When this is done the stone is of itself assured of a good bed, while it offers the same to those that are to be both against and above it, and all present close-fitting joints to the exterior. Less regard is paid to the stones that are to form the inner face of the wall, although some measure of the same kind has to be meted out to them. Those that are to be consigned to the interior of the wall are taken as they come and filled in as they are required, small regard being paid as to how the hammer affects them so long as they yield before it.

Best Class of Stones for the purpose.

Stones of the nature of sandstone—the various freestones—are of all kinds handled by the mason the most readily put in shape for building purposes. Limestones and some of the shaly rocks are not far behind them. Granite is not so bad either. But hard trap rocks such as whin which fracture at sharp angles are difficult to coax into shape suitable for a good wall. With hammer alone an expert mason can work wonders on them, yet it is easy to understand how hard it is to dress a stone of this class into form that will afford all round the outer face that uniform and effective joining with contiguous stones referred to above. For this reason these stones are not very well adapted for rubble work, at least of the kind seen at the ordinary steading. It is not easy to build a wall with these that will keep out rain. With hammer and chisel they can be dressed into blocks having good beds and side joints, and in this shape be built to form an excellent wall, pleasing to the eye as well as impenetrable to rain. But this implies increased expense compared with ordinary building. With care, however, it is possible to have a dry wall even with these hammer-dressed alone. It may be thought that the homestead walls have no need to be so carefully erected as the walls of dwellings. They must, however, be dry as well as strong, and neither consummation can be attained without the exercise of care and pains-taking. Boulders are sometimes the most readily available source of either granite or whinstone and their allies. A mason experienced in the handling of these can quickly knock them into shape, and a wonderfully good wall they make under a man of this kind.

Finishing of Corners and of Door and Window Openings. The corners of walls and the outer sides of the various openings therein—doorways and windows—require to be finished with dressed stones of a uniform size. This affords solidity and strength to these parts, which they would not have were they merely a continuation of the rubble wall. The corner stones are hewn level above and below, and squared at the sides. This gives them a uniform bed all over the breadth and length of the stone, and allows them to sit solid irrespective almost of mortar as an aid. The remainder of the wall has to await the time of the mortar before it becomes really solid. Secure corners thus keep the wall together while it is green, and are ever after solid buttresses guarding the flanks and angles of the building. They serve as a sort of firm framework in which to set the remainder while in its incoherent state.

It is possible, of course, by exercising special care, to finish off the corners and the sides of the various openings without any special treatment of the kind, and thus make them uniform with the rest of the building. But done in this way they can never be strong, and certainly they are neither so sightly nor so symmetrical-looking as when completed after the ordinary fashion. The sides of doorways are often built in this rather primitive way, but seldom the sides of the windows or the corners of the buildings, unless indeed the work is of the crudest description. Doorways finished so are spoken of by the Scottish tradesmen as being "scuntioned," the term evidently applying to openings in the wall not edged with stones hewn to a uniform shape and size. The inner part of the sides of windows, the part splayed inwards to allow the admission of as much light as possible, as well as the inner corners of door openings, are on the same account termed "scuntions." These, in dwelling-houses, are hidden behind the plaster, and so long as they are made strong, have no need to be finished in hewn stone. But at the steading "scuntions" such as we are discussing are left as they develop under the mason's hand, he just taking a little more trouble in the selection of stones for these positions and in the fitting of them together, and in their pointing afterwards. Inside, a corner constructed in that way may last for long enough, while outside it might early show signs of decay. Notwithstanding this, it might prove serviceable enough long after appearances were against it. Experience, however, has taught the builder that it is economical to use dressed stones of the kind referred to in the construction of the rubble wall at the homestead. In brick buildings nothing of the kind is necessary, because each brick, each unit that is in the composition of the wall, is of uniform size and shape, and at any part thereof a break can be made the sides whereof are as strong as the rest of the wall. The rectangular ends of the bricks make ever sure of a hard, clean-cut solid corner either at gable or opening through the wall.

In Fig. 17 the hewn or dressed corners show themselves in contradistinction to the plain rubble building. The stones of a similar kind used for the sides of doors and windows as represented in Figs. 18 and 19 are technically known as "rybats." These, it will be observed, are built alternately with side and end outwards, in order further to bind and keep together the irregular stones lying near to them. "Inband" and "outband" are the terms in use for this arrangement of the stones, the first implying that the stones are laid lengthwise across the wall, the other that their length runs with the face of the wall. The corner stones are similarly laid in this alternate fashion so as to tie the corners firmly to the whole fabric.

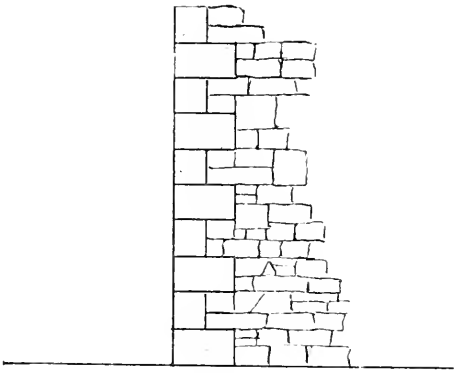


FIG. 17.

Lintels. The door and window openings require, further, to be bridged over. A single stone known as the "lintel," marked *a* on Figs. 18 and 19, accomplishes this. In some cases it is practicable to arch over a wide opening, which is a stronger method than lintelling

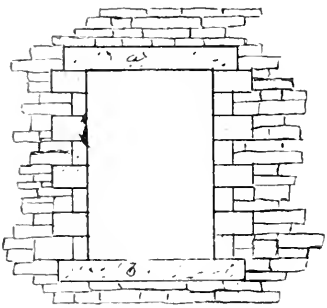


FIG. 18.

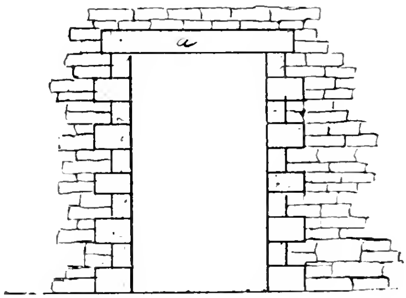


FIG. 19.

with stone. When the opening exceeds a certain width either wood or iron must be used: stone is not fibrous enough to withstand fracture when placed under a strain of this nature. It will bear compression or a squeeze to almost any degree, but compared with either wood or iron it is weak under contortion or twisting. The ordinary-sized openings of either doors or windows are, however, well within the minimum that stone can be relied upon to bridge over with safety, and it gives us a material that will prove co-existent with the building. The same cannot be said of wood nor yet of iron. The latter with care might be made almost as lasting. But continuous care of this kind is not usually exhibited at the homestead.

Sills. The window openings have to be provided with still another dressed bordering, the sill, *b* on Fig. 18; and in the generality of cases so have the doorways, with steps. The window-sill is necessary by way of a level support for the window-case as well as to ensure a watertight base for the exposed part of the opening. Something strong is needed in each instance, and in a single stone we find a proper medium.

Damp Course. A damp course is a necessity in the walls of a dwelling-house of any kind. It is not, however, usual to put them in farm buildings, though the cost thereof is so small compared with the benefit likely to be derived therefrom that we consider their use justifiable economy in a great many cases. The object a damp course serves is to cut off from the wall all direct communication with the ground damp that is open to affect the foundation. A little above the level of the ground surface a so-called watertight course is laid all round the walls. Sometimes one material is used, sometimes another. A row of slates embedded in Portland cement is a common form of damp course, or it may be the same cement used alone. Asphalt makes one of the best. The stuff is melted and perhaps sand added; it is then ladled out of the cauldron and laid along the level surface in one continuous sheet an inch or so thick and the full breadth of the wall. When this coating has become firm the wall is begun upon it and carried up as usual. If effectively done it completely prevents ground damp rising in the wall, whether under capillary attraction or the influence of other forces. Asphalt is a material less likely to fracture under pressure or irregular strain than Portland cement. The latter, as we indicated previously, hardens before the wall has had time to adjust itself to the various strains that play upon it and settle down to stable equilibrium. On that account the cement gets fractured. It cannot adapt itself to changing strains like a softer material can, and in consequence has to break instead of bend. Every break means a crack, and up a crack ground damp, if present to any extent, will readily find a way. Asphalt, on the other hand, is elastic, or yielding, and capable of giving way to pressure without fracturing, and it is quite as impervious to moisture as Portland cement. We sometimes have prepared paper and various felty materials brought under our notice as likely substitutes for damp courses. But something of a more tangible nature than either of these is required in the make-up of what has to hold its own in the life history of the outer shell of a building of stone and lime. We hinted above that a damp course might be apt to break the bond of continuity between wall and foundation. There is not much in this, however. To push it home would be like making a mountain out of a molehill. A course of the description last referred to might break the bond, but hardly either of the other two. Even if they did, we could look for the wall still to perform its duty.

Thickness of the Walls.

We are now free to discuss the wall proper. The usual thickness of the rubble wall as we find it at the steading is 21 inches—1 foot 9 inches. When bricks are used the hickness of the outer walls is 9 inches, or at the outside $14\frac{1}{2}$. The reason of a thinner wall being allowable when bricks are taken in place of stone ought now to be somewhat apparent to those of our readers hitherto unacquainted with such matters. Unlike the irregular-shaped stones that go to form rubble, the bricks are identical in size and shape, and can be fitted close together with little effort and without having recourse either to hammer or chisel. Each brick comes to the builder's hand ready shaped, to bed easily and firmly with what have already been deposited, and in turn to form an equally firm bed to what have still to be added to the structure. In like manner do they lend themselves to easy combination with those either to right or left of them.

With stone matters are entirely different, unless of course the pieces happen to be blocked out and hewn into rectangular form like bricks as we see in some of the better kinds of mason work. Even then, however, it is usually but as an outward veneer to the wall, the rest of it being built of irregularly-shaped stones. But with the rubble wall pure and simple we are at the antipodes of building from one of brick. The corners and sides of openings are, as we have seen, something on the line of brick building, but the remainder of the wall, with the exception of its outer skin, is more of the nature of coarse concrete than anything else.

"Headers," or Throughbands.

In order to distribute as equally as possible throughout the wall the pressure of its own weight, and what in turn it supports, which is no slight matter in an incoherent erection such as a raw or newly-built rubble wall, experience teaches that the frequent introduction of large stones that reach right across the breadth of the wall help to stiffen the mass into one coherent whole. In Fig. 20 it can be seen how these throughbands, or "headers" as stones thus put to account are termed incline to do this. They begin afresh, as it were, with a sound base on which to lay the smaller stones. Every other throughband is, as it were, a renewal of the foundation. If one compares Fig. 21 with Fig. 20, it is easy to see the importance of this point in building. In Fig. 21 the stones are so arranged that there is little to keep the wall from splitting should it ever come to be subjected to strains tending that way. A badly-put-together roof, as we shall see under that head, may bring about strains of this kind. The ties, or throughbands, in Fig. 20 entirely prevent this. If judiciously distributed throughout the wall, they bind the several pieces of the fabric as one, even when the other stones are small and not well shapen for building. They equalise the strain due to gravity as well as those that incline to thrust it beyond the plumb. It is usual to stipulate that so many of these are to be built in a certain area of the wall, and that they be placed alternately as regards their vertical position.

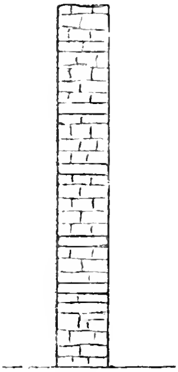


FIG 20.

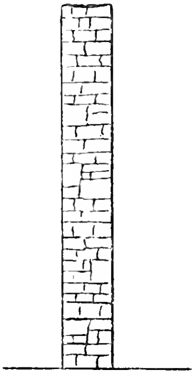


FIG. 21.

Those of one row must not be laid directly over those in the next row beneath. They must be distributed as equally as practicable over the superficial area of the wall. Fig. 22, which shows the ends of the throughbands in thicker lines than those of the surrounding stones, represents the point in hand.

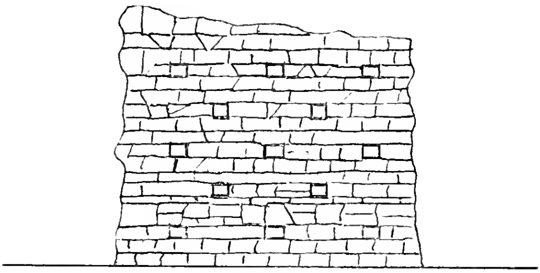


FIG. 22.

Flat stones, we need hardly state, make a better wall than either angular or roundish ones. A wall constructed of flat stones, as in Fig. 23, has not the same need of throughbands as one after the nature of that shown in Fig. 21, which perhaps is rather an extreme example made to point a moral. The wall of flat stones is nearly all throughbands together. It can be so built at any rate as to make it quite possible to dispense with these being introduced specially.

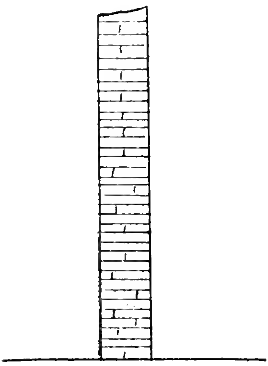


FIG. 23.

Bedding the Stones.

Builders of rubble work can hardly refrain from setting up the stones on edge rather than bedding them flatwise in the wall. They are so intent on getting ahead with the outer face of the building, the most finicking part, that they will readily sacrifice efficiency of the interior of the wall to this motive. A flattish stone set up on edge makes sure certainly of a goodly addition to the outer skin. Its shallowness, however, or rather its thinness, makes weakly the joints of such armour, and rain when beaten against it will very soon find its way behind. The same stone laid flat adds little in comparison to the outer face, but adds far more to the efficiency of the wall than the other instance. It makes it stronger, and it defies rain to find a way easily into the interior of the wall so far as the joints of its armour are concerned.

A leaky wall brings mischief in its train. The rain, once an entrance is gained, seeks down for an outlet, and no one can tell where that is likely to be. It may be inside, it may be outside; as likely as not it will appear in a steady drip from the lintel of door or window. But wherever it goes harm is resulting to the wall and bad effects are apt to follow on either man or animal housed thereby. The lime can never set properly under these circumstances; in fact, if much rain finds passage into the wall, it in time carries a good deal away in solution, as one can see from the rudimentary stalactites or limy deposits that gather about the points of exit.

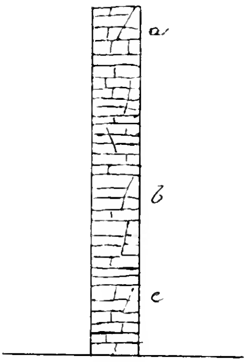


FIG. 24.

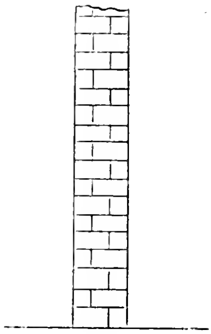


FIG. 25.

A badly jointed wall—that is, one the face joints whereof go no depth inwards—can hardly be kept dry if it stands exposed to gales of wind. The driving rain is certain to find a way through the outer surface, more especially if the heart of the wall is not well packed, and moreover is devoid of its due measure of mortar. Wind will then get into the wall and with it rain when the two assault in company. Looking at the stones *a*, *b*, *c* in Fig. 24, one can grasp the defective jointing of each at a glance. Wind and rain have only to beat long enough at the weak part of each to gain entrance beyond. Compare these now with the section of a brick wall as represented in Fig. 25. Here we have the perfection of bedding and jointing, an even and level bed extending over the whole area of each brick above and below and similarly with its jointing faces at sides and back, these touching uniformly at all parts the same shaped bricks at either side and behind. Built with good mortar, it is easy to see that wind and rain will hardly be able to drive rain through the joints of such a structure.

Bond in building as exemplified in Brickwork.

A demonstration in the interlocking of bricks in a building, or "bonding" as the technical term goes, brings home at once to the tyro the importance of the matter of placing the stones of a wall on the lines we have been seeking to make plain the reason thereof. There are various systems of doing this, but they are mostly modifications of the best known two, viz., the old English bond and the Flemish bond. Fig. 26 shows the arrangement of bricks in the former and Fig. 27 that observed in the latter. In the old English bond a row or course of headers—bricks laid crosswise, through-bands, in fact—alternates with a course of stretchers—bricks laid longwise or stretching along the face of the wall. Thus the side or end joints of one course never coincide with those of the course immediately beneath or of the course immediately above it. The bond is "broken," as the term runs. The joints of one course strike the solid bricks of the course next below, and in this way the points of least resistance to shearing force are equally distributed throughout the area of the wall. This is the aim underlying the different varieties of bond, and whichever comes nearest the mark is the most effective. There is not much room for choice of either before the other of the examples represented. To make for strength in the wall there ought to be more headers than stretchers: but the bricklayer nearly always steers clear of headers until appearances fairly force him to introduce them. Like the mason setting the flat stones on edge, he gets along speedier with the stretchers than with the headers.

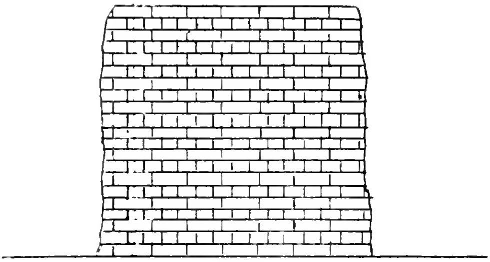


Fig. 26.

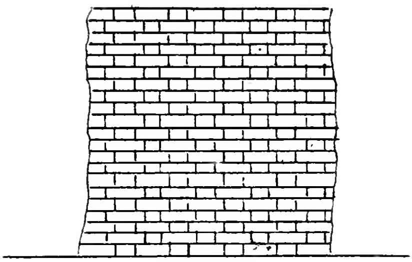


Fig. 27.

Standard Size of Bricks.

The standard size of bricks is 9 inches long, $4\frac{1}{2}$ inches broad or wide, and 3 inches deep or thick. They are indeed barely $4\frac{1}{2}$ inches broad. Were they made the full width mentioned, there would be no room left for the mortar joint when the headers came to be placed over a stretcher, as in Fig. 28; or, what is the same thing, they would fail to maintain with the almost mathematical precision we usually see in a brick wall the relative position of the joints in alternate courses. The headers would gain on the stretchers and the joints of the former would strike the latter at all parts as well as the centre of the bricks. The joints too of the two courses would come to coincide in their regular turn.

Either when starting from or finishing up at a corner it is necessary to introduce "closers," or bricks reduced to a size that will gradually lead the bricklayer into the regular rhythm of his work as regards the due measure of the bond he essays to keep. Fig. 29 will serve to make plain what we mean. Were he to lead off with whole bricks as in the lowest part of the fig., he would never be able to break bond. Starting with a course of stretchers and following with one of headers, the joint of the second two of these would coincide with the edge of the stretcher beneath. Halving the second header, as in the middle portion of the fig., would let the bricklayer out of the difficulty, and with a little chipping off the succeeding two or three would bring him to the desired symmetry. When the wall is a single one, of stretchers alone, the difficulty is simply got over, as in the uppermost portion of the fig., by halving a brick in every alternate course. A reversal of these processes has to be observed in winding up or breaking the line at a corner as represented in Fig. 30.

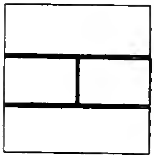


FIG. 28.

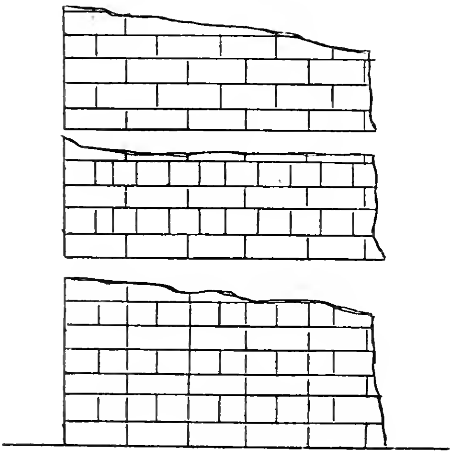


FIG. 29.

Bricks come in handy for erecting some of the partitions of a rubble-built homestead, seeing that a brick partition takes up less room than a stone one, and consequently saves outlay in roofing, and in front and back walls as well. In some cases a $4\frac{1}{2}$-inch dividing wall suffices; in nearly all others a 9-inch one will do. Sometimes it is practicable to reduce one of the last mentioned breadth to one of $4\frac{1}{2}$ inches after the level of the wall head has been reached.

Pointing the Outer Face of Walls.

When the wall is erected the joints of its outer faces are afterwards carefully pointed either with common lime mortar or with Arden lime mortar, or it may be Portland cement. The original mortar is first raked out of the joints, whether the wall is of brick or of stone. The workman opens the joint from half-an-inch to one inch deep and fills it up with the pointing material, leaving it neat and ship-shape on the outside as he proceeds. He has various ways of finishing it off, which differ mostly in accordance with the character of the building material, but the one that sheds off water most readily is bound to be the best. Rain is the assailant that has to be withstood. If the heart of the wall be fairly solid, there is less fear of rain gaining an entrance; and, on the other hand, good pointing will go considerably to make up for defects under this head. But each has sufficient to do in performing its own part, and, if possible, it should be seen that this is carried out in practice.

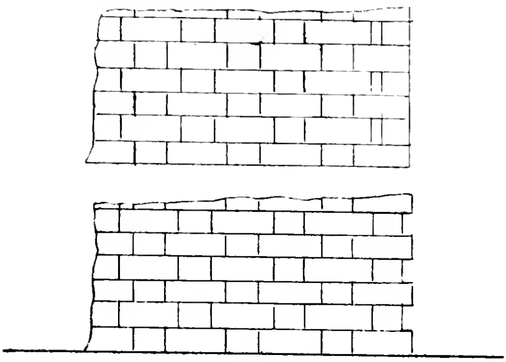


FIG. 30.

It is unwise to allow pointing to be done near to the season in which frost is liable to come on, either too late in autumn or too early in spring. If a sharp frost gets the pointing in its grip before it has had time to set firmly, most of it will need renewal. The inner joints are smoothed off as the building proceeds and no more attention is paid to them. It is practicable sometimes to finish off the outer face of brickwork as the building proceeds—only, however, in second-rate work and in seasonable weather.

CHAPTER III.

The Roofs—Their Framework.

Less choice of Materials for Roofing than for Building.

In the construction of the framework of these we have less choice of materials than we find available for building the walls. True enough we have only brick and stone as the groundwork of the latter, but then while the stones are of many sorts, the wood made use of is of pine and fir alone, and only one or two species of each. These are the soft woods in contradistinction to the hard woods, such as oak, ash, beech, elm, &c.

The Hard Woods.

The hard woods are deciduous in habit: they shed the whole of their leaves on the approach of winter and develop a new set in spring, fresh and green, in the delicate network whereof the slowly coursing sap gets full and free exposure to the light of heaven and the surrounding air. The soft woods—the pines and firs, and their allies—with the exception of the larch, retain their spine-shaped leaves through winter. In spring they part with some as others make their appearance; but they do not change the lot at the short stated periods coincident with the altering seasons as do the bigger leaved forest trees and shrubs. It is with their leaves something as with the covering of our heads when in the vigour of manhood—hairs are constantly dropping out, but others soon take the vacated places. The larch resembles the first-mentioned leaf-shedders in so far that it parts with the whole of its leaves at the advent of winter and starts afresh in spring with an entirely new investiture. And there are evergreen members of the deciduous family called so because they retain their leaves from springtime till springtime—sticking to them all winter and parting with them just as the fresh lot are about to burst the buds.

The Soft Woods.

The soft woods are of quicker growth than the others. They, at any rate, come earlier to maturity. They are lighter, more easily manipulated, and cheaper, and, at the same time, well adapted to the purposes of the carpenter and joiner in building, hence their general use in that connection. And not only are we limited to the use of the pines and firs as a whole, but we are further limited to those of foreign growth. There is abundance of home-grown timber in Britain fit to do good service in building were it cut into proper sizes and seasoned. Timber for building purposes can still, however, be sent to us from abroad cheaper than we get home-prepared stuff, and so long as that is the case with our forest products will we have to rest content with matters as they are.

British Forestry of small moment in the Timber Market.

The foresters of Britain, like the farmers thereof, are still victims to foreign competition, but unlike the latter, they so far have failed to make themselves felt in the available markets of their respective neighbourhoods. Forestry with us is, generally speaking, on too small a scale to be practised systematically and on strict commercial lines. On a few large estates which embrace the class of land which it is considered profitable to plant there is scope for the full practice of forestry as an art, and on some we find this going on. But these are few and far between, and the timber raised therein is unknown in the home markets for building material. The most of it, indeed, is used up in other directions before it attains the dignity of timber. The mature residue, however, is never available to the builder. Much of it there is no doubt is bound to be equally good with the foreign supply ; but, unfortunately, it is produced in so small a quantity, and so intermittently, as to have no distinct place of its own in the catalogue of the builder—it has no place there at all, in fact. Rural economists are awaking to this state of matters, and British foresters will now get a chance to keep their profession abreast of others. They have slow and stern work before them, however.

A somewhat similar relation to that which forestry in general bears to the building trade exists on the smaller estates with regard to their being self-supporting in the matter of wood for the erection of farm buildings. Even with good growing timber available on the ground the builder has to look elsewhere than on the estate for what he wants even in the elementary department of roof-making. He can get it cheaper and in better condition as imported from the Continent or from America than he can from the woods on the estate. This arises, it is but fair to state, from the fact that on the small estate there are neither the appliances for manufacturing timber into the stock sizes customary to the building trade, nor the accommodation suitable to the tedious process of seasoning the wood, without which preparation it is more profitable to use it as firewood than in the roofs of buildings with the slightest claim to permanency.

Some of the positions where home-grown Timber can be advantageously used at the Homestead.

There are parts of the homestead where it can be used to advantage without any very elaborate preparation being bestowed on it. Failing larch or oak, Scots pine makes quite a serviceable wood for shed-posts. In this case all that is wanted to begin with is to make sure that the wood is sound and fairly dry. If care is then taken that the end of the post inserted in the ground be embedded in Portland cement concrete, it will, so long as the stick is given fair play, last a considerable time. And timber derived from most of our forest trees, provided the wood is matured and seasoned, is as good as imported timber for "safe" or inner lintels. Providing these for the builder implies no saw-mill or other timber-converting machinery. The fencers alone with axe and cross-cut saw could see to their being forthcoming. Where the forester is in evidence, and good trees are about—and a few are to be found on nearly every estate—it says little for the management of the estate when crude timber, such as we have been referring to, is not available when additions and repairs are going on at the different homesteads thereon.

It seems far from creditable indeed that each landed estate cannot be self-supporting in such rude materials as the roofing timber of the homestead—the rough rafters and covering boards—and the divisions in stables and byres. A very elementary sawing apparatus would do the work of conversion, and if other motive power were not available, an oil engine is not an expensive item to charge against the upkeep of the estate. Imported timber ready for use is, as we have said, easily obtained anywhere, and at prices that cannot under usual management, even with the trees at hand, be quoted on the great majority of estates. There is room for enterprise here apparently, and for the encouragement of rural labour in our home districts. We may enlarge on the subject further on: meantime we may say that spruce and silver fir make excellent boarding suitable for homestead purposes, and they also, together with Scots pine, are equally good for roofing baulks, door-stiles, lintels, &c. And there is nothing better than larch for posts of all kinds, Scots pine not being far behind where it is not likely to be exposed to weather. Larch does either outside or in, and will for long withstand the rigours and quick changes of our climate irrespective of paint or other artificial protection.

Fir and Pine Wood in general.

Strictly speaking, most of the white pine of daily use is not pine-wood at all. It is got from the spruce fir. Red pine is the wood of the Scots pine tree. But our carpenters include the timber of different species of trees under these two heads. What we say is correct so far as it applies to our timber supplies from the shipping ports on the other side of the German ocean. From America we receive large quantities of wood of various kinds which is classified under the two heads of red and white pine as above. Pitch pine is another wood now much in vogue among country carpenters, but there are few jobs at the homesteads in which its place cannot be as well taken by red pine or larch. This is a product of warmer climes than suit either the spruce fir or the Scots pine. Yellow pine is another of the soft woods much taken advantage of by joiners. It is clean and close in grain and easy to work, and makes excellent finishings in house-work. This being its special province, we consequently see little or none of it at the homestead, except, of course, at the farm-house, and may be in a partial manner in the cottages.

Red pine. Red pine is fuller of resinous matter than the whiter wood of the spruce fir. In fact, the presence of that accounts for the reddish colour of the wood. The woody fibre is closer and apparently better packed in the red than in the white. That, together with the turpentine and resin contained in the substance of the wood of the red pine, enables it to resist the effects of weather longer than white pine can do. But where the two are placed under conditions that ensure dryness, and are otherwise favourable to the welfare of timber, the one that in our comparison has come out unfavourably will have as long a life as the other. For doors and windows and other fittings that are either wholly or in part exposed to weather, or for posts partly inserted in the ground or with an end resting thereupon, red pine is the proper wood to use; but where the fitting will be altogether inside, white pine or fir is quite good enough. For roofing purposes, therefore, the latter is not far from being equal to red pine, and it is cheaper.

The seasoning of Wood for building purposes. But whatever the kind of wood we elect to use it must be seasoned to start with, whether it be for the roofs or any other part of the buildings. The sap must be dried out of it, and no part must be of the nature of newly-grown wood; it must be mature. Wood to begin with is formed of soft cells full of moisture. In time these elongate and cohere in the stem and branches of the tree to form the fibre of wood. As this is taking place, the cell contents are gradually being absorbed, or at any rate becoming changed in character. In the young wood there is exchange of matter from one cell to the other, and in this way a general circulation throughout the mass goes on. But with age the cellular matter becomes firmer and takes part in building up the tough fibrous matter and this sort of circulation stops. The cells have then lost their individuality and become incorporated as part of the wood. The older, or rather, the riper the wood, the less of the original cell matter does it contain, and the less apt is it to decompose. The cell contents are soluble matters that readily break up into simple compounds, which implies decay or death of the cell, and with it of the mass of which it is a component part. The growing parts are all cellular, while the inner or mature parts have lost the cellular construction and are fibrous and tough.

To make use of wood therefore that is either in the cellular condition or has sap in its interior (for even with mature wood more or less sap penetrates by means of channels or open vessels that can easily be detected by the magnifying glass) is to court decay in the same. The newly grown sappy cellular stuff will soon break up; and so ere long may good, well-ripened wood that contained sap at the time of its use. Cut at any time of the year, be it summer or winter, sap will be present in the interior of the tree—much more of course in summer than in winter. No one fells trees in summer on this account, but even timber secured in winter holds sufficient sap in its interior to cause premature decay if steps are not taken to counteract this. The sap must be thoroughly dried out of it, or, to put it in a more scientific way, the soluble matters must be fixed or rendered insoluble before the wood is fit to be put into work that is meant to endure for a reasonable time.

How Wood forms.

The trees of our woods and plantations, in common with those of the forests of countries with climates like our own, deposit the new wood of each year's growth at the outer circumference of stem and branch. The outer part of the wood is, therefore, as we have been hinting, more cellular than the inner, and, in consequence, is to be avoided as much as possible. But as the trees approach maturity their annual increase of wood becomes less, and the proportion of young or sap wood to the more fibrous material within lessens considerably, until a very small ratio is attained. The wood from matured trees not only shows a smaller proportion of sap wood to the proper fibrous material, but in addition the wood is of a more stable nature than we find it in the immature tree. Much more of the organic matter from the original cell contents remains unaffected in the younger timber. In old trees it has almost completely given way to inorganic—that is, earthy or mineral—matter, and then we have almost insoluble matters to deal with; they are such at least that have little tendency to break up into other combinations, inducing the woody fibre that harbours them to follow suit. The centre of a well-grown oak tree—a piece of heart of oak—is a good example of what we mean. The original cells are there represented by hard fibrous matter impregnated with earthy stuff that enables the wood to withstand for long, and without protection, the utmost rigours of our climate. The red-coloured inner wood of a good larch tree is of a similar nature.

In the expression "well-grown wood" is implied wood from a tree that has added to its circumference steadily and not too quickly. A cross section of one of our trees reveals a series of concentric circles, or zones, widening outwards from the centre, each of which represents a year's growth of the tree, or the annual addition of wood thereto. Usually some are wider than others, telling thereby of varying seasons—of one that happened to be favourable to vegetation, on account of much sunlight, or it may have been much moisture, and during which more wood than usual was made, and of others, cold and bleak, that interfered with growth. Others show the zones fuller at one side of the tree than the other, indicating that the side of the tree where they were situated was more fully exposed to sun and air than the other. These circlets of wood grow less as maturity of the tree is reached, after which they cease to form and the general decay of the organism begins.

In well-grown timber these rings of annual growth are thin and well compacted. They are regular, too, not thick at one side and thin at the other. Our native or home-grown timber is very defective in this respect; this is due, it is now generally believed, to our system, or rather, want of system, in growing trees. We give them too much elbow-room, which allows them to slouch and take on bad shapes, as well as exposes them irregularly to air and light. Continental foresters, following Nature's teaching, keep them close together, obliging them to stand straight and stretch up their heads to where alone air and light is to be found. They find neither at any side of them, but have to look up for both. Trees situated so are long, tapering, and branchless; and their separate rings of wood are thin, well packed, fibrous, and of a regular thickness.

Mature wood of the latter kind is not difficult to season. The whole tree left as felled would require some time before it was dry right into the centre, but whole trees are rarely wanted for service. The trees are sawn up to the sizes that are most likely to be in demand and the pieces laid aside to be seasoned. Exposure to air is all that is needed to effect this. Rain will not do much harm provided it runs off as it falls, but the boards must not sit in wet; they must sit free of the ground, and each piece must be separate from the other, except of course at the points of support. Stacked up in this way, with wind free to bear upon them, the pieces of timber, if from well-grown and mature trees to start with, will soon become seasoned and be fit for the manufacture of doors and windows that will hold together without shrinking or warping. Wood used too soon simply undergoes seasoning in the door and window instead of in the original deal or batten. It is advisable, however, to have the ultimate contractions and expansions incidental to the seasoning of wood taken up and done with before the boards are put in the hands of the joiner.

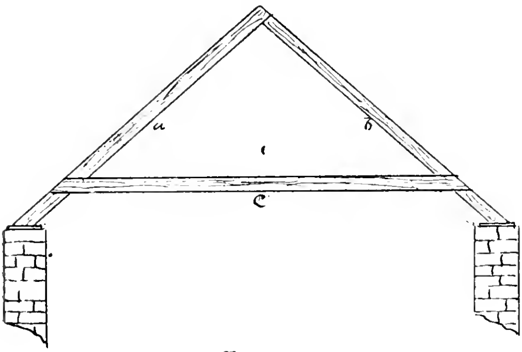


Fig. 31.

The ordinary "couple" Roof of the Homestead.

The commonest framework of roof at the homestead, at least, throughout the North Country, is the exceedingly elementary one depicted in Fig. 31: *a* and *b* two rafters set to form a more or less acute angle and nailed together, and further held in position by means of a cross piece *c* up a little from the free ends of the sticks. The cross piece, as we shall by-and-by see, is very often placed too high up for strength; it is there to prevent the feet of the "couple," as *a* and *b* together are technically named, from spreading or straddling too far. The tendency of the couple feet, it is easy to see, is to widen the space between them, and the tie *c*, the "couple baulk" of homely phrase, is there to counteract this; the lower the tie is placed the better will it be able to hold the pieces together. In Fig. 32 we show a roof frame with the tie nailed on level with the free ends of the couple. Bound thus, the feet can straddle no further than the stretching limit of the tie beam, or baulk. But then, if the sides of the couple are long in comparison to their "scantling," or size in section, they will incline to yield to the weight of the slates they are there to support, and bend inwards, showing an unsightly hollow where all should be on a regular incline from ridge to eaves. One or more supplementary ties as dotted in would of course prevent this; they could hardly, however, in this instance be correctly termed ties: they would be stiffeners or supports more than anything else. The tie proper hinders stretching of the couple legs, but their purpose would be to keep them asunder; thus there would be the absurdity of having both a tie and a stretcher in this simple petty triangular affair.

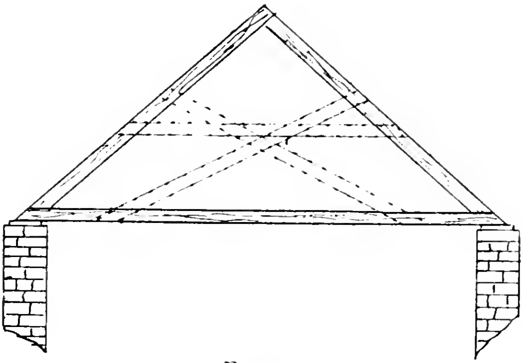


FIG. 32.

The Principles involved in its Construction.

In a simple combination of this kind the forces must be so balanced that the part of the couple leg from the tie upwards to the top must not be given more to do than it is easily capable of accomplishing for the sake of making matters at the wallhead doubly sure. A safe position of the tie is that its lower edge be about eighteen inches above the level of the wallhead on which the couple feet rest, or, what is the same thing, eighteen inches above the level of the soles or ends of the latter. Couples of a span of say fifteen feet wide are quite efficient if tied with one baulk. For greater widths we must begin with another tie (or rather, half tie and half strut) placed perhaps half way between the apex of the triangle and the lower tie; but beyond a certain width of span this manner of roof is incorrect in principle.

In Fig. 33 we give the side elevation of one of the couples of a building fifteen feet wide inside. The sides of the couple, taking their extreme length—that of the outside line, which gives the length of the spar before it was fitted into shape—are 11 feet 6 inches each.

The extreme height of the apex of the couple—the juncture of the two sides—above the level of the wallhead is 7 feet 6 inches, it being usual to keep the perpendicular height somewhat less than half the full width of the building about to be roofed over. Judging by eye alone, this gives a sufficiently well-proportioned "roof truss," as the technical name of the couple or similar combination runs. The tie is apparently in a good position for preventing the feet of the couples from becoming further apart; and the part of each of the couple sides, from tie upwards to apex, seems not to be set a difficult task in having to bear up its share of the burden of boards and slates without sagging. Framed accordingly the truss would in turn exert a fair downward pressure on the wall, the one the latter is built to bear. Taking the tie and the two sides above it, we have a triangle the base of which, taking the extreme or outer length, measures 14 feet 3 inches, and the sides each 9 feet 3 inches, the whole firm and unyielding, supported steadily on the walls by two short, stiff legs which cannot be forced apart without fracture, there being little or no elasticity or spring in so short pieces. If for the sake of economy we provide a shorter piece of wood for the tie, it must be placed higher and the well-balanced parts we refer to lose their symmetry. In a work of this kind one cannot demonstrate to a point where the line of safety lies, beyond which it is dangerous to stretch the relationship of the different parts of the roof we are dealing with; nor would we care to waste our time in that way had we the chance. Brains and common-sense tempered by observation are satisfactory enough guides here, and will, we daresay, serve to convince intelligent minds anxious to learn that we are not leading them astray over the import of the simple facts we are seeking to set forth.

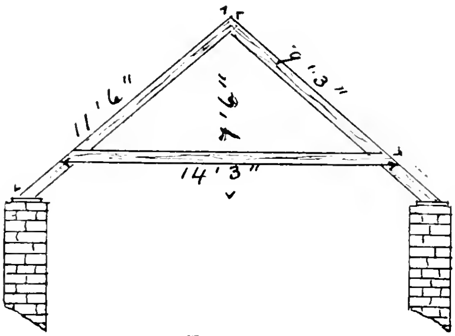


Fig. 33.

The Pitch of Roofs.

It is customary to keep roofs of this sort at a pretty high pitch. North country carpenters speak of from eighteen inches to two feet below the "square" as being a fair height of ridge above wallhead. Turning to Fig. 34, we can see what this means. It is the section of a building eighteen feet across inside, having its roof two feet below the "square." The walls being each twenty-one inches thick, they consequently add 3 feet 6 inches to the inside width for the extreme outside measurement of the section. The latter is therefore 21 feet 6 inches and the half thereof 10 feet 9 inches.

Were we to make the apex of the couples 10 feet 9 inches above the level of the wallhead, then the roof, as ticked in on the figure, would be formed to the square represented by the two sides produced in ticks.

The pitch of a roof is, to speak correctly, the degree of inclination of its sides to a line level with the wallhead. The perpendicular forms of course with this line a right angle at either side. A right angle is, as we all know, one of ninety degrees, which leaves other ninety degrees to be accounted for in either triangle which forms half of that represented by the roof frame, there being one hundred and eighty degrees in every such figure. Further, two sides of the triangle being the same length, necessitates the angles which these respectively form with the base—in this case the side of the roof—being the same. There being ninety degrees to dispose of, each must, therefore, be one of forty-five degrees. The ticked line on the section indicates in consequence an angle of forty-five degrees at the point in question, which in this connection speaks to steep slope. The angle of the ridge is a right angle—one of ninety degrees, seeing it is made up of two forty-fives: or otherwise, since the angles at the eaves are forty-five degrees each, thus taking ninety of the total one hundred and eighty, the remaining one must be ninety degrees.

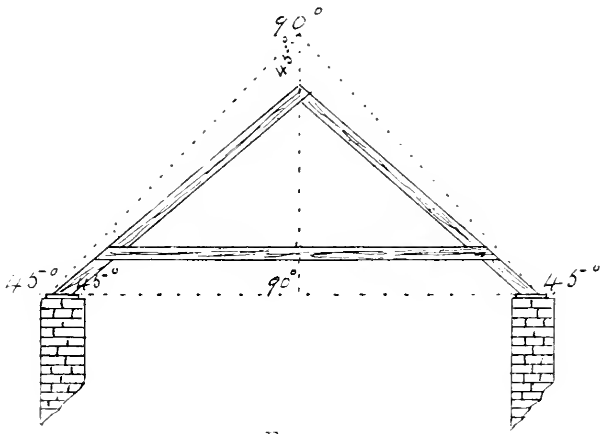


FIG. 34.

Reducing the degree of the pitch of the roof is equivalent to increasing the angle at the ridge, which, as it grows greater, means the lowering of the height thereof above the level of the top of the walls. The lower the ridge the shorter are the spars that make up the couples, and this tends towards economy. Six inches or so less in the length of these spars implies over a considerable amount of roofing (even though the rate per running foot of these should be little more than twopence), a saving in material that is not to be despised. Not only does it mean a reduction in the quantity of wood needed, but it means fewer slates and less labour in the putting of them on. But the nature of the roof framework which we are discussing is against its being set to a low pitch. The more upstanding it can be kept the less severe will be the strains that go to thrust the legs apart. The forces are then more directly downwards than slanting to the sides. A reference to Figs. 35 and 36, showing in outline a low-pitched and a high-pitched

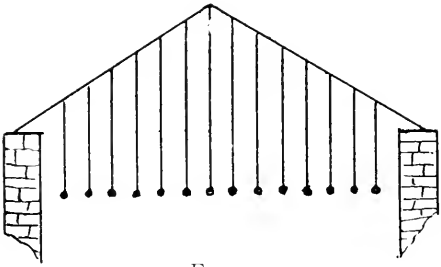


FIG. 35.

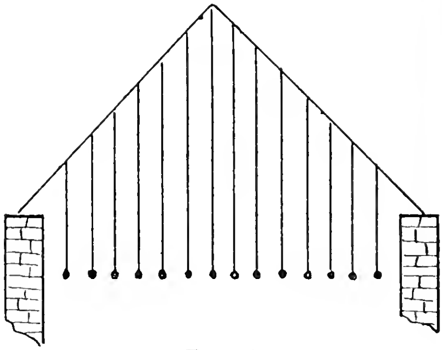


FIG. 36.

roof ranged alongside each other, will make this clear without further demonstration. The weight bearing upon each is represented by balls hanging from the couple legs at the same distances apart. It is not difficult to tell which of the two stands the better to its work. As we raise the pitch the point of attachment of the several balls draw apart from each other but at the same time run more with the length of the stick than across it. A stick placed in a half upright position, its foot on the ground and its head resting against the wall as in Fig. 37, will carry a greater weight hung free from its centre point than it can do if laid flat and supported at each end only as in Fig. 38. Were we to support it in a perpendicular position, as in Fig. 39, its carrying power would be vastly in advance of what it would be capable of exerting when acting as a bridge from one supported end to the other. Somewhere halfway between these extremes comes Fig. 36. So with the framework of our roof, the steeper we make its sides the firmer and stronger it will be. But there is a limit to this as to most things. Pitched to be two feet or so "below the square" is, however,

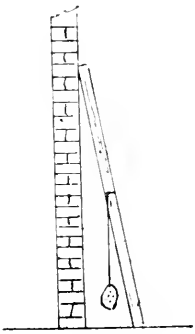


FIG. 37.

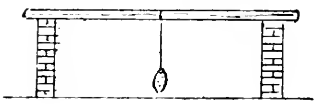


FIG. 38.

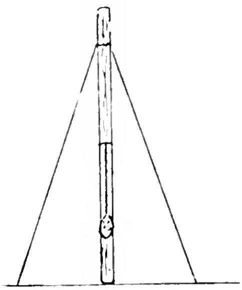


FIG. 39.

a safe standard to observe in roofs of this kind at the homestead. Two feet "below the square" is equivalent to a pitch of thirty-nine degrees.

Size of the Spars of the Common Roof.

Spars six inches by two inches form a common scantling observed in constructing the framework of roofs of this class. The ties are usually of the same size. Sometimes they are a little less, but this is doubtful economy at the farm. If adjusted to the critical place, they might do a little lighter, but those who know the ways of farmers would be more inclined to have them stronger instead of lighter. Handy places for storage are these couple baulks, and much miscellaneous stock, both bulky and heavy, finds a resting place thereupon. Where an extra tie is used it can with more safety than applies to the lower one be a little lighter.

Some of the Disadvantages of this class of Roof.

We can, of course, gain strength to the couples, and make them better fitted to resist the strains that they are subjected to, by increasing the scantling, and similarly with the ties; but this is merely adding to what we take to be one of the disadvantages that accompany these roofs. That in our opinion is the great amount of wood they project into the building they are set to cover. With only sixteen inches between the trusses, what an obstruction so many of these are to the free circulation of air and to the rays of sunlight! How can one or other have free course to shed forth its vital influences among such a dust-laden and spider-web-festooned forest of baulks as so many roofs of this nature develop into? That by itself condemns the application of this roof to buildings wherein live stock are to be housed. Neither is it in our opinion good for many of the other houses. In some its use can hardly be avoided, but we would have it erected as seldom as possible.

While not favourable, therefore, from a sanitary point of view, this roof is certainly inferior from a constructive one. Unless carefully adjusted, it is, as we have seen, both sore on itself and severe on the walls. We have come across a badly built wall split fairly up the middle for a great part of its length on account of the spreading effect of couples tied too high up. And it is quite common to see the walls of buildings pressed over the plumb from the same cause. The walls, as we sought to impress when treating thereof, are not built to stand lateral pressure. If they were, they would have to be constructed on a different principle. They would require to be thicker all the way up or be built with a gradual slope or batter. They are intended to support a down-bearing pressure and no other, and the roof they support should be framed accordingly.

And too often, as we have hinted, do roofs of this kind act as a temptation to the farmer as a store for all manner of stuff, from implements of various kinds down to sheepskins and sacks. The thriftier he is the more does he deposit in these quarters. On the baulks he stows away sowing-machines, sheep-troughs, and appliances of a like nature; and when he has the advantage of an opening in some gable, a capital place he finds the top of the baulks on which to lay out his long ladders. If he cannot avail himself of an opening already made suitable for sliding them in, he soon makes one. The worst of it is, whether from want of knowledge of the principles of mechanics or because there is most room there—we suspect it is the latter—he places his property at the centre instead of towards the ends of the baulks. This is their weakest part; but then, there is head room about the middle, but none at the sides. What he is unable to get up through and lay on the top of them he will, not infrequently, lash to the bottom of the baulks. The carcase of a slaughtered animal even at times gets hung up therefrom to cool down. Worse than all, the dairy farmer, as previously pointed out, up till now has looked upon the couple baulks over his cowhouse as the proper position for the henhouse. Among other effects thus put out of reach at the small farms, it is not uncommon to see the spinning-wheel silently rotting away.

The "principal" Roof better.

A much better style of roofing than the one we have described is that found prevailing at English homesteads. There is not near the amount of spars stuck across the roof space under this system that we are accustomed to at the Scottish and North of Ireland steadings. Moreover, it is most decidedly fairer to the walls. A strong, well-bound truss is put up at every nine feet or so. These rest on a strong wall-plate which serves to distribute the weight more equally over the length of the wallhead than where it is wanting. For the same reason a wall-plate is also used in connection with the roof just spoken of. Across these trusses, as we shall describe the whole roof more fully afterwards, are placed in position, running parallel with the length of the house, a series of spars called "purlins"; and bearing on these in their turn are laid the rafters, which are equivalent to the couple sides of the foregoing pages, and come in at the same distances apart. These rafters are joined together at the head, but, unlike the couple sides, have no further direct communication. There is no special tie for each pair. They are fastened to a board at the top—the ridge board, which runs the whole length of the building. This board is supported on the trusses, and as each rafter is fixed in position one opposite another, it becomes jammed between the heads of these and is there held firmly in its place. The rafters, we repeat, have no other connection one with the other. They simply bear on the purlins, while their heels rest upon the wall-plate. These, we need hardly say, can exert very little outward thrust on the walls. The purlins take this upon themselves and pass it on to the trusses.

Here, then, we have something on a better principle than the primitive affair we started with. True, the weight of the roof is not so uniformly distributed over the length of the wall in the one as in the other. With the first-mentioned the weight is applied equally at the short intervals of sixteen inches; with the other, the points of contact of the forces of weight in the roof and of resistance in the wall are about nine feet apart. There must, of course, be a certain amount of weight at the foot of each of the rafters in the latter, but the large proportion of the weight of the roof undoubtedly falls to be borne by the trusses. The wall-plate of both roofs enlarges the respective points of contact, but it needs little reasoning to lead one to understand that, as a short space is easier to bridge over than a wide one, so is it easier to distribute weight over an extended area when it touches it at many points instead of few. Increasing the scantling of the wall-plate brings matters to a sounder footing, but beyond a certain limit it is hardly practicable to go far in this way. But when all is said and done it is found in practice that these somewhat fine-drawn though perfectly sound theories may, without any resulting harm, be almost entirely left out of sight. Danger or risk there can be none in the usual practice, but, the balance being the other way, there remains to be answered the implication of false economy in making the side wall of a house all the same thickness, while all that is really required are so many pillars on which to rest the ends of the trusses, and a strong lintel from one of these to the other to bear up the ends of the rafters. A set of pillars and a screen wall in the spaces between would answer the requirements of the case. In practice, however, it is easier, as well as more expeditious, to build the wall of one thickness from end to end. Besides a wall all angles and corners at the inside would never do for a farm building of any kind. What is more, such an arrangement, whether outside or inside of a wall in rubble work, would cost more than one of an equal thickness throughout. It comes to this, therefore, that it would be no saving to make a rubble wall thick and thin in places in accordance with the more or less widely distributed points upon which the weight of the roof was intended to bear. With a brick wall it is different; and where experienced men have a hand in the management of the estate it is quite common to see the walls of a brick-built homestead dealt with after the manner indicated in order to save materials. A nine-inch wall which swells to one of fourteen and a half at the parts intended to support the trusses means a considerable saving in this way over one fourteen and a half inches thick all its length.

The Wall-plate.

It is not, as we have said, very practicable to increase the size of the wall-plate beyond the usually accepted standard. Nine inches by one is a common size for the ordinary couple roof, and it answers well enough, seeing how comparatively close together are the points of application of the weight of the roof. Such a one is not always laid on the wall-head, indeed. And rarely is a larger one used in connection with the truss roof. As in the other case, it is often thinner than as thick as that quoted. To have a much thicker wall-plate implies the propping up or elevating the framework of the roof too much above the wallhead, leaving odd places to be filled up somehow or other with stone, mortar, or wood. There is not much room for a "body" of either of the first two substances, and the less wood we leave exposed to the atmosphere the better. It might do to build the wood flush with the top of the wall, sinking it in the latter till the tops of each were level. That, however, would be burying the wood almost entirely in the heart of the wall, which is not a good thing to do. It gives the wood a bad chance for preservation, and goes to the splitting of the wall at the top. At any rate, the wallhead is virtually coincident with the bottom side of the wall-plate. The thickness of building above this to the upper side of it is simply laid on; and it has little real connection with the wall. In fact, the wall-plate, although originally intended for the better distribution of the weight that bears upon the wall, does better service in keeping both the trusses with their accompanying rafters and the couples free from contact with the stones. And while it acts as buffer to these and keeps them so that air gets about them, sitting free itself, it, too, has some chance in the same direction. If, therefore, the wall-plate does not completely fulfil its original office, it does good in other ways. Still, it must to some extent help to distribute the weight of the roof equally along the length of the wall. And another end it serves well is admitting of a level and steady bearing both to truss and rafters and to the couples, one far more uniform than is likely to be obtained on the wallhead itself without the intervention of the board. On the bare wallhead one couple might happen to rest on a stone, and the next one upon a daub of mortar certain to yield to pressure more readily than the stone. This bridging over weak places, however, brings us back pretty close to the chief end of the wall-plate.

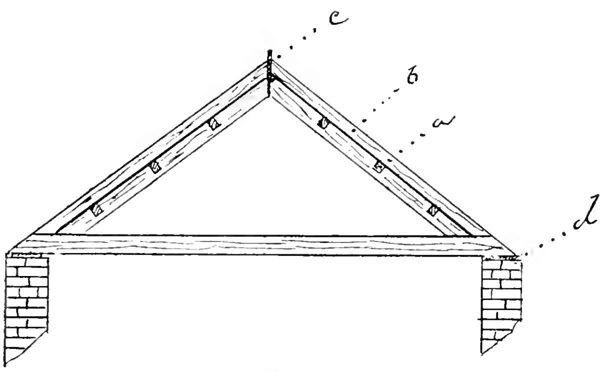


Fig. 40.

The Roof-Truss or "principal Rafter."

In Fig. 40 we show the construction of a truss or principal roof, suitable for a small span, up to sixteen or eighteen feet say. The purlins *a* shown in cross section stretch from truss to truss and bear up the rafters *b*—the equivalents of the couples previously described. They are slightly checked, and sometimes, in addition, mortised into the trusses. In this fig. they are shown flush with the upper edge of the sides of the truss, but, as we shall afterwards point out, there are many other methods of connecting the two. The ridge board *c* is for the purpose of butting the intermediate rafters against, and *d* is the wall-plate.

Coming to wider spans, up nearly to thirty feet inside, which is the widest we show in any of the plans of our supposititious homesteads,

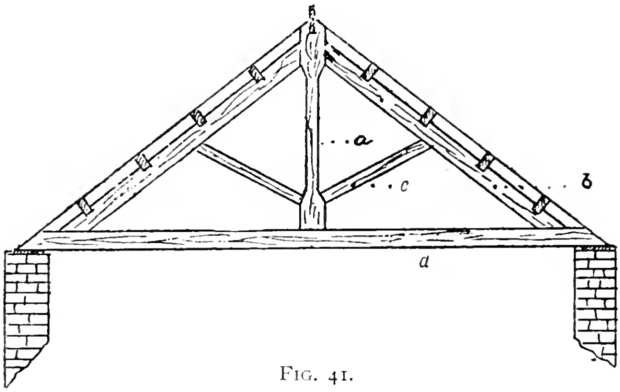


Fig. 41.

Fig. 41 is a suitable one. It differs little from the other one except that, being a larger affair with longer sides, these need some stiffening and bracing to give them rigidity. The upright piece *a* which bisects the figure is, in technical terms, the "king" post: the two that spring from

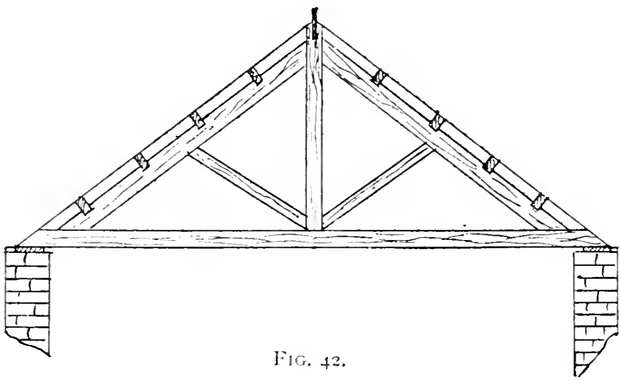


Fig. 42.

either side of the base of the post and are attached to the "principal rafters" *b*, as the sides of the truss are termed to distinguish them from the small or common rafters (*b* on Fig. 40), are the struts *c*. The other parts are as before, viz.: wall-plate, purlins, and ridge board. In this and the following case we dispense with the common, or intermediate rafters, and secure the roofing boards directly to the purlins. The king post, held up by the tie *d*, steadied at the same time by means of the struts *c*, gives support to the ridge and the sides of the truss or principal

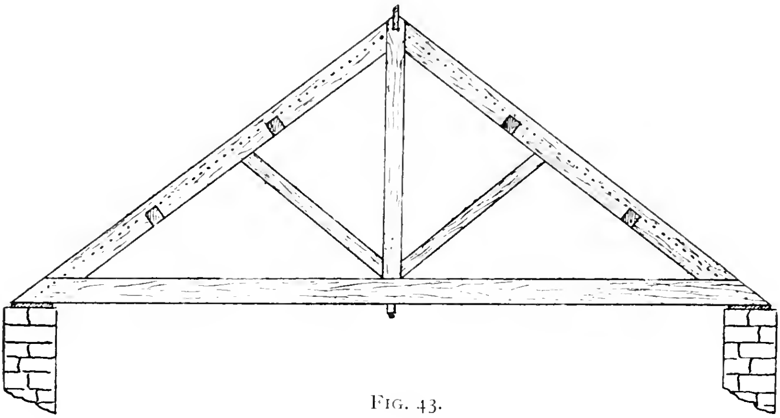


FIG. 43.

rafters *b*. But the latter in turn props up the head of the king post and thus helps to keep the tie from sagging.

It is the general plan to let the struts spring from the king post, as in Fig. 41 we show them doing; but in our opinion more good is got from

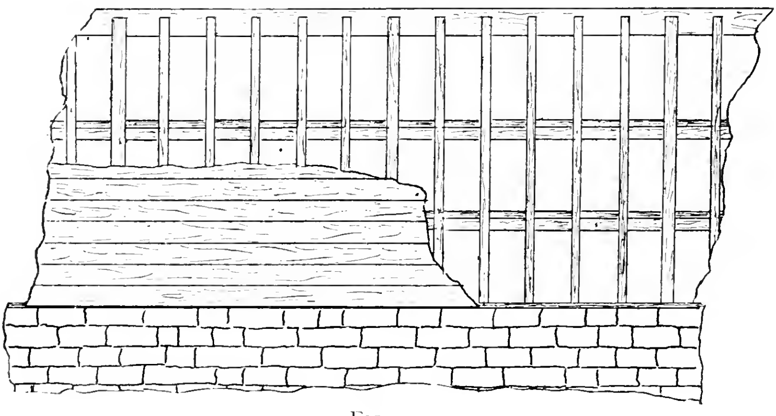


FIG 44.

the strut when it springs from the root of the king post, as in Fig. 42. There it is applied to the principal rafter at a better angle than in Fig. 41. It gives a better support because it is more upright in position, and springing thus from the king post, there need be none of the waste of wood in this part that is implied in that fig. The latter is certainly the more picturesque of the two, but economy with efficiency is our first maxim in the erection of farm buildings. Reducing the post in the manner represented brings its strength down to that of the thinnest part, so it may as well be no more than this all through to start with. The strut we recommend is longer than the other, but the

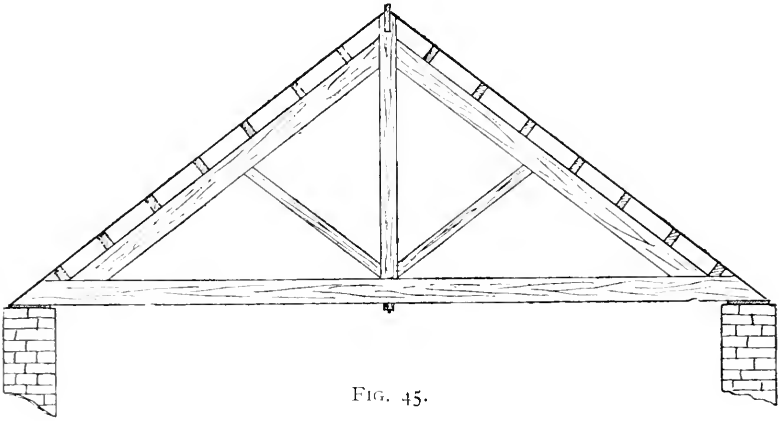


FIG. 45.

extra length is counterbalanced by the continuous smaller scantling of the king post it is related to compared with that in Fig. 42.

Figs. 43 and 44 show the truss on a larger scale than before. Typical sizes of the parts are: the principal rafters (the sides of the truss) and the ties, 9 inches by 4 inches; the king post, 6 inches by 4 inches; the

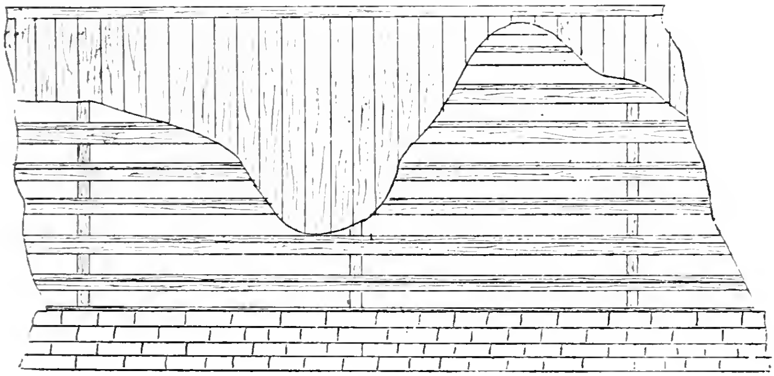


FIG. 46.

struts, 4 inches by 4 inches; the purlins, 3 inches by 4 inches; the common rafters, 4 inches by 2 inches; the ridge board, 10 inches by $1\frac{1}{2}$ inches; and the wall-plate, 12 inches by 1 inch. In Figs. 43 and 44 the purlins are shown placed flush with the bottom of the principal rafters, being let in between these and checked thereto; while in Figs. 45 and 46 they are shown passing directly over the purlins and bearing thereupon. In this case it is necessary that the purlins be either checked a little into the principal rafter, or be held in place by brackets as shown in Figs. 47 and 48, else they will tend to overturn. The purlins, it will be seen, are more numerous in Fig. 45 than in Fig. 43; in fact, in the former instance they are serving the purpose of common rafters as well as of purlins, the roofing boards, as we show, being nailed directly thereto. In a roof constructed according to Figs. 43, 44, and 49, the upper edges of the common or intermediate rafters sit flush with the upper edges of the principal rafter, and the roofing boards are fastened

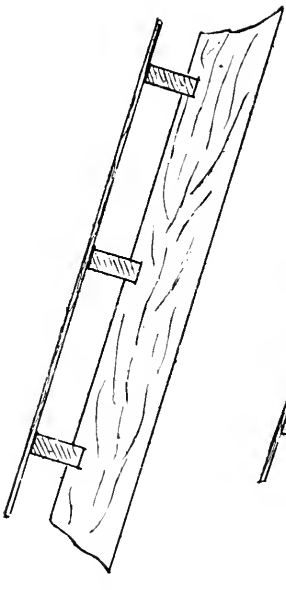


Fig. 47.

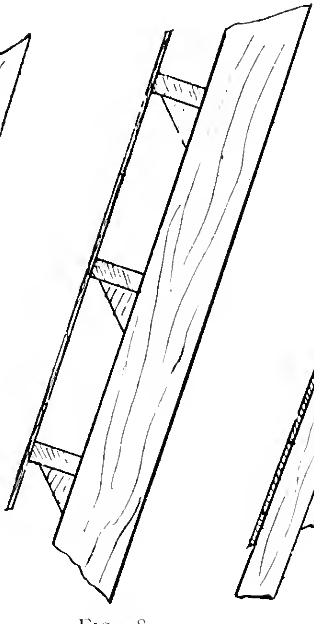


Fig. 48.

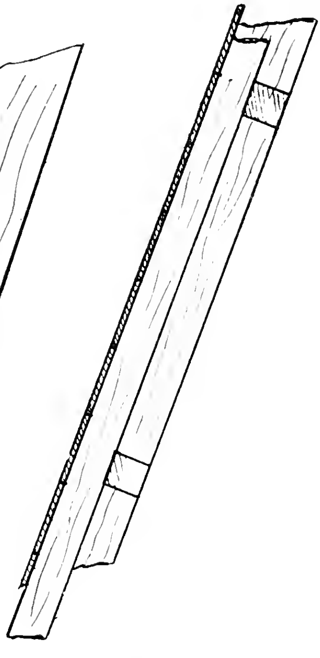


Fig. 49.

to principal and common rafters alike, thus bringing the upper edges of all continuous with the under side of the boarding. But with a roof put together after the plan indicated on Figs. 50 and 51, the principal rafters have a common one between them and the boards; at least, a space equivalent to the depth of a common rafter intervenes between the two, for it is not necessary that the small rafters span so that one exactly coincides with, or rests upon, each principal rafter.

The piecing together of the "principal" Roof.

We prefer, when the common rafter is left out, to have the tops of the purlins flush with those of the principal rafters, as in Fig. 52, not passing over them at all, but let down between each pair, there being a slight check made in the sides of the rafters so as to hold the purlins firmly between. When thus fitted to the rafters a very shallow check is as good for securing the purlins as a deep one under the last-discussed arrangement where they rest on the upper edge of the rafters, because in the one case there is not the same tendency to cant that holds good as we saw with the other.

We like, where possible, to steer clear altogether of this checking or mortising of purlins into the rafters. All work of this sort is in the

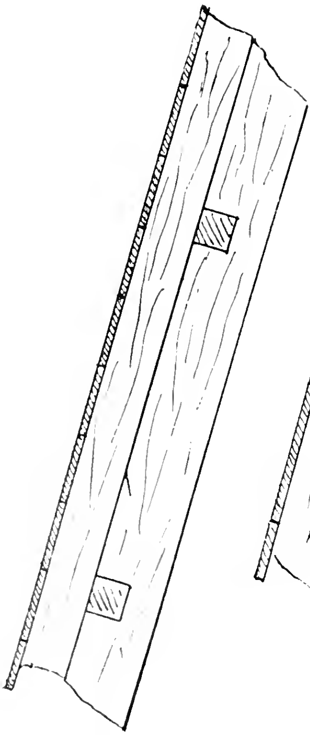


FIG. 50.

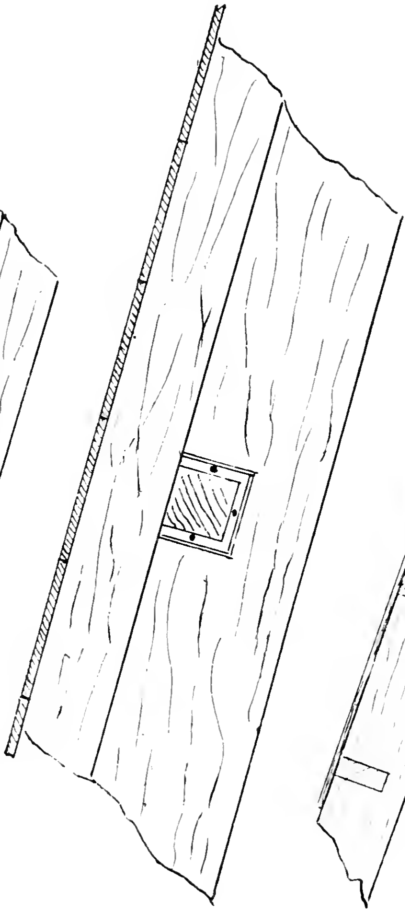


FIG. 51.

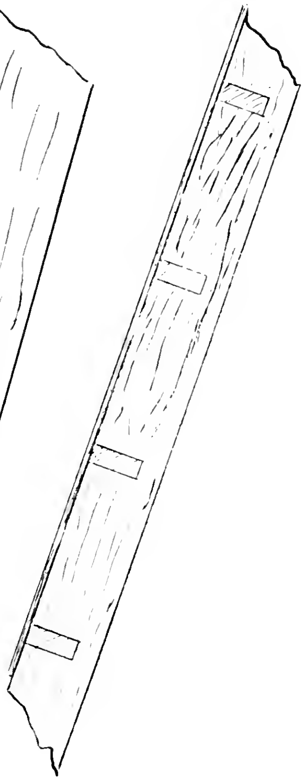


FIG. 52.

direction of weakening the pieces so manipulated. It is better to make use of lighter timbers and join them without taking from their strength. Theoretically a well-made joint may not cause any weakness of the parts cut into. The vacancies in one piece ought to be almost more than counterbalanced by the outstanding pieces of the other that are inserted therein. It may be so when the joints are afterwards kept from influences apt to cause disruption. But exposed in such a way as the roof timbers of farm buildings usually are, slackness in the joints is not easily prevented. On this account the carpenter whose branch of the trade is the one almost dependent on spikes and nails for holding his handiwork together is more in evidence at the steading than the joiner who trusts to his skill in making cunningly-devised joints for the framing and fitting together of what falls to be turned out of his department.

To avoid the necessity of cutting into the rafters to form these joints between purlin and rafter we have frequently made use of cast-iron shoes in which to insert the ends of the purlins. This means a little extra cost, but it is worth it, we consider. An arrangement of the kind is shown in Fig. 51. The shoes are fixed to the rafters by means of screw bolts passed through, which, when tightened up, hold them firmly in position without in any way weakening the pieces of timber to which they are attached. When finished in this way the purlins and rafters can then be left flush on top and the whole has a strong and ship-shape appearance. There is one drawback to the shoes, however. Subjected as they are sure to be in their position at most parts of the steading to moist air, rust will soon disfigure them and the adjoining wood as well unless they are frequently attended to in the way of a little scraping and painting. This attention, unfortunately, they will but seldom get. But galvanizing them adds very little to their original cost, and after undergoing that process they are independent altogether of the farmer and his paint-pot.

When the purlins, as in Figs. 45, 46, 47 and 48, pass right over the principal rafters, the small or common rafters can then, as we have already said, be dispensed with and the roofing boards be fastened to them directly. In this instance the purlins are already too high above the principal rafters to allow of the intervention of more space between them and the boards. There would not at any rate be room between the two to admit of the insertion of the common rafters. If, however, we dispense with the common rafters, we must, as we have seen, allow for more purlins, else we deprive the covering boards—the "sarking," as it is termed in the North—of their due support. The accepted spacing of both common rafters and couples along a roof is to place them at eighteen-inch "centres" as the expression goes. The centre of each, no matter the thickness of the pieces, although there is little range in this respect, is in accordance with this ruling set up eighteen inches apart from the centres of those next to it; or, beginning at the gable, the first rafter or couple if say two inches thick, is set up with its side sixteen inches from the face of the wall; the next is placed sixteen inches from it, and so on until all are in position. The length of the building may be such that it is impracticable to divide it exactly into this spacing; but with a little contrivance to begin with either the excess or the shortage can be equally applied to the set of spaces without revealing any sensible departure from the standard quoted.

The purlins, in the absence of common rafters, do to be set a little wider apart than at eighteen-inch centres. From their position, which causes the covering boards to be laid down the slope of the roof instead of across it, they can afford this wider spacing. A board laid lengthwise on the slope having the same support as one laid crosswise is the stronger of the two. It will sagg less. To space the purlins at eighteen-inch centres measured on the level—horizontally that is, instead of up the slope—would bring the two into closer relation. And this rule may be observed by way of guide in this connection.

Our preference is, however, for fewer purlins and the introduction of common rafters into the framework of the roof. The roof then looks lighter and more finished. There is not a great deal of difference either in the cost of the one compared with the other. The extra purlins in the one, together with the whole of them having to pass over the principal rafters in place of being let in between each pair, helps considerably to meet the cost of the common rafters. We get more good out of the wall-plate, too, when we have the common rafters heeled against it. Similarly with the ridge board. It is kept firmer and steadier when jammed between the opposing heads of these pieces than holds good when only sarking boards butt against it. All this tends of course to equalisation of strain and general stability of roof, which when it is coupled with a more pleasing appearance, ought to tell much in favour of the arrangement of roof we are referring to. It causes an increased number of projecting pieces into the air space within, but these stand out in such a manner as to be less a drawback in this respect than the purlins. One of the latter will interfere with the air currents up the inner sides of the roof to a greater degree than many common rafters will. These run up the slope and guide the currents, we may say: the others stretch across and, if we are right in judging from analogy, hinder the currents. And there are more of them when we leave out the small rafters as part of the roof. A reference to Figs. 44 and 46 will make our reasoning clearer.

The spacing of the trusses may, as hinted above, be such that it is not practicable to give the common rafters their ordinary room, and yet keep them running in union with the principals. It is so much more tradesman-looking to have these so arranged that one always falls coincident with each principal rafter than to have them coming in at no regular rotation to the same that it is pardonable to practise a little come and go to gain this. A nine-foot spacing of the principals makes a very suitable one as regards strength of roof; and it lends itself also to the standard spacing of the common rafters while making these observe due coincidence with their stronger fellows.

An Iron King Post substituted for one of Wood.

Sometimes, as in Fig. 53, iron is substituted for wood in the construction of the king post. It makes a much lighter-looking as well as an airier roof no doubt, and it will be as strong, if not, indeed, stronger. With a screw and nut at the bottom and the prongs or clamps at the top as depicted on the fig., the whole frame can be tightly screwed up and held firmly together. But we dislike to have much exposed ironwork about the roofs of farm buildings, more especially in those houses that are occupied by live stock. The cold iron condenses the moisture from the warm vapour-laden air within the house, keeping the metal nearly always wet and allowing it to drop therefrom either on to the adjoining timber or the floor beneath. At times, of course, the iron is at a similar temperature to the air in the building, and no condensation takes place. Oftener, however, it is at a lower temperature, with the result we have mentioned. Keeping the iron well painted will prevent harm befalling it from this cause. But it does not hinder the condensation we speak of, which is capable of causing harm to the woodwork in touch with the iron. Besides, the matter of painting is generally a frail reed to depend upon. If under circumstances where no one

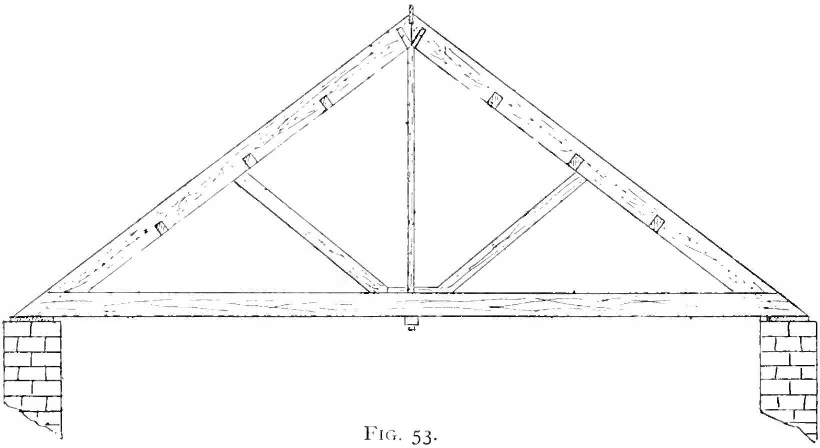


FIG. 53.

grudges the work it is so often overlooked, what can we expect in those where it is shirked on every occasion? There is galvanizing to fall back upon, but that is not always practicable, and the moisture still has to be faced.

Another sort of Roof.

In Fig. 54 we have a description of roof occasionally met with that is sort of half way between the two classes of roof that we have hitherto been dealing with. It has the merits of both, and the faults too of each. It is airier than either, because what ties there are find a place close up to the ridge. There are as many as we find in the ordinary couple roof, but so high as not to interfere much in the circulation of the air. They are so far above the level of the wallhead as to be useless for holding together the feet of the couple each one is connected with. To counteract this a thick wall-plate is left for them to butt against. The heels of the couples are checked into this so that they cannot widen the distance between each pair without shifting one or both of the wall-plates out of position. The wall-plates, it can easily be gathered, from what has gone before, have a great strain thrust upon them judging from the distance between the feet of the couples. If simply laid on the wallhead, whenever the framework of the roof began to adjust itself to the various strains, it would be pushed off as the couple ends increased the distance from each other. We might fasten the wall-plate by means of bolts built down into the wall, and their heads so made that it could be screwed down firmly. But this would be throwing upon the wall a burden that it was not intended to bear up against, its construction being such as to warrant its subjection to downward pressure alone. The consequence would be that shortly after its erection the top of the wall at one side or the other, perhaps at both, would be thrust aside. To guard against this the iron tie rod *a* is

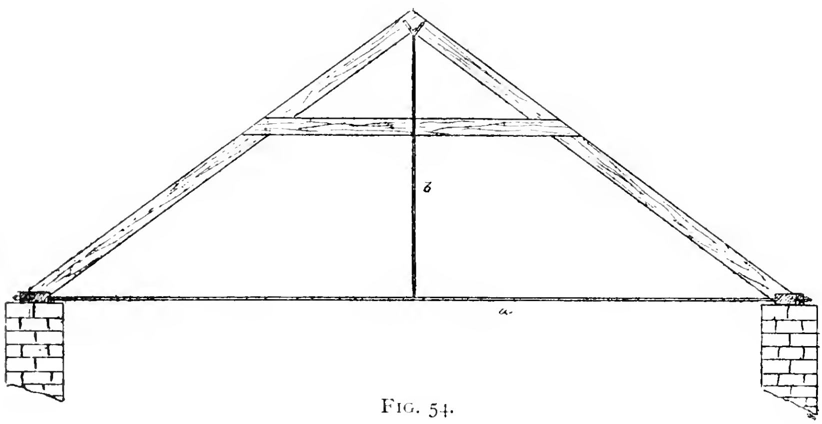


FIG. 54.

introduced at spaces of ten or twelve feet. On these, therefore, falls the brunt of keeping the whole together. They are not so thick but what they come and go with change of temperature which cannot be otherwise than prejudicial to the roof as a whole. And then we see how comparatively frail the whole area of the roof between wall-plate and tie is. If the preceding part of this chapter has gone for anything with our readers, we need hardly here point out to them in wearying reiteration what weakness there lies in the long leg unsupported from wall-plate to tie.

In short, it is not a roof that one can recommend. The extra thick wall-plate is not in its favour; neither is the unstable manner of holding that in its place, and the length of unsupported couple induces liability to bending, if not fracture, in these. Its good point is its airiness. It possesses another in minor degree. In company with the principal roof it forbids application to storage purposes, more strictly so indeed than the other. At either side of the king post it is practicable to stow long-shaped articles that will do with bearings nine feet apart, of which, however, there are not very many about the homestead. But nothing hardly can find a resting-place along the iron ties, and the wood ones of this kind of roof are too far out of the way and afford too little room to act as the basis of a store. The iron ties, in fact, need support themselves, as we see from the rod *b* shown in the fig., passing from the tie up to the apex of the roof were it is attached in order to keep the cross rod up to its work.

Sound Economy to fill up the Angle formed between Wall-head and Roofing Boards.

It is sound economy, we think, to have the angle formed by the wallheads and the roof filled up. This space if left open affords a lodgement to dust and to matter out of place in general, even if beyond reach of the farm hands. When it happens to be within reach all manner of odds and ends get laid there, with the intention no doubt of getting them when wanted; but an article that is worth keeping should find a more business-like place of storage, and doubtful ones had better be thrown away than placed there, helping to gather more dust and dirt. When masons build up this angle they speak of "beam-filling" the wallheads. It certainly adds to the appearance of the interior of a building to finish it in this way. And it must help to make it a little more sanitary as well. Every settling-place for dust means a harbourage for germs, whether of a harmless or harmful nature, and the more we keep clear of the latter the better. They are thick enough in the air without our providing lurking-places for them.

It is questionable if the filling up of the space with stone be a good one. It confines the wood too much—shuts it out too much from access to air. This undoubtedly tells on the durability of the wood. The more air it gets about it the better able is it to withstand the ravages of time. Enclosed in dry stone and lime it is more favourably situated for lasting than if it were embedded in any other ordinary substance—dry sand or soil, for instance. Longest of all it endures when open all round to the air and not allowed to remain damp should it ever happen to get wetted. We can close in the angle with wood instead of stone and so get beyond the difficulty. It is easy to fit a board or boards into the place. A fillet on the sides of the couples enables us to butt it against these and fasten it thereto. It will be resting on the wall-head too flush with the face of the wall which will give it firm support: and if the wall-plate be the same distance back from the face of the wall as the thickness of the board to be made use of for filling up the angle the board can in addition be nailed thereto. Where the principal roof is in question, attachment to the wall-plate and to a fillet fastened to the underside of the roofing boards would have to be the plan adopted for fixing the board. It could stretch in one piece from truss to truss, being checked out where necessary to fit over the common rafters or kept entire where these were absent. The board would never fit so tight that air could not gain access into the angular space behind, and the roofing boards never fit so close to the wall as to stop air from getting in at the eaves. There is thus assurance of a draught of air playing on the couple ends and wall-plate and maintaining them in good condition.

The same cannot be said of beam-filling by the mason. He buries up the wall-plate and completely surrounds parts of the couple ends. These and the wall-plate are consequently deprived of air and left liable to succumb to the results that may follow thereon. Still, we would rather have it so than have the angles left open.

Advisable to plane all interior exposed Wood Surfaces.

We strongly advocate the planing of all the exposed surfaces of wood within the farm buildings, in the barn, as well as in the byre. This extra work, which does not amount to a great deal, seeing that it can either be done by the apprentices or quickly accomplished by the wood merchant's machinery, is, we consider, well worth the money it involves. If nothing else, it adds much to the appearance of the different places. It is from a sanitary standpoint, however, that we look for most benefit from it. The rough, unplaned surfaces are all so many lurking-places for dust and sort of shelter-beds to the countless representatives of the microbic world that none should be suffered within the farm buildings. The other conditions that render these buildings favourite haunts to bacteria—their moist, warm atmosphere, the habits of the animals they contain, and so on—are all sufficiently conducive to the welfare of minute organisms without our affording them places well adapted to their perpetuation. The doors and the travises are planed smooth; why, therefore, should the same not be done with the roof wood—that which sins most in this connection? And we strongly recommend galvanizing the nails to be used in putting together the roof wood of the various buildings, more especially those set apart for the housing of the animals.

Hitherto we have dealt with the more permanent buildings of the homestead. There remain the various sorts of shedding that come in auxiliary to the main block—the lean-tos, the corn and hay sheds, and other constructions of a like nature. These we shall discuss in a chapter by themselves.

CHAPTER IV.

The Roofs—their Covering.

What the Outer Covering of a Roof has to face.

Slates, and in a few cases pantiles, are the accepted material for the outer covering of Scottish and North of Ireland farm buildings that are built with a view to some degree of permanency. England, on the other hand, seems to have as many tile-roofed as slate-covered homesteads. There is no other natural material that can show the slightest approach to the properties slates possess of answering the purpose to which they are put in keeping our roofs water-tight. The requirements expected of them are arduous in the extreme when we consider what they have to contend against during their exposure to all the vicissitudes of our changeable climate. One day they are so hot under the sun's rays that we can hardly bear to place our hand upon them. On another, a month or two afterwards, their temperature may be at zero. And between times rain-water has poured over them in tons; they have lain for days, or weeks, smothered in snow, and occasionally they have been peppered with hailstones. Yet through it all for a hundred years or more are they capable of holding their own, and still presenting a good front to the wear-and-tear effects of the elements.

Wood alone not fit for the Ordeal.

Of what other material can the same be said? None of our woods naked and unprotected are able to go through such an ordeal. Nor would they for any length of time even if fortified with paint or any of the preservatives that are sometimes applied to them. Under strong heat, as well as on account of dry wind, they would curl and shrink if they did not also split. Rain and damp winds would cause them to swell and force each other out of place in the row. What, therefore, with being contracted and shrivelled up at one time and puffed out with too much moisture at another, they would soon lose their recuperative powers and come to fall away. The shingle, or wooden slate of the United States and Canada, proves that some kinds of wood can be turned to account in this way; but we never heard otherwise but that they are a sort of makeshift, and never had recourse to where slates can be obtained at a price that does not forbid their use. We have no metal either of a reasonable price that can take the place of slate on our roofs. For a metal to be able to withstand what slates are subjected to on a roof

Which of the Metals are?

it would need to be proof against the oxidising effects of the atmosphere, be all but insoluble, and be not liable to expand very much under the influence of heat. Were it one that encouraged the attentions of oxygen, it would soon succumb to that busybody among the chemical elements. Were it ever so slightly soluble in water, rain in time would eat it away. If not liable to be dissolved in water of itself, but sure to be in water containing acids, then there would be every chance of its falling in the way of such a combination, because rain, even in the country, is not wholly free of such a taint, while near populous places, or in the neighbourhood of factories of various descriptions, it cannot escape this contamination. And were it to expand to any considerable extent under heat, as all metals do more or less, the result would be rather detrimental to the efficiency of the roof. With clear spaces between the metal slates or scales at one time, and at another, each jamming so hard against the adjoining ones as to be difficult to keep in position, the conditions would be such as to try the fastenings very severely. In contrast to this the slate defies both air and rain; it neither contracts nor stretches, neither does it exert any strain on the nail beyond its tendency to slip over the eave, except under the times of storm and stress when it lies direct in the teeth of a gale, or, what is sometimes even worse, when it gets caught in the suck of the whirling eddy that so often strips off the slates when once a weak spot has revealed itself and laid them open to unfair attack.

We can mention four metals that come up to the requirements we have just stated. These are gold, copper, lead, and zinc. The first of these is all-round the best. It resists oxygen, is practically insoluble, and does not come and go to any appreciable extent with change of temperature. Old-fashioned chemists on account of these properties of gold classed it as one of the "noble elements." But its price puts it out of count, and we may leave it to serve more noble if not always as useful purposes.

Copper slates are used in exceptional cases, from which it is apparent that copper is capable of ensuring the requirements referred to. It does not so fully, however, as the metal just mentioned. The atmosphere has a slowly corrosive effect on it. Both the oxygen itself and the various acids found in air make a prey of it and in time eat it away. Pure rain-water does not dissolve the metal, but rain, as hinted, quickly picks up any acids that happen to be in the atmosphere. Copper comes and goes too with its temperature.

Lead is less soluble than copper—at least, the combinations it forms through exposure to air, to oxygen and atmospheric acids, are. Some of them, in fact, are amongst the least soluble of the metallic compounds. Lead was in time past extensively used as an outer covering for roofs. Until slates were introduced we expect there was little else available for roofing than thatch and lead—lead for church, abbey, castle, and the rich man's house, and thatch for that of the man who could afford no better. Many a noble edifice was laid open to ruin through the stripping of lead from the roofs for bullet-making in the times of the civil wars. Lead is much used yet in roofing, but only in a subsidiary way. It lends itself easy of application to the nooks, corners, and angles into which slates cannot be moulded or trimmed, and as a means of connecting the slates to various parts of the building and making these places watertight. Lead is never used in the form of slates, but is always applied in the sheet form, cut to the size wanted. It is too expensive to be used as slates are, although quite capable of being applied in that way and taking their place. On many occasions it is still the medium taken to cover over flat roofs, and now as formerly it is laid in the sheet. Lead is little affected by changes of temperature as compared with other metals. The little there is, however, waxes big when a large sheet of it is in question, and possessing as it does little elasticity, it needs care in laying, else tears or rupture will be induced, and its effectiveness be spoiled. It must be laid in such a manner that the sides and ends of the sheet are free to follow contractions therein and give way before expansion in the mass when affected by heat. It will not bear the restriction of being nailed down like a carpet.

Zinc could be manufactured into the shape of slates and take the place of the real article were it not for the expense involved. The appearance of such substitutes would be against them, however. They would resist weather sufficiently well, and otherwise be answerable. Zinc, like lead, but in less degree, is already put to service as a subsidiary to slates. It makes a good material for finishing off the ridge angle with; and sometimes is turned to account in the manufacture of eaves-gutters, or "rhones," as these are often called. It is a common medium, too, as we shall find, for the construction of ridge ventilators. It is too brittle, however, to take the place of lead in covering the open joints in slating or finishing off where slates abutt against walls, and in situations of a like nature. Lead, being soft and ductile, can be easily dressed or moulded so as to lie flat upon or close against either wood, slate, or stone, which with its other good qualities as a resister of weather effects, render it very valuable in this respect. Zinc is not so accommodating, and will crack at once if meddled with in the manner that lead is pulled about and beaten in this connection.

That zinc is endowed with a fair amount of weather-resisting qualities is proved from the fact that it is now so much used in the protection of iron that is exposed to the atmosphere. The galvanizing of iron is simply the coating of it all over with a thin skin or film of zinc. The process is somewhat similar to that of electro-plating—the covering of articles made of nickel or some similar composition of the baser metals with a coat of silver, and giving them the appearance of being made entirely of that beautiful metal. In this case, however, the iron articles are simply dipped in molten zinc, and in that way coated over with protective material. Were the zinc wanting, the iron would at once be attacked by oxygen. It might escape if there was little moisture about, but once let dew or rain or other form of dampness get in contact with it, then oxidation takes place at once and rust is the result. So long as it is protected by a film of zinc it is secure from attack by oxygen. Paint, could we apply it as closely as the zinc, might be equally effective in keeping oxygen at bay, but we cannot bring about such a close relationship between the paint and the iron as exists between zinc and it under the process of galvanizing. Paint cannot be applied so intimately to the iron as zinc can, nor does it last so long when applied. The zinc appears to enter into a sort of chemical combination with the iron and be merged into its substance at the point of application of the two. It is different with paint, which at the best is but smeared over, leaving dust and other matter between it and the metal, there being more or less of this in accordance with the condition of the latter. Could the paint be applied to the metal when its surface was thoroughly clean, a close connection would be gained, but this is seldom practicable. Zinc is not altogether proof against the effects of exposure to the atmosphere. It is less so than either copper or lead, but is cheaper than these. It scores considerably, however, on account of its galvanizing capabilities.

We might have included tin among the other four as a metal fit to be manufactured into roofing scales or squares after the fashion of slates. But were the price not prohibitory the appearance these would bear would in itself put them out of court. Tin resists weather stoutly. Tinned goods, as most of us are aware, are made of sheet iron coated with tin. So long as the tin stands good, so will the iron, but whenever the tin film is rubbed off or worn through rust attacks the iron and the usefulness of the article is destroyed. It is marvellous how thin a sheet of iron and how delicate a skin or envelope of tin can together be turned out by the manufacturer. And aluminium has, we suspect, a future before it, in connection with parts of our roofs.

Slate the best Natural Material for the Purpose.

There is nothing therefore in nature to equal slates for the exterior covering of the roofs of our buildings. Composed of inert earthy matter that affords no attraction to the meddlesome oxygen that surrounds us, they can easily resist the other trials that follow exposure. Sun and rain have no appreciable effect on them, neither has frost. At any rate, they take a long time to show much result from their continual siege. It seldom slackens, one being ever ready to begin as another leaves off. Some kinds there are of course that show no such powers of endurance; but plenty are to be had, and at a reasonable price, quite capable of lasting after the manner described.

The English roofing tile of the best quality is not, indeed, far behind slate as an external roof cover. Not so fibrous and tough, perhaps, it is still very inert under weather influences. A roof covered with these tiles is, in fact, one coated with brick.

The Basis for the Attachment of Slates and Tiles.

But preparations have first to be made for securing a firm basis for the attachment of the slates or tiles. We left off last chapter at the completion of the skeleton or framework intended for support to what has to give a foothold or bed for the outer covering. English builders follow the practice of fastening both slates and tiles to spars or laths nailed to the rafters at distances spaced to suit the size of the slates being made use of. In Scotland such a practice is rarely observed. There the prevailing system is to cover the rafters with rough boarding and attach the slates thereto. The more boisterous nature of Scotland's climate is sometimes advanced as a reason for this difference of practice. There can hardly, however, be so much difference between countries so close together. There are bound to be parts of England more tempestuous than the best sheltered parts of Scotland, and what stands good in the one will surely in the other. The class of slates available in the respective countries seems to us to be at the root of the matter. Slating on spars makes it obligatory that the slates are nearly all of one size and large. It does not, of course, make the rule absolute. On boards, however, it is much more practicable to use slates of assorted size than it is on sparring, the spars affording too little range in spacing to be readily adaptable to the change in cover or lap that is implied in the use of slates of different length. The slates native to Scotland are generally sent from the quarries in various sizes, due, no doubt, to the fact of their being sold by weight. It is out of this, we suspect, that there has arisen in Scotland the practice of providing a continuous covering of boards for the slater's field of operations. And accustomed to this kind of slate to start with, Scottish builders have seldom sought for a better. We rarely, at any rate, see in Scotland the best kinds of Welsh and English slates. Scotsmen seem to import only the inferior sorts. The English builders keep the best to themselves: they keep the big smooth ones, and send north the smaller and coarser sorts. These suit, however, otherwise they would not be taken.

Roofing Boards for Slates.

The boarding for slates is, as we have mentioned, technically known as "sarking." These sarking boards are nine inches wide by five-eighths of an inch thick, and vary in length in accordance with the tree they are sawn from. They are used rough from the saw, but squared at sides and ends of course. They are firmly nailed to the rafters, as close together as they can be placed by hand assisted by an occasional tap from the hammer. There should never be less than two nails in each of the boards at every rafter. We have, as already expressed, a preference for galvanized nails for this purpose, especially in the roofs of byres and stables. They cost very little extra, and serve to make things more secure. We have seen so much harm occur from nails becoming rusted through exposure to the atmosphere of such places, and giving way, and thus allowing the boards to slip, that we find it well worth while to guard against that by taking this slight precaution. It may be said, and with some show of truth, that it would be more satisfactory to guard against the cause of this decay by taking steps to prevent the implied foulness of air in these situations. In the due course of our work we shall recommend that too, but carrying it out is by no means such an easy matter as it can be made to look on paper. The matter of substituting galvanized nails for those ordinarily in use is a simple one, however, and once completed it looks after itself.

The rafters, as we pointed out in last chapter, are set to leave a space of about sixteen inches between them. It seems about enough one would think to expect to be bridged over by boards only five-eighths of an inch thick with their load of slates. But there would appear to be no reason for seeking improvement in this direction. The arrangement so far as it goes answers well enough apparently. For our part we would rather have thicker boards and have the rafters a little wider apart. When the boards are so thin the ends of the slate nails project through and are unsightly and give an unfinished look to the job. If, however, we go to the expense of planing all the wood that shows inside the roof of the buildings, as we have already recommended should be done in the instance of byres and stable, we may as well at once have the rafters covered with $1\frac{1}{8}$-inch flooring boards. These give us a smooth surface on the inside of the house and at the same time provide us with a thicker board. The increased thickness will, if we think fit, enable us to set the rafters farther apart and so help a little to counterbalance the extra cost. It will also almost entirely hinder the points of the slate nails showing themselves. The sarking boards are to be had "half-checked" as in Fig. 55, which shows a section through two of them placed near each other. There is not much use for this as regards farm buildings, although, seeing that we do board in the roofs, it may as well be done effectually. It is argued that the more chinks there are in the boarding of the roof the better chance is there of some ventilation being assured. But we prefer to place the ventilation of a building on a surer basis than leakage through the sides of the roof. Checking the boards helps somewhat to keep the joints closer, but not to the extent one might readily suppose. The sarking boards are seldom seasoned to the extent we have a right to look for. They are too often cut out of bulk and dispatched right off to the carpenter. Hence it comes that these boards frequently shrink to a considerable degree. In this way the check very often becomes of little avail. Flooring boards are supposed to be better seasoned, and generally speaking, they are, and with them we are sure of a closer joint than with the others. They are tongued and groved as Fig. 87 shows. This

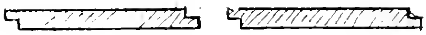


FIG. 55.

ensures a tight joint so far as the passage of wind is concerned, but we are thinking more of their presenting a close surface joint to the interior of the building. But even if the boards do shrink a little, which in every probability they will, and form wider joints than we care to see, it is good to have the exposed face of the boarding—that next the house—smoothed down by the plane. The why and wherefore of this we have already hinted at and shall revert to and take up in fuller manner when we come to touch on sanitation at the steading.

The admission of Light by way of the Roof.

Whatever the class of boards chosen as a foundation for the slates is, whether sarking boards or flooring boards, there is a good deal to do besides nailing them on before slating can be commenced. It may have struck some of our readers that when referring to the walls we made no special reference to window openings therein. We did not for the reason that we prefer to light all farm buildings by way of the roof instead of through openings in the wall. Side windows in farm buildings are often in the way. They are seldom kept clean, and the window sills, like the wallheads when within reach and not closed in, become so many places of deposit for rubbish. When the lights are up in the roof they are out of the way and the glass has less chance of being broken. The glass is sure to be washed on one side whenever rain falls, which cannot be said of it when in the side window, and no other agent ever cleanses it—at least, we never saw the window of a farm building being cleaned. Moreover, more of the sun's rays will penetrate the building through roof lights than side lights. Up in the roof the windows see more of the sun and its reflected light than it is possible they can do when built into both sides of the building; they can never be so much out of sight of the vault of heaven as those in the side wall. The latter have only while the sun is about level with the eave they pertain to in which to get a direct glance, but the skylight, as its name conveys, is ever looking heavenwards, and has the fullest chance of obtaining light for the interior. First those on the one side and next those on the other follow the sun in its daily course almost from horizon to horizon.

Another point in favour of the roof light is its cheapness in comparison to the side window. It saves sill, rybats, and lintel, which together account for more than the extra rubble work taken to fill up what would have been the window opening. Safe lintels are also dispensed with, and the framework of the roof light can be had for less than the framework of the side window, and it will last longer, there being no wood to decay, and from its position placing it out of harm's way.

A suitable size of Roof Light.

A common size of roof light is thirty inches long by sixteen inches wide—of glass, that is to say. This size admits of the light fitting in exactly between the rafters, the usual distance between them being as we saw sixteen inches. The frames of these lights are of cast iron, and they are made either as dead lights, in accordance with Fig. 56, or with hinges, as in Fig. 57, that allow of their being opened at pleasure. We always advise the use of opening skylights; they are essential, we think, to the houses meant for live stock, and in the other places we consider them preferable to the unopening ones. The frame of the roof light is screwed to the roofing boards over the hole sawn out of these for the purpose. The slates lap over the frame at top and at the sides, and the tail or bottom of the frame laps over them, thus keeping all shipshape and dry. The roof lights have therefore to be fixed up coincident with the slates; they cannot, it is evident, be put in position until the row of slates that comes within touch of the bottom of the opening left for the roof light has been secured.

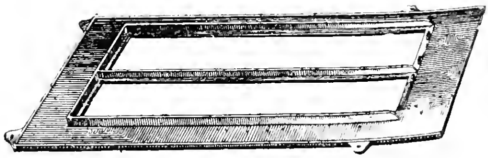


Fig. 56.

The Advantages of the Roof Light.

Our advocacy of roof lights may at first thought seem a little self-contradictory. We have hitherto been against the introduction of iron into the interior part of the roofing of farm buildings on account of its liability to condense moisture out of the warm air of these places, bringing harm to itself and to the adjoining wood as well. But, notwithstanding the framework of the roof light being of iron, there is so little of it exposed to the interior of the building, almost the whole of it resting on the outer surface of the roofing boards, that but small harm can ever result from this cause. Moreover, the glass is so fixed that what moisture happens to condense on the inner surface of the glass escapes at the tail of the frame on to the apron or bottom end of the frame of the roof light. We have already pointed out that rain kept the outside of the glass clean; here on the inside we find the same service being done, though not so thoroughly perhaps, by the condensing moisture of the interior. But the rain that washes the glass rusts the iron frame which holds it—at least, the part that is exposed—and this means the application of paint pretty frequently if the roof light is to be maintained in good order. Left to itself after the initial rub over which

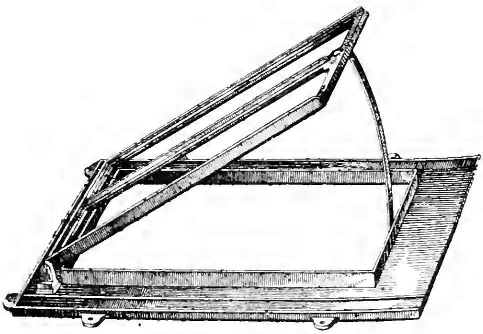


Fig. 57.

it is supposed to get, it will grow rusty and become difficult to open. The putty will crack and eventually lose hold and drop off. But if kept regularly painted the iron-framed roof light will last an indefinite time.

We would fain of course be rid whenever possible of the necessity of having to paint. This proceeding is, we repeat, so apt to be overlooked at the homestead that any parts of the different buildings that depend on paint for protection from the weather are nearly always in a precarious condition. There is excuse for a roof light being overlooked in the matter of paint: there is none, however, when the side window, generally within easy reach, is found bare and weatherbeaten. A door or a beam, if the wood is sound to begin with, once it is seasoned, will last for long without the aid of paint. With a window it is different. There are so many joints in the latter into which rain can enter and cause decay if they are not safeguarded with paint that two or three years of neglect in the way we refer to puts it past repair. If the putty gets slack, rain gets in behind it to the serious harm of the wood. Paint alone will keep the putty from shrinking and cracking.

But if we find the side window so much neglected in this respect, what need we expect regarding the roof light? The framework of it too might be galvanized and thus be made sure of. There would still, however, remain the putty to be dealt with. But if that were well attended to at first it might not need looking to for a long time afterwards. There are indeed methods in vogue of glazing roof lights without the aid of putty which, if adopted in connection with the suggested galvanizing of the roof-light frame would make matters about perfect in this connection. But, should these precautions be thought a little far-fetched, then let the ironwork receive three coats of good paint before being placed in position, and after glazing let the putty be well coated also, when the whole will be in good condition to start with, after which they must trust to events for after-attention. We cannot provide for self-upkeep and protection altogether, although at the homestead, if anywhere, automatic, or rather, self-renewing apparatus, would have an undisturbed field to practise themselves in.

Other Operations preparatory to Slating.

We have been a little premature with the roof lights. They are put in position concurrently with the slates; but previous to the commencement of slating there are some important, if slight, operations in the way of plumber-work to be seen to. Hooks for the rhones, eaves-gutters, or spouts, as these are variously termed in different districts, have to be fixed to the roofing boards; and whenever lead has to be introduced and be partly covered by the slates, it must be put in its place before the slates can be laid.

The Eaves-Gutters.

The rhone hooks (see Fig. 58) are put on at three feet apart, and fastened to the sarking boards with slate nails. The rhones themselves are in six-foot lengths; thus each one gets two hooks for its support. We are assuming that cast-iron rhones will be used. Both lead and zinc are, in some districts, put to the purpose of forming these eaves-gutters. Lead is too expensive for this, however, and neither of them is so serviceable as cast iron. The bangs that these gutters sometimes receive when clumsy fellows are setting ladders against them with a view to repairing roofs or mounting thereon, necessitate their being made of a sturdier stuff than either lead or zinc. There is no soldering needed in the case of cast-iron rhones. They fit on to each other, end for end, on the principle of spigot and faucet pipes. The faucet is lined with putty, upon which is laid a corresponding spigot; a screw bolt is passed through the hole common to each piece, the nut is screwed home, and the two lengths are as one. A new length can at any time be submitted for a fractured one. With lead or zinc it is different. Eaves-gutters of either material take longer to fix up, and they take far more trouble in time of repair. Neither needs paint, but the iron rhone brings us face to face with this difficulty once more. Here, however, we can with even greater confidence than in the previous instances recommend the troublesome metal to be disguised in zinc. The hooks are now almost always galvanized. They are troublesome to replace, and experience has taught that this is the best method of safeguarding them against weather. To do the same by the rhones or drop-pipes or conductors, although it adds to the first cost thereof, is eventually well-spent money. After that they are for all time coming independent of paint. It would be well indeed could we say the same of all exposed perishable materials that take part in the fabric of the homestead.

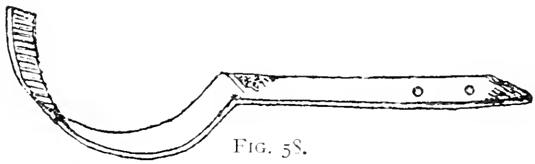


FIG. 58.

No Building should be without them.

We have been taking it for granted that everyone interested in the construction of homesteads allows the necessity there is for eaves-gutters to the various buildings that form the group. When these are wanting the side walls are certain to suffer. Every shower means a wetting to the foundation. Over and above what falls to the share of the surface at the base of the side wall of any of the buildings, it gets what rain descends on half of the area of the building, the other half leading down the slope on the other side of the ridge. And this extra share is not let down in the manner characteristic of rain. It comes like a cascade, splashing upon the base of the wall and wearing away the soil therefrom. Outer walls of buildings provided with eaves-gutters are kept damp by the atmosphere, so that where these are not erected it can easily be imagined that the condition of such walls is made worse in that respect. A damp course, it can be understood, will have its beneficial effects hindered very much when eaves-gutters are denied to the buildings. But if solely on the ground of discomfort to man and beast we would advocate their adoption. How unpleasant it is in times of rain coming out and in of the doorways of buildings that have none

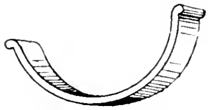


Fig. 59.

of these appendages to the eaves, especially if the doors happen to be stiff, or their fastenings are out of order and want coaxing to be led in the way they ought to go! On a dark, wet, windy night, the lamp difficult to keep in, uncertainty which key is the right one, and the mimic waterfall free to find our neck, there arises for us no slight trial of temper. The very horses wince, and seek to force the passage as they come under the rude shower-bath. Melting snow helps when there is no rain to prolong the discomfort from this cause.

The Manner of fitting up the Eaves-Gutters.

The various objects on Fig. 60 make plain how conveniently the cast-iron rhones or eaves gutters are manufactured for being put up in any sort of position. Each ordinary part of the gutter is, as mentioned above, six feet long, and one fits to the other—the plain end of one into the faucet end of another, or of an odd piece. A little putty is bedded round the faucet,

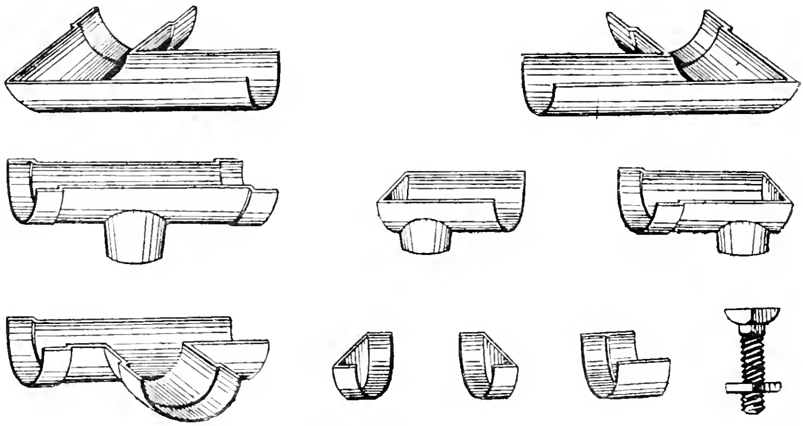


Fig. 60.

and the junction is made thoroughly secure by means of the little screw bolt and nut. Any piece can be easily procured, so that repairs are easily effected. On each edge of the gutter, as on Fig. 59, is a bead or thickening of the metal, which gives additional strength to that part. The rhones are given an inclination to the various points above where the water is to be led to the ground. There offset pieces are introduced which are connected to conductors or drop-pipes. Rhones four-and-a-half inches across are a good size to use. A three-inch conductor is ample to serve these, provided, of course, each conductor is not given too much to do. As may be gathered from Fig. 61, these pipes are also of the spigot and faucet pattern, and are, consequently, easy of connection. A faucet end is slipped over the nozzle of the rhone. That length of the conductor is fastened to the wall by means of a hold-fast *a* on the fig. driven into the wall close up to the faucet. Another piece has its faucet slipped over the free end of the piece just fixed in position and made fast in the same way, and so on until the ground is reached. No packing of the joints is necessary. If meant to deliver the water on the ground clear of the wall, a shoe piece *b* is generally finished off with, but if it has to be led directly to the drain the free end is carried below the level of the grating of, a Hart or other trap afterwards to be described. Swan-neck pieces *c* are made use of when it is not practicable to place the nozzle directly over the mouth of the conductor, or *vice versá.*

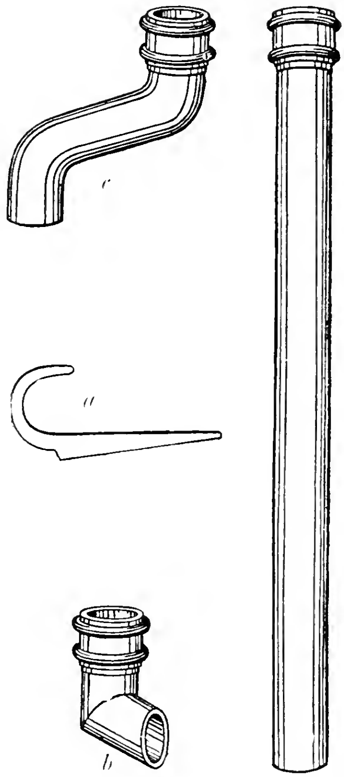


Fig. 61.

The Centre Gutter to be dispensed with wherever practicable.

Wherever practicable centre gutters are to be avoided. They are out of sight, therefore all the more likely to be neglected. What is daily in view is apt to be overlooked; what cannot readily be seen has less chance of being attended to. Leaves, if trees are about, lodge in centre gutters; and straw too that gets whirled up on the wind lands there. These accumulations if undisturbed come to obstruct and by-and-by to choke up the waterway, with consequent flooding of the hollows and evil results to the wood affected. And snow under certain conditions of the weather if left to itself in the centre gutter often causes flooding there.

The Valley, the Flank, and the "Piend."

Fig. 62 tells what a centre gutter is. It serves also for us to point out some of the other parts of the roof that the plumber must attend to before the slater can commence operations. The centre gutter *a* is the angle formed where the two roofs meet on the mutual wall. Two roofs converging as at *b* form a valley. A roof running into a wall as at *c* forms there a flank, with its accompanying raggle or raglet. These parts require the intervention of sheet lead to make them watertight.

The part marked *d*, which is the reverse, as it were, of the valley, is termed the hip or "piend." It, like the ridge, is the water-shed, and the two are finished off similarly—the one, in fact, being but a continuation of the other. Zinc is the usual material for finishing off with here.

The Securing of Lead on the Roof.

Both in the centre gutter and the valley the lead must be laid sufficiently far under the slates to make sure that water running down the roof cannot gain entrance between the two. In Fig. 63 we show a section of a centre gutter in order to make the matter plainer. It is advisable to make the gutter a fair breadth; one has room then to move about

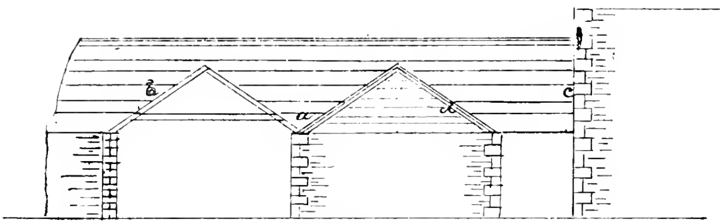


FIG 62.

thereupon without breaking the ends of the slates. A platform, or sole, *a*, is first laid on which to bed the lead. Bearers for this are attached to the rafters. The joints between the boards of this sole must be close,

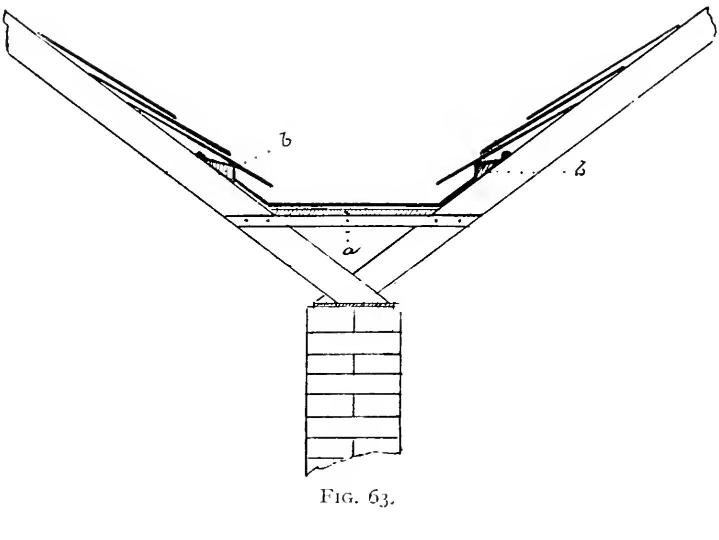


FIG. 63.

else they will subject the lead to a likelihood of being rent or torn. It is well therefore to use flooring boards for the purpose. The broader we make this platform the higher we raise it above the level of the wallhead. But this does not necessarily affect the appearance inside either of the buildings, the roofing boards generally being carried down to the wallhead as usual. They could of course be dispensed with beneath the level of the gutter sole; but then an unsightly as well as insanitary space would be left. If the wallhead angles are to be filled in on the principle we suggest at p. 68, the roofing boards need, however, be carried no further down than will clear the room required for this.

With the sole in position the laying of the lead is then gone about. It is carried far enough up the slope of the roof on each side as well as

FIG. 64.

at the head to allow the gutter to contain two or three inches of water without any getting over the edge. At the edge it is dressed over a small angular piece of wood *b*, known as a tilting fillet. This fillet, while it checks the progress of water that might, were it absent, be drifted over the edge of the lead, gives the necessary tilt, afterwards to be referred to, to the tail of the first row of slates.

Lead, as we have already said, will not suffer the restraint of nails. It must have free course to come and go as temperature dictates. But in positions of the kind we are dealing with it needs no such curbing. It will lie still enough except for its own molecular motion. This, however, though barely perceptible to observation, if interfered with is

FIG. 65.

enough to destroy the efficiency of the watertight sheet. It hinders us from using large continuous sheets of the metal. In consequence the gutter has lengthwise to be broken up into several sections according to how far the combined roofs stretch. The breaks are introduced in a series of steps as in Fig. 64, due care being taken to overlap the connecting lead in such a way that water will not penetrate at the junction. As we gain the top section of the gutter it broadens out on account of the slope we are obliged to give each of them as well as of the steps that mark one from the other. The joining of sheets on the flat, which here may only be done parallel with the slope, is accomplished by means of a roll as in Fig. 65. But at the farm the sheets of lead applied to roofing are rarely so broad as to call for this. The centre-gutter may dip both ways and thus afford escape to the water if both ends are free—if no buildings abutt against either end of the conjoined buildings. If only one end is free it will dip thitherwards. The water ought never, if possible, to be drained down through the buildings. If it is, mischief is certain to result at some time or other.

Cast-iron Centre Gutters.

Cast-iron centre gutters such as in Fig. 66, of which there are many modifications, are occasionally made use of in connection with farm buildings. The respective lengths are put together in the same way as the rhones referred to. They are strong, and so long as in good order quite effective. They have one serious fault, however: wherever moist air

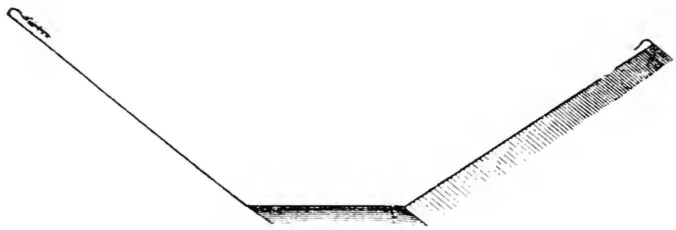


FIG. 66.

gets access to them they, when cold, act as condensers. If they happen to be in buildings that contain live stock, water is constantly dripping from them. From this cause they are liable to become a source of

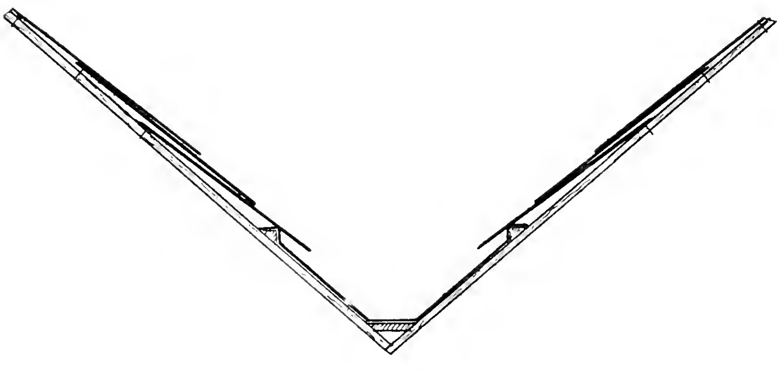


FIG. 67.

damage. Shrouding the outside of them in felt or encasing them in wood prevents the dripping. But it is not always practicable to do this. Felt would fall away in time, helped, perhaps, by rats in want of a lining for nests, and unless the wood be close home against the iron, condensation would still take place. They are cheaper than lead gutters, but we would never recommend them for situations where they would be subjected to the lung exhalations of animals. Lead would act in much the same way were it not hindered by the closely-fitting boards on which it rests in the gutter. An iron gutter may be serviceable enough in connection with open shedding, but it should never be used as part of either byre, stable, loose-box, or any other place that is set aside for the housing of live stock.

The Construction of the Valley.

Fig. 67 gives a section of how the valley is constructed. It, too, is provided with a closely-fitting wood sole and a tilting fillet at each side. This sole is, of course, a narrowish one, simply being there to keep the lead from liability to split through being forced into the otherwise acute angle at the junction of the roofing boards. The lead is broad enough to fit to the sole and be dressed over both fillets. The latter do to be smaller here than at the sides of the centre gutter, their purpose being mostly that alone of confining the water to the channel. In the centre gutter they have in addition to give tilt to the slates, although even here they have also something to do in that way.

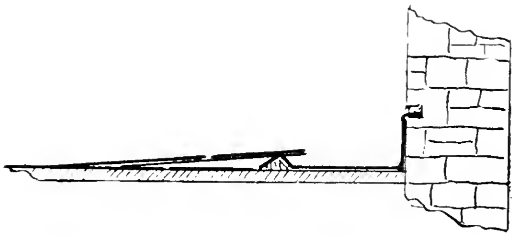


FIG. 68.

The Raggle.

The flank and raggle differ somewhat from both the gutter and the valley. Figs. 68 and 69 show one method of finishing the flank. This, indeed, resembles the valley. It resembles one halved. The sole is just the roofing boards. A tilting fillet is there, too, on the side next the roof. At the other side the lead is dressed up the wall three or four inches and then inserted at right angles into a narrow groove worked in the stone. This groove is the raggle or raglet proper, and is an inch or an inch and a half deep. The lead is finished off therein with a slight curl of the lead back on itself. When the lead has got its proper set the remaining space in the groove is filled up with cement and neatly smoothed off. This is generally left over until the slating has been completed. When the raggle is completed no water can get between the lead and the wall. This form is sometimes termed an "open gutter."

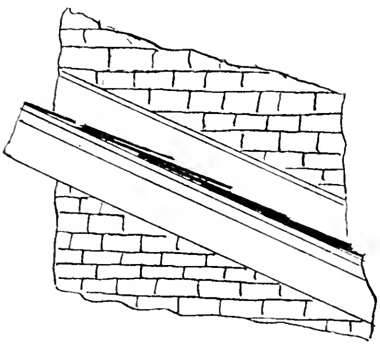


FIG. 69.

Fig. 70 shows another method of finishing the raggle. In this instance the part of the lead that projects on the roof, instead of being put under the slates, lies over them, they being laid close against the wall. The remainder of the lead is fixed as before. The slates require a tilting fillet to themselves in order to lay them so that the water they pass on may be diverted from the wall. The former, if the more troublesome to complete, is much the neater as well as the more thorough of the two.

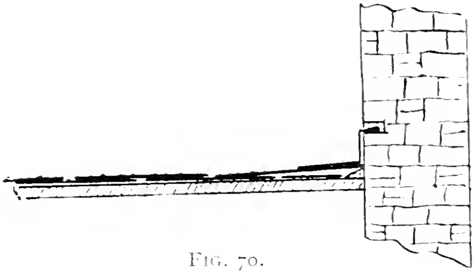


Fig. 70.

Sometimes it is practicable, as in Fig. 71, to finish off a raggle without the intervention of lead at all. But the grove in the wall needs then to be a wide one, with the slates projected a little into it, and bedded in cement. When the slater has finished, the gap remaining in the raggle is filled up with cement and a good coat of it, projecting well over the slates, is firmly laid on. This answers for a time: if away from the stormy side it may be for a long time, but we prefer to have lead in all cases. The tiled roof and the roof covered with flag-like slate, lend themselves to be finished off with either cement or lime in this manner much more effectually than the ordinary description of slated roof.

The Junctions with Chimneys. Where chimney heads pass up through roofs, or are in the gables thereof, the junctions between them and the slates are finished in a manner similar to these flanks and raggles we have been discussing. Fig. 72 shows a chimney-head finished thus, one side with an open gutter as in the flank represented in Fig. 68, and the other as in Fig. 70, with an apron of lead over the slates. The ends of the chimney are finished like the latter mentioned of the two sides, with aprons projecting over the slates. Chimney-heads usually being of brick and a raggle being difficult to cut in such hard material, the skirting, or the "flashing," as it is sometimes termed, of lead is stepped as shown in Fig. 73. In rough work they may be safeguarded with cement alone, as with the flanks mentioned as being so done in some cases.

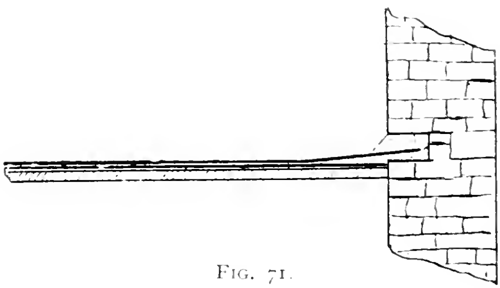


Fig. 71.

The fewer Breaks in the Roof-Line the more easily is the Roof maintained water-tight.

It may be gathered from what we have been describing that the fewer breaks and junctions there are in the roofs of a group of farm buildings, the better will it be for all concerned. By breaks we mean any change in the continuity of the elevation or sky-line of any of the sides of the homestead—differences in their level, in short, and by junctions the duplication of buildings, or the placing of two together in such a way that the dividing wall is mutual to both. Breaks

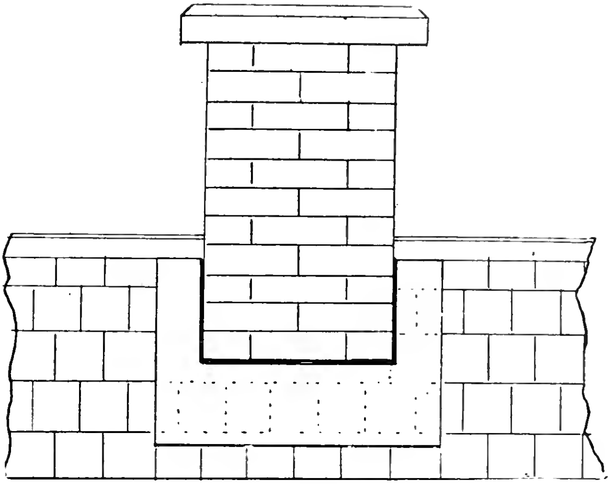


FIG. 72.

necessitate lead joints between the roof of the lower building and either the gable or the side wall of the higher. Each joint of the kind is expensive to begin with and by no means cheap to repair when flaws

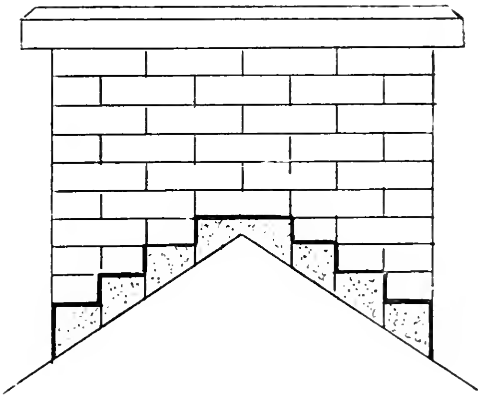


FIG. 73.

begin to appear. Plumbers' wages are high, and much of their time at country repairs is taken up in journeying to and fro.

Not wise to range two Buildings together.

The ranging together cheek by jowl of buildings of equal height means expensive centre gutters between the parallel roofs. Oftener than otherwise this arrangement is the result of seeking to make one wall answer for two. We question, however, if this is sound policy. It can hardly be avoided in many cases; but where it arises from no other cause than the avoidance of an extra side wall it is a mark of false economy. When finished in a thorough way there is not so much saving after all, and the place is left with a weak part that is almost certain to be neglected until the decay it may happen to be responsible for obliges someone at last to take it in hand. Another bad effect, but one more of a sanitary nature afterwards to be discussed, of this duplication of buildings is the interruption which it causes to the easy and effective ventilation of the space covered, unless of course the two buildings be treated as one. But when the two are separate, instead of each being in contact on both sides with the outer air, there is but one side thus advantageously situated.

The Choice of Slates.

The slater has now a free course. The slates chosen for him will, as we have already remarked, depend very much upon the kind most easily procurable in the district surrounding the homestead being built. These may indeed be of a description that one does not care to use, which leaves it open to him to make a wider selection. Scottish slates are roughish, but hardy and long-lasting. Both bulky and heavy, they become comparatively costly if transported long distances. Welsh slates are the most generally prevalent of all our British sorts. They are thin, and many go to the ton, and in consequence the carriage of them does not amount up to the figure payable for the bulkier kinds. There are good slates too to be had from quarries in the North of England—in Westmoreland and Lancashire. The Westmoreland slates are, however, more of a fancy nature. This and the limited supply thereof put them out of count so far as the steading is concerned. The best of them are of a nice green colour. The Lancashire slates make a first-class cover for roofs. Both they and those peculiar to Westmoreland are thicker and coarser in grain than the Welsh kinds, but a little less so than the Scottish. It is only therefore within a reasonable distance from the source of supply that we find Lancashire slates on the roofs of homesteads. But all over the country we find the Welsh product in evidence. Their supply seems endless, and the situation of the rock that yields them being close to the sea, all ports have an easy as well as cheap communication with the quarries.

But whatever the slate selected let it be good of its kind. We have a liking for a stronger sort of slate than the Welsh—at least, the sort of

Welsh that is sent North—for use at the steading. And of the remaining two that are available we prefer the Lancashire to the Argyleshire, as being of a little smoother exterior. When farm servants mount the roofs of the buildings for some purpose or other, the slates require to be strong to withstand their tread—and even tradesmen, whether painters or plumbers, in their angel-like visits, can hardly avoid cracking a few slates as they pass up and down the roofs. But on a cover of good stout Lancashire slates one can move about with freedom so far as a dread of fracturing them goes.

The other extreme from the thin Welsh slate we meet with in districts where rocks of a flaggy nature crop out. From the west of Yorkshire up to Carlisle and west over the Border a little to near Dumfries we find semi-flags doing the duty of slates. In Forfar and then away in the extreme north of Scotland—in Caithness—we come across them again. It is in the latter district that we find these sort of pavement roofs in perfection. One can perambulate them without fear of consequences—to the outer covering, that is to say.

In dealing with these large-sized slates it would of course be waste of material to cover the roof with sarking boards. Two-thirds of these would never have a slate nail driven into them. Good stout spars are used to bear up the slates, or flags, rather, and form a catch for the attaching nails.

We have already adverted to the fact that Scottish builders never take kindly to the English practice of slating on laths instead of on boards. The slates native to the country as well as those imported being both small and irregular in shape has much to do with this, we consider—much more we suspect than that other cause, the stormier climate of the North, which is sometimes advanced as accountable for this difference in detail. Where followed out in its entirety of having the inner side of the slate cover between the laths rendered—that is, coated more or less smoothly with haired plaster lime—an efficient cover is obtained. It is one, however, not easy of repair once wear and tear begins to have effect, or should accident overtake it. A stone or a chimney can falling from any distance upon a roof cover of this nature would go through it almost unchecked. A roof slated over on sarking boards is capable of giving a better account of itself. Moreover, how easy of repair such an one is! The English finished roof, with its larger and more symmetrical slates, is pleasing to the critical eye. But for standing the everyday usage and the storm and stress common to the lot of the homestead north of the Border, commend us to the more rugged Scottish one, with its stronger inner shell.

The Slate Nails. The nails used for attaching the slates ought in every case to be galvanized, and of a size suitable to the class of slate selected. Thin composition wire nails do for the smaller Welsh slates, but stout wrought-iron ones are required for the larger and thicker kinds of slates. A single nail is sufficient for the smaller sorts, but two at least are needed for the larger. Sometimes it is stipulated that every third row shall be double nailed. This arrangement allows the slates in the other rows to be shed apart in such a manner that the nail-holes of all can be exposed with a view to repairs. Were all double nailed it is obvious there could be no shedding of them.

The Manner of arranging the Slates on the Roof.

Turning to Fig. 74, we see how the slates are arranged in position on the roof. The first row is double, the uppermost slates being laid over the joints of those abutting underneath. Were this precaution not taken rain would get in at the unprotected joint between the tail of the second row and the eave. The space on each side of a joint covered by a slate laid over the same is termed the "bond." The cover is the lap that each row has over the nail-holes of the alternate one beneath it. Were these nail-holes not covered over by the row of slates second above it, there is nothing, it is easy to see, to hinder water on its way down the slates

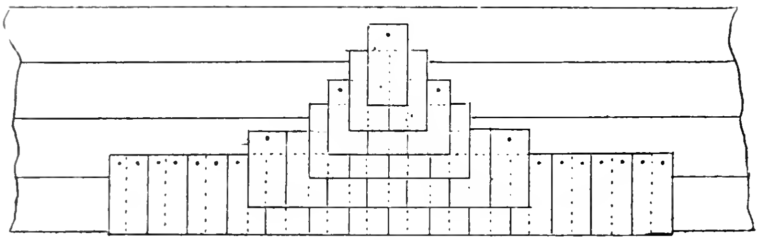


FIG. 74

entering the roof thereby. It is this that calls for so many slates being used in making a roof thoroughly watertight. Wonderfully little cover does when the roof has a quick slope and there is no wind to check the water as it flows thereon. But let a gale play upon that roof, blowing upwards at times and retarding the flow, or let fine snow come drifting in the wind that swirls about the roofs, then will soon appear cause for regret that greater care was not observed on this head. With roofs such as we have demonstrated on our plans of representative steadings, the usual cover arranged for is to start with three inches or two and a half at the eaves and diminish gradually to one of two or one and a half inches at the ridge.

The Lap, or "Cover," of the Slates.

Fig. 75, which gives a section of part of a roof, enables one better to understand this matter of cover, and it may further perhaps make plain what purpose the tilt at the eave serves. The latter serves to give the first two or three rows of slates a grip at the tails as well as at the heads of the slates. Were they nailed on without any such tilt as in Fig. 76, then the tails of the slates would sit free and out of touch with the slates immediately beneath them, with the consequence that, cocked up in the air in this way, they would offer such a leverage to the wind as to be easily stripped off thereby, and rain and snow would at times be driven up past the point of safety. Fig. 75 shows, as we have said, an efficient tilt being afforded by the outer edge of the wallhead, the roofing boards being far enough in from the edge to admit of this. Sometimes a dressed free-stone plinth is added to the wallhead, as in Fig. 77, to constitute a more thorough tilt: but when the outer edge of the wall is finished off with good material, there is no need for this extra expense. Where the wall is narrow, as when built of brick, it is practicable to gain tilt much in the same way by adding to the breadth of the wall-plate, as in Fig. 78.

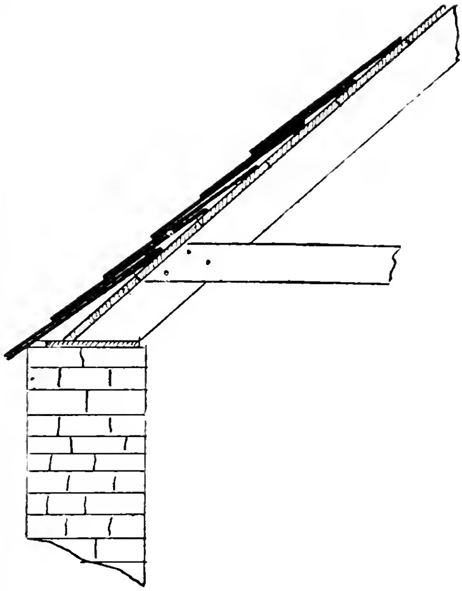


FIG. 75.

In higher class brick-work than prevails at the Scottish homestead this is obtained by working in a plinth in various arrangement of the bricks. In Scotland tradesmen speak of this tilting up of the slates as "bell-cast," from its resemblance to the splay of the mouth of a bell, we presume.

The Tilt or "Bell-Cast" of the Slates.

Fig. 75 shows the slates started with a sufficiency of "bell-cast," and in consequence gripping together at the proper places, and in addition having ample cover,

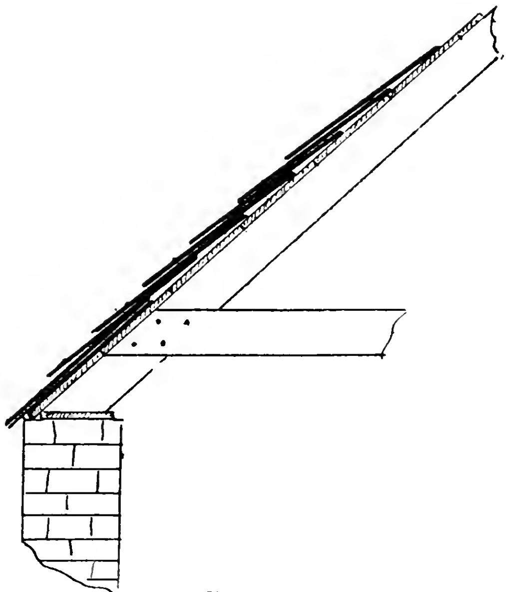


FIG. 76.

the nail-holes of each row being rendered secure by the overlap of the second row next above. Were it enough to overlap the nail-holes of one row with the slates of the next, there would be an immense saving of slating matter. More is required, however. Turning again to Fig. 74, we can see at a glance that it is by reason of the side joints of the slates that two superincumbent rows of slates are needed to make one row water-tight. Moreover, were the slates not brought down as far over each other as Figs. 75 and 76 show them to be, then the water that got in between the joints of the second row of any three would find its way through the nail-holes of the third. If the rows could be continuous, like strips of felting laid parallel to eaves and ridge, there would then be no call for this triple arrangement; each row would require to project no further over that beneath it than would securely cover the nail-holes in the same.

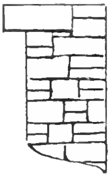


Fig. 77.

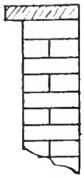


Fig. 78.

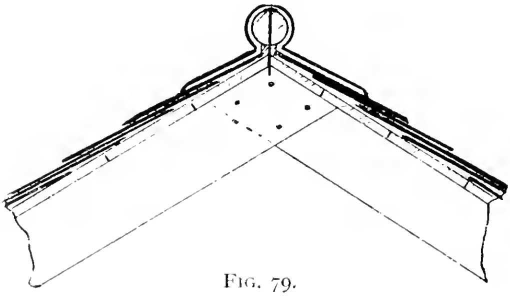


Fig. 79.

Several kinds of slates are not dressed square up to the head. With these care must be taken that if the nail-holes are above the squared part of the slate, the cover must then apply to its relationship with the top of the squared part instead of with the nail-hole. Hardly any slates but those from Wales are delivered ready dressed. The others have to be dressed more or less, and in all cases be assorted into the various sizes, so that the biggest may be started with and the smallest ones find a place at the ridge. Both Welsh and others have to get nail-holes formed in them after delivery.

In some instances the vacancies left by these rounded shoulders are filled up with plaster lime, thus bringing the head of the row to a uniform level. "Shouldering," this is called. It is not a good practice to observe in buildings occupied by live stock, because the moist air of such places keeps the lime damp, and this tends to corrode the nails that are in contact with the lime.

The finishing of the Ridges and "Piends."

The slates being attached, the ridging and the "piends" fall to be finished off. Zinc is now more commonly used than any other material. Fig. 79 gives a cross section of the form this ridging takes when finished. The zinc measures twelve inches across and is manufactured in six-foot lengths. It is shown in position fitted to a ridge pole about two inches in diameter, spiked to the apex of the roof. Galvanized iron hold-fasts or clips of a similar section to the zinc, and which accordingly fit it close, are nailed at two feet apart to the ridge pole and thus hold the zinc firmly in position. The slovenly method of attaching a squared piece of wood instead of the roll has crept into practice. It is evident, however, that the latter gives the zinc a far better hold. It should, therefore, always be insisted that it is supplied.

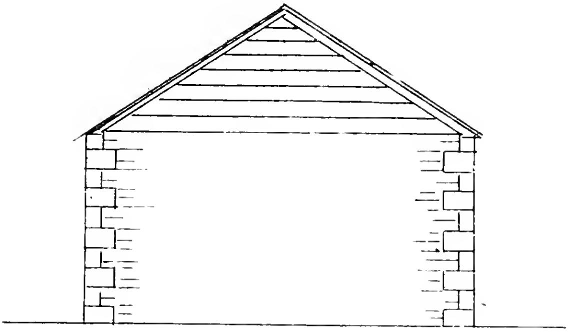


FIG. 80.

At the time the ridging is being put on, the ventilators we shall afterwards describe are also fixed up, the zinc being fitted close up to these and holding them in their places.

The Finish at the Gables.

An important matter which we have not touched on yet is the finish of the slating at the gables of the building. Where the gable is carried no higher than the general level of the wallhead, and the roof, as in Fig. 80, takes upon itself the duty of closing in the opening at that end there is of course no difficulty in the matter, there being no junction of slates with wall of gable. The slating is merely continued at right angles round the corner. "Piends" are the result of this class of roof—the pavilion, or "hipped" roof as it is called—but these are easily dealt with, being but a continuation of the ridge. There is more trouble where the gable is carried up in the ordinary way as in Figs. 81 and 82. There the slating is shown as finished with a "skew." This, in our opinion, is not a very satisfactory method. It is difficult to keep the joint between the slates and the skew stones

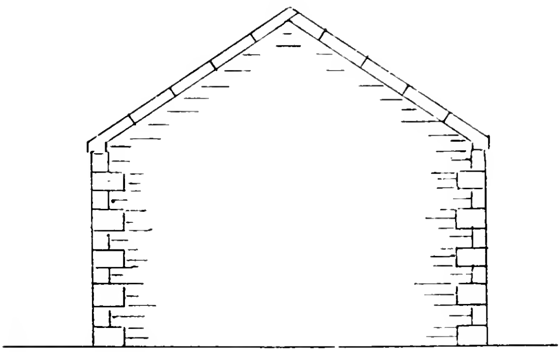


FIG. 81.

watertight. Generally the slates are simply butted against the "skew," and the angle is filled with either lime or cement. The latter cracks or falls away and rain gets in. It will do so by a very slight crack—one that cannot be observed from the ground even when within the range of vision. Sometimes more or less of a raggle is formed in the "skew" and the mortar inserted therein; and lead is occasionally had recourse to by way of a flashing. Either is an improvement, but with so little room to work upon, each is very liable to displacement with consequent leakage. When finishing against a "skew," in either of these ways, it is usual to have a tilting fillet under the slates for the purpose of diverting water from the raggle or joint.

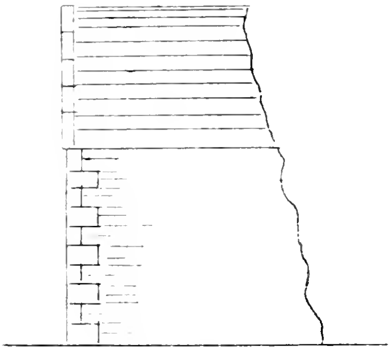


FIG. 82.

But even with this joint thoroughly secure, the skew stones by themselves are very apt to draw water. It works its way down between the joints. If the latter happen to remain tight, it will in the case of many kinds of stone find its way down through them even.

We can seldom be confident, in fact, that the gable is dry unless the slates are carried right over beyond its outer face as in Figs. 83 and 84. No water can then gain admittance at the head of the gable. But having gained this advantage, we are met with the difficulty of how to finish the exposed sides of the slates that project over the face of the wall. If we carry these too far over, we lay them at the mercy of the wind. The first gale that strikes the gable will, very likely, tear off the projecting slates and leave matters in a mess at that critical part. If we keep them too close in to the gable, we leave a weakly place between the two where rain may be driven in. The joint is pointed on completion of the work, but the mortar soon falls therefrom.

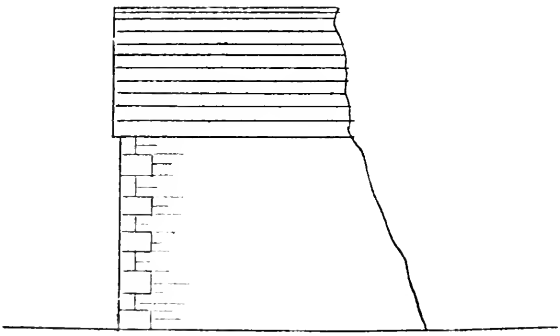


FIG. 83.

There is, however, a way of finishing off here that enables us to make matters secure without either contingency occurring. If instead of finishing off the gable-head level, as usually is the case, we raise two or three inches on the outer edge up to the level of the roofing boards, as in Figs. 84 and 85, we can then dispense altogether with pointing at the outer angle between slates and gable. This can be done with cement as the slating proceeds, which will allow the slates to bed themselves down in the material while it is soft. The boards must, of course, come as near to the edge as will allow of the proper nailing of the slates, which here ought in all cases to be double nailed. A finish of this simple description will make sure of a dry gable and at the same time a secure edge to the slating, two matters which are of considerable importance. This is a part of the roof that is rarely out of trouble, is seldom paid attention to, and when it is, mere patching is all that it gets. Radical treatment gives the impression that a great deal is being done for a small end, therefore it is seldom adopted. A little pointing staves off the business until some other occasion, but pointing has no secure foothold and it soon drops off. With wood behind slates at one side, and stone at the other, all differing in temperature and in degree of expansive property, the lime or cement gives way on account of these disruptive tendencies of its supporters.

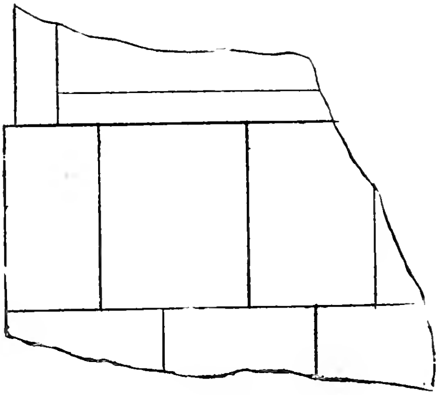


Fig. 84.

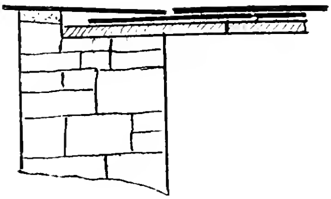


Fig. 85.

CHAPTER V.

Floors and Drains.

The ordinary available Flooring Materials.

The floors of the poorer class of homesteads still depend to a large extent on the nature of the material that is available in the district of which they are representative. The floor paved with small boulders prevails in those parts where flags are not to be had, where fire-clay is not a natural commodity, and where whin or granite is not at the surface. Flags, as a rule, make excellent flooring material for most of the farm buildings. As to be had in Caithness and Forfarshire and in parts of Wales, material of a better sort is hardly to be wished for. With their edges sawn they can be laid closely together to form a suitable floor for nearly all the houses composing the homestead. Almost the same may be said of the fireclay bricks that are manufactured in nearly all the coal-producing districts. They can be turned to account in every place where flags answer the purpose. They can further be used in the stalls of stables, a situation for which flags are not suitable. Granite and whin setts (square dressed blocks) are both material of the very best nature for the latter purpose. At places where they are plentiful they are frequently turned to account as a substitute for more suitable stuff in other parts of the buildings, though there are few where this cannot be done. The rounded boulders, or "kidney" stones, whether gathered from the fields, the river bank, or the sea shore, we find forming the complete pavement of byres, stables, cattle-courts, and loose-boxes. It is one, however, which comes far short of what is now required of a proper floor.

What is required of a first-class Flooring Material.

What is required of such it may be as well to tell here as anywhere else. To begin with, we want one that will stand some tear and wear. We want it to be smooth, yet by no means slippery. We want it smooth enough to afford a comfortable bed for animals that have both to stand and sleep thereupon; smooth enough to allow water to flow along its surface unimpeded; smooth enough to be easily swept, and to allow shovel and scraper to glide over its surface while the working edge of either all the time fits closely to the floor. We want it to come up to this standard, and yet be able to allow either horse or ox to move about upon it with freedom and sure foothold. What is more, we want it to be jointless so that moisture from the surface cannot percolate to the soil beneath, neither can ground damp ascend from below. Nor are we content with that even: we must have the floor material impervious in itself, and one continuous watertight sheet. And over and above being able to hold water in check it must be capable of resisting the burrowing powers of rats.

Which of the different materials we have just mentioned comes up to this standard? Not the last one, certainly. It is all joints together. The animal that sleeps on a floor of this kind is almost in direct communication with the soil. Its droppings drain therein until it can absorb no more. The irregularities of the surface of the floor in time become packed with excrement—they get rounded off with dirt which it is impossible wholly to remove by means of broom, shovel, or scraper. The foothold is good, but alas for the comfort of a bed having this for a basis unless the stones be small and exceptionally uniform! "The clartier the cosier" holds good in this instance, for the dirtier it becomes the more effectively will the spaces between the stones be levelled up. Its lasting powers cannot, however, be gainsaid.

Setts, whether of granite or of whin and its allies, are as lasting. They are smooth and afford a more comfortable bed. But they have almost as many joints. Bricks are even better than the latter in the way of comfort, but they have even more joints, and are not nearly so lasting. The floor can be more easily cleaned, however. Flags are better than either. If the right sort, they last long. They are comparatively smooth on surface and have far fewer joints. Not one of the three, however, can keep rats in check. These sappers and miners of the four-footed world look on floors constructed of these materials as safe retreats and bases of operations rather than as serious obstacles to their free run of the homestead.

Portland Cement Concrete one of the best Materials for Farm Floors.

Where, then, if these widely prevailing materials fail us, are we to find one at all likely to reach the standard we have quoted? We have it in Portland cement concrete, a material that is not very costly, is easily manipulated, and answers in a satisfactory manner the requirements we set forth. No rat can force its way through concrete. It is impervious to water, whether seeking a way down or a passage up. It can be laid in one continuous sheet, covering over, without crack or seam, the whole surface area within the walls; consequently there is no chance of the subsoil ever becoming contaminated by excrement, either solid or liquid, and henceforth diffusing ill-favoured emanations throughout the place. A floor laid with this material can at any time be swilled out with water, and yet be fit for occupation in a minute or two thereafter. It affords a smooth and level if a hard bed for cattle. For horses of the heavier kind it is by itself hardly so suitable. It is, indeed, quite in place and thoroughly effective in all parts of the stable excepting the two or three feet at the ends of the stalls with which the hind feet of the horses come in contact. The calkins on the shoes are too much for the enduring powers of the concrete. What with the wetness there and the frequent poundings, and constant grinding or boring force of the horses' heels that the concrete is subjected to, it soon gives way. The forefeet of the horses are not nearly so severe on it, and under them it will stand for long. But in this critical place the concrete can be supplemented with whin or granite setts. Elsewhere in the stable it is as desirable to have it as in the other buildings of the farm.

In the barn, where no wet or moisture is supposed to be, concrete makes as acceptable a floor as in the places above mentioned. Grain is easily swept up or lifted by shovel therefrom, and no vermin can undermine it. In the cooking shed, the meal store, and the root house it is equally desirable and effective; likewise for pig and poultry houses, and the dairy premises generally. In fact, there is hardly a place about the homestead that is worthy of a floor in which concrete does not serve as a material of the first class.

Tar Macadam very suitable in some Cases.

Unless it be the so-called tar macadam stuffs, we know of no other material that has the slightest approach to equality with concrete as a floor-laying material at the farm homestead. In some respects tar macadam is even superior to concrete. It is softer, or more elastic, and makes a more comfortable bed for animals, and is warmer to the touch. It is not inclined to be slippery like concrete. Wherever concrete can be turned to account in floor-laying so can this material. It too is hard, continuous in surface, and is equally impervious to damp. It also is proof, in no small degree, against rats. It comes behind concrete in so far that it is not strong enough to make a corner of itself. With concrete we can mould the surface as we like, forming raised walks, gutters, beds, and steps, all without the aid of other materials to stiffen the corners or sharp edges. But with tar macadam we need kerb-stones alongside the grips, "settle stones" along the foot of the beds, and stone steps at the doorways as a strong bordering to the stuff. It is a cheaper material than concrete, and as easily laid and repaired. It is not one, however, that the country mason can manipulate. It requires to be taken in hand by men accustomed to work with stuff of the kind.

The Method of laying Tar Macadam.

Tar macadam is tarry matter and broken stones similiar to road metal well mixed together and firmly pressed down over the surface it is meant to cover. The soft substance is the thick residue left in the process of tar distillation. It resembles asphalt, and, like the latter, requires to be melted before it will mix with the stones. It can be laid in two layers or in three—the first one containing larger stones, the second smaller, and the upper mere chips or rough sand. Each layer is well compressed with a heavy roller. The floor soon sets and is then ready for use. It is a floor that is not much known as yet, but judging from its capabilities it is one that promises to be widely turned to account. Our experience of it has hitherto been more in connection with streets and footpaths than farm houses. A material that can stand the wear and tear incidental to these situations, while very suitable in other ways, is well adapted, one would think, to bear any stress it may be put to at the homestead. It is available at only few places, however, without running to expense in the matter of transportation, tools, of materials, and experienced manipulators thereof.

Both concrete and tar macadam are laid abont the same thickness—five inches or so. A basis either of land-strewn or quarried stones, broken tiles, or brickbats packed well together and broken to form a smoothish surface is prepared on which to lay either. This is better than laying it directly on the sub-soil. It affords it a more uniform bearing, and at the same time cuts it off from direct communication with mother earth, thus acting both by way of cushion and non-conductor.

The Method of laying Concrete.

Most country masons are now able to lay concrete floors in a satisfactory manner without the aid of the plasterer. Formerly that tradesman's assistance was thought essential in this job, especially the laying of the last coat. But the floors are not wanted to be finished so smooth as the plasterer is accustomed to complete his work. Concrete floors are laid in two coats, the first three-and-a-half or four inches being of rough material, and the remainder of cement and sand alone. The first layer is beaten down with a broad-faced rammer; the second is spread over it by means of trowel and float.

One part of good Portland cement, four of broken stones, similar in size to road metal, and one of sharp sand, make a good mixture for concrete. The best job is made when the different materials are mixed on a wood platform. There is no danger then of mud or dust getting amongst them, and every chance is afforded of a thorough mixture of the different bodies being attained. It is advisable to turn the heap twice before wetting it. Water is added at the next turning, and this is repeated until the concrete is plastic enough to be spread out as required. It is then in condition to pack closely together.

Broken whinstone constitutes a capital medium for the cement to merge upon and harden against. But granite and hard freestone will also serve the purpose sufficiently well. Anything of a crumbly nature had better be rejected. Gravel, where plentiful, is made to do service instead of chipped stone, and apparently with good effect. We prefer the angular to the round stones, but would never think of going to the expense of obtaining these when gravel was plentiful.

Portland cement, unlike lime, will set without the aid of sand, but it is none the worse for a fair proportion of that in the mixture. There might, if it is good, safely be at least two parts of sand to one of cement. The fragments of stone or other material simply serve, as we have said, for the semi-fluid mixture of cement and sand to cohere to, embracing these in its grasp, which gradually tightens as the cement hardens. They are thus bound into a solid mass by reason of the cement eventually growing as hard, if not harder, than themselves. They have no such intimate relation to the cement that the sand bears to it, therefore they may be left out of reckoning on that head. It is the sand alone that effects the strength of the cement. If clean and sharp, two, as we have said, or even in some cases three, parts of sand may be allowed to one of cement, and the concrete will be all the better. It must be good, however, else the result is sure to be disappointing.

The mixing thereof is a most important point in the preparation of concrete. If there is more cement at one part than another, the concrete cannot be of equal strength. At the parts where there is least of it the chips or fragments of stone will be more loosely held together than where it is plentiful. Some of the pieces will be lying against each other with little or no cement between them, consequently devoid of coherence. It is true that when in the form of a homestead floor there is not much pressure put upon concrete, and what there is usually happens to be uniform. But it serves no end other than the encouragement of carelessness, with its train of evil results, to allow work to be done in a slipshod manner. In a job of this kind it is well to begin with the clear understanding that there is to be no undue hurry over the mixing of the various ingredients. Unless sufficient work be given to it at the start, we can never be certain that we deserve to earn the full benefit from our materials let them be ever so good. With regard to tar macadam, there is not the same likelihood of harm resulting from improper mixing of the components. The tar is melted in a large cauldron affair. As it becomes thin the chips of stone are added to it and all stirred about like thick porridge. There is little chance, therefore, of the prepared stuff varying much in consistency. All the stone gets the opportunity of being thoroughly enveloped in the sticky matter. When it has reached the right degree of consistency it is ladled into iron wheelbarrows and conveyed to the seat of operations.

Other Materials and how to deal with them.

Failing one's being able to avail himself of either of these desirable materials for the formation of floors, there is nothing for it but to fall back upon the best of the others that happen to be obtainable. Whichever it is, let it be laid in the best manner we can accomplish. If carefully assorted according to size, one class to be used at one place and a different one at another, to begin with, and pains to be taken to bed them uniformly, even boulder stones of a suitable kind can be set to form a surprising sort of floor. It is out of count of course in the majority of the houses. In the barn the bare earth trodden flat is preferable, and so would it be in other places the floors of which need to be easily swept and must offer no resistance to the free movement of the shovel. In the pigs' house a floor of this nature would not resist the snouts of the animals for a day. And pity the attendant who has to keep clean the floor of a byre paved thus, but pity more the cow that has to stand and lie upon it! The stable and loose-boxes are about the only houses regarding which it can be said to be suitable. It gives a firm foothold to the horses, and with sufficiency of bedding affords them a comfortable bed enough. There is never so much semi-liquid filth about these places either but what the floors, no matter the kind, can be easily cleaned up. When well laid with stones of a uniform size it makes a capital pavement for a courtyard. And the passages in front of the cattle-boxes might on a pinch be so paved.

But whether cobble-stones, bricks or flags are being dealt with it is essential that a firm, level base be prepared for them; whatever it consists of, it must be well consolidated. Over this is spread an inch or two of sand or fine ashes on which the paving material is at first laid gently down until some yards have been covered, when it is gradually beaten down to its proper level. The loose sand or other stuff used spreads out from beneath the bricks and flags to the free side, and thus enables them to be brought to a firm yet elastic sort of bearing. Without this soft cushion between them and the unyielding sub-soil it would be impossible to lay either bricks or flags evenly. Were the foundation of equal consistency throughout and absolutely level, or at least regular in gradient, conditions, which, under the circumstances are impracticable of attainment, there would be no necessity for the free layer above it. In the absence of the latter, however, neither the bricks nor flags could have a uniform bearing. One part might be hard home on the unyielding sub-soil while another was sitting free. The result of this, taking the floor as a whole, would be an unequal surface. The flags especially, because the larger, would be constantly at the risk of fracture. Let any force come down suddenly on the unsupported part of the stone, then in all probability it would snap there. More than likely, however, such vacancies beneath the flags and bricks would be filled with liquid matter that had leaked through the joints and thus be offending against the sanitation of the house.

The intermediary layer both gives a level bearing and hinders the accumulation of noxious matter in places by themselves. The sand or the ashes may in time become more or less sodden with offensive organic matter, but the latter will be uniformly disseminated consequently, well watered down, and not present in pools here and there, which it might if the sand is wanting. But the interposing sand offers an easy mine to rats. It is next the walls, however, where these engineers elect to break ground, and if these parts be fortified for a foot or two out therefrom with concrete check is given to these bold depredators. The most vulnerable part of all in this respect is along the foot of the stable wall at the horses' heads. It is under the mangers, pretty well out of sight, and corn is nearly always to be picked up there, therefore a common haunt of the rat. When this part is protected in the way mentioned the stable floor is pretty secure against these vermin. The floor of the straw barn being nearly always covered over, needs protection in this way all round the walls.

Occasionally the joints between the bricks are grouted, or filled up with lime or cement. When this is done the bricks are laid a little apart from each other in order to allow room for the grouting material to get a good catch. The object in view is to give the bricks a firm hold and at the same time render the surface watertight. It is wonderful, however, how little moisture penetrates by the joints when the bricks are merely laid in sand or ashes. Once the sand has consolidated the exposed portions seem to skin over and become watertight. This can be seen when a well-laid floor of this kind is being lifted. If the bricks grow slack, there is of course no hindrance to the percolation of liquid matter downwards through the floor. It is disgusting to have to do with a byre wherein the bricks are loose and the filthy water beneath goes squelching out at the joints as one puts down his foot.

It is impracticable to grout a boulder-laid pavement, and it is hardly worth while going to that trouble with one of flags. These are so much larger superficially than bricks, that there are not many joints to deal with: and the flags being so much thinner, they allow but little depth for grout. Rats have less freedom at the start with a flag than a brick floor: they find it easier to circumvent a brick than a flag; but once a passage underneath has been forced they have more of their own way under the broader cover of the latter. A flag bridges over an excavation such as they form, while a brick subsides thereinto. Under a flag floor nests can be formed and galleries be led to turn the fortifications of adjoining houses, but not so with a brick floor. In them at a rat-infested homestead the runs of these destructive creatures can be traced in the disturbance of the surface-level of the pavement.

It is we say at the wall sides of the flag floor as with the others that rats gain access beneath. If the floor is rendered secure there, they may be kept at bay. A row of slates laid against the base of the wall at the four sides effectually cuts off their burrows from communication beyond the boundaries of the house. With this precaution, and the flags fitting tightly against the walls, there is then little chance of the floor being undermined from any base by the pests referred to.

Solid Walls and Concrete Floors keep Rats at bay.

Solidly built walls and floors of the nature of concrete, and we may add of tar macadam, though perhaps less restrictive, are, it will have been inferred, the most thorough and reliable preventives against the attacks of rats. The heart of the wall and under the floor are their favourite positions.

These afford them retreats in touch with where their food is to be found and from where they are free either to range the other buildings or to gain the outside. There, too, they increase and multiply as they can so quickly. But deprived of these strongholds they are powerless for evil and are obliged to migrate to a homestead where matters are more in accordance with their habits. It is not enough that they can gain admittance by door or window, and be able to leave by the same. They are too proficient at skirmishing to break cover in that manner. If they have not the places mentioned to fall back upon, buildings so constructed are not for them.

Wood Floors. Floors of wood are hardly ever represented on the ground floor of the steading. If there happens to be a bothy, or room for the lads on the ground level, it perhaps may be laid with wood, and may be the harness-room may profitably be floored with the same material. With these exceptions a wood floor is seldom made use of in the situation indicated. Overhead nothing else is of course very readily available.

In laying a ground floor of wood it is essential that there be free circulation of air beneath. The flooring boards are laid on sleeper

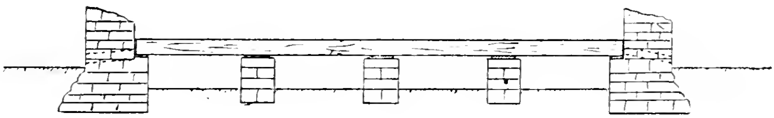


FIG. 86.

joists which in turn bear on sleeper or dwarf walls. The sleeper walls stand a little above the ground, and thus keep the sleeper joists from contact therewith; air-holes protected by galvanized iron gratings which guard the mouths of these openings allow free passage to air, but none to the enterprising rat. Fig. 86 gives a section showing the arrangement we are describing. The side walls show on their inner sides a shelf or scarcement on the same level as the tops of the sleeper walls. These scarcements support the ends of the joists, and the sleeper walls take up the weight where they are placed. Scarcement and sleeper wall are alike provided with a wall-plate in order to give uniform bearing to the joists. The wall-plate is sufficient if an inch in thickness, and from four to nine inches in breadth, according, of course, to the thickness of the sleeper wall. It is bedded on lime to make the bearing as equal as possible. The space between the sleeper walls is ruled by how the breadth of the building will best divide. Four or five feet apart is a safe minimum to observe. A sleeper wall of single brick—four-and-a-half inches wide, that is to say—is ample in many cases, but a nine-inch one is more satisfactory if there is likelihood of much weight at any time being placed upon the floor.

The Sleeper or Floor Joists.

The sleeper joists are arranged at eighteen-inch centres as a standard. These need not be much heavier in scantling than say six inches by two inches. Their bearing points are abundant, and the strain upon them diminished in corresponding ratio. It is advisable to use red pine for sleeper joists. On the ground floor there is more call upon the constitution of the wood than is the case of that in the overhead floor. The overhead joist has freer access to air and more of sunlight than falls to the share of the sleeper joist. For similar reasons we would have the boards of the ground floor to be of red pine.

The Flooring Boards.

Flooring boards, it is almost unnecessary to say, are made on the "tongue and groove" principle, the tongue on one side and the groove on the other. By this means the boards, as in Fig. 87, are so locked together that they can neither twist nor buckle. Usually they shrink considerably and gape at the joints. It is almost impossible to avoid this. Boards seasoned long enough to have done with shrinking are not to be had; therefore the best we can get will contract a little. The narrower the board the less in proportion will the joint spaces be, so if we would avoid very open joints, we must use narrow boards. But narrow boards are the dearer, and circumstances may

Fig. 87.

not be such as to justify their use. They are not in respect of the ground floor at the homestead; neither are they as regards those of the first storey. Six inches is the maximum width of flooring boards as manufactured nowadays, and three the minimum. The latter is the size used in houses of a good class. The former serves well enough for farm buildings. Such comparatively close joints as one is justified in looking for in a house is not a necessity at the homestead.

Ventilation beneath the Wood Floor to be unstinted.

The ventilation underneath the ground floor must be as free and unstinted as is possible. The more the wind blows through between ground and floor, the longer will the wood last. If the air beneath is stagnant, conditions arise that are favourable to fungoid growths establishing themselves on the planks and boards, and these will flourish at the expense of the wood. Damp it will be as well as stagnant, and dampness alone will set up decomposition of the woody fibre. If dry rot gets a foothold, it will soon bring matters to a crisis. It is so named, not because it thrives in a dry atmosphere, but on account of the dry, snuff-like condition of the wood when the fungus has had its will of it. It thrives in out-of-the-way corners, where the air is both stagnant and damp, and its work of destruction is often accomplished ere the inexperienced are aware of its presence.

Door-Steps. Steps are a necessity at the outer doorway of each of the farm buildings. In some of those finished with concrete the steps may, if thought advisable, be of the same material; but in the others stone has to be had recourse to. The harder and closer-grained the stone is the more enduring is it likely to be.

Overhead Floors. Ascending to the next floor, there is nothing for it but to construct it of wood. There is no other choice justified. We could, of course, have it of iron and concrete, but then, the cost to be faced! The joists of the upper floors require to be heavier than the sleeper joists. In addition to their extra size, it is necessary, wherever possible, to contrive a centre support for them. Spanning over sixteen to eighteen feet, and carrying, at times, a heavy load to boot, is giving them too much to do. Many an accident occurs from this cause. It is no uncommon sight to see a big heap of corn piled up along the middle of the granary floor. This means many tons bearing upon the joists at their weakest part—their centre point. The wider the building, all the more danger is there of collapse. The cautious farmer grows frightened occasionally when he sees the joists showing an ominous bend, and slips a support in here and there. Others, less careful, go on until disaster arises. We have known the floor of a new granary collapse in the first season simply through overloading. The builder, to whom was left the planning as well as the erection of the house, took no thought of what was required of the floor; the farmer never for a minute questioned that the granary was not capable of holding a full supply of grain, the consequence being that one morning the joists gave way, and floor, corn, and all were precipitated into the barn beneath. Luckily, no one was under. But cases have occurred where lives were lost through carelessness, or want of experience on this head.

Undoubtedly a centre support should be under the joists of all granaries. The granary is there for storage purposes, and the floor is expected to be capable of holding a goodly store at a time; if it cannot, the place is inefficient. A little management can provide for pillars being erected to sustain a beam or girder for support to the joists, and partition walls often come in handy for the purpose.

The joists of the granary cannot safely be of a less scantling than nine inches by three inches. The ends should be let well into the wall, and there rest on a wall-plate. In a badly built wall—one that does not turn rain very well, and consequently is damp in the interior—the ends of the joists are apt to become decayed before very long. If the building itself is damp inside, and air has little circulation within, which condition is usually mother to the other, the same may happen, although the walls are sound on the outside. Precautions must be taken to guard against either contingency. When the ends of the joists become affected in this way they grow slack in their holes, and the floor gets misplaced and put off the level. We have already spoken against inserting wood into building, or, what is much the same thing, the building up of the crevices on the wallheads between the feet of the rafters. The two cases are, however, hardly on the same footing. The couple feet are in the majority of instances in an atmosphere which consists of spent air that has recently done service in the lungs of animals, and is, in consequence, both warm and moist. Under such conditions wood and mason work are better apart. This is a state of matters scarcely to be avoided. But there is no necessity for circumstances that are adverse to the two existing harmlessly together arising where the joists are inserted in the wall. The conditions we have mentioned are either of them apt to be the cause or the result of carelessness combined with roguery in the one instance, and carelessness alone in the other. Neither needs to be taken as a non-preventible condition. Granted a firm, dry wall and a well-aired room inside, there should be nothing whatever to prevent the ends of the joists remaining sound for an indefinite time.

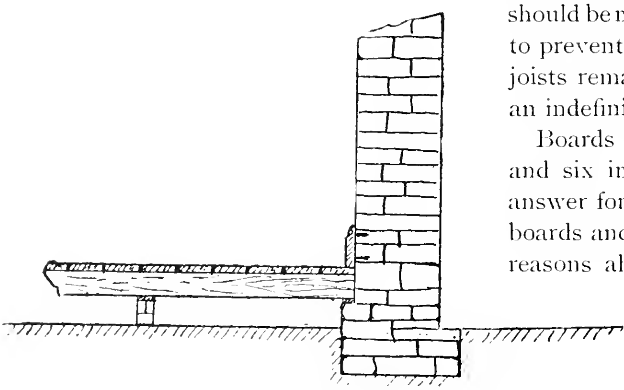


Fig. 88.

Boards $1\frac{1}{8}$ inch thick and six inches broad will answer for the floor. Both boards and joists may, for reasons already stated, be of white pine. A wood floor is hardly complete without a skirting board along the base of the wall as in Fig. 88. It securely covers the joint between wall and floor, and it gives the job a more finished appearance. Very often, instead of a skirting of wood, one of cement, as being proof against mice as well as rats, is fixed up. On the ground floor it is an equally necessary finish. Some of the concrete floors, too, such as the dairy scullery one, are all the better to have it.

A combined Floor and Ceiling.

Should there be a storey over the dairy offices, providing for cheese-room and other accommodation, a good sort of floor for it is one of two layers of boarding with felt between. A floor of this description serves as a ceiling to the rooms beneath. Fig. 89 shows how it is arranged. There is a good deal of moisture in the dairy places arising from the hot water used in the scullery and vat room, or churning room. This, together with the storage of cheeses overhead, and the consequent changes in strain which that implies, is rather trying on a lath-and-plaster ceiling.

It is annoying when the plaster in these situations begins to drop off here and there. After that, one is never sure but damage may be done at some time or other through plaster falling into milk or cream. An overhead floor, such as we are drawing attention to, puts an end to all that sort of thing. Of planed wood beneath, varnished if considered necessary, there is nothing to fall from it that can do any harm. It can lodge no dust, so even that cannot float down from it. The two thicknesses of wood with an intervening layer of felt make it a good non-conductor. It is also much stronger than an ordinary floor, which is a good point considering what it has to carry at times. It does not take many sixty or seventy-pound cheeses to make a ton, and they pack closely together on the tiers of shelves. The fig. shows the top layer running at right angles to the under one. The under one may be laid diagonally on the joists if a little better appearance is wished for, but this means some waste of wood, small, no doubt, but all the same hardly justifiable in the majority of cases. Care must be taken that the felt made use of

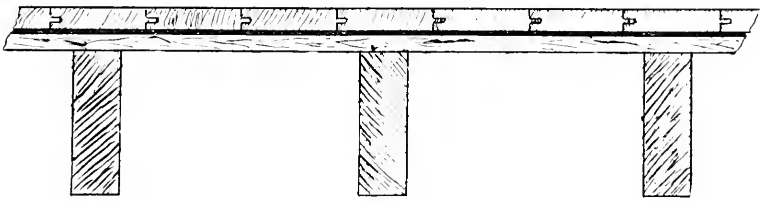


Fig. 89.

is inodorous—has no tar or stuff of that nature likely to raise an offensive smell at any time.

Another good point that this combined floor and ceiling possesses is that no harbourage such as there is in the space between floor and ceiling of the usual type is afforded to mice. These do serious damage when they command an entrance to the cheese-room, not on account of what they consume, but what they disfigure and lessen in value. Cut off from this retreat, these little creatures have the side walls alone to shelter in, places that are much easier made impregnable to them than it is.

The Drains. From floors to drains is quite a natural transition. The two are closely related so far as regards the majority of the houses, most notably in the byre. Drains have, according to all accounts, a good deal to answer for. There is no cause, however, if well constructed at the start, why they should give trouble. But better by far that there be no drain than a scamped one be palmed off upon us. There is nothing very deleterious about the drainings of a byre that are turned out on the surface to seek a lower level on their own account so long as they have air about them. What effluvium does escape therefrom dissipates harmlessly into the surrounding atmosphere.

It is different, however, when the drainings are concentrated in a faulty underground channel—one that is neither able to pass the stuff along readily, nor to hinder them from escaping at the joints before doing duty as carrier of the thick or solid part. Here the stagnant or slowly-moving excreta blocked up in the passage gradually decomposes, and in the absence of a full supply of air the more lowly organised ferments get the upper hand. These produce more fœtid odours than result from the process of decomposition as it takes place in full face of the atmosphere with its liberal supply of oxygen. There being few outlets whence these odours can escape, where they do, they make their presence felt. Besides these comparatively harmless gases, that issue from an attenuated cesspool such as we are speaking of, there is a far greater danger attending an offensive drain of this kind, in the probability of its acting as a breeding-ground for disease-causing microbes. In this direction lies the risk of defective drains at the homestead.

There is no need, however, because the drain is to be out of sight, that it should be laid anyhow. And this is, fortunately, being better acted up to nowadays. Were it to serve any purpose, we could here launch out *in extenso* on such a fertile subject as defective drain-laying and what annoyance and much more serious results we have known to arise from the same. It is one over which a person can easily wax virtuous and self-righteous. But wherein lies the good? To bring both proprietor and builder to realise that drains are an essential department of a building, which requires as much attention as either walls, roof, or floors, and one that must be paid for accordingly, will be more beneficial than harping over the question how this branch of building has been neglected in recent years.

Both architects and tradesmen, fearing that they might frighten the prospective builder, were inclined to keep back from him the necessity of providing a sufficient margin to defray the cost of the drains in a manner they were well enough aware these underground passages ought to be constructed. The consequence was that, failing the necessary money being forthcoming, the drains were obliged to be scamped. The impression that the completion of a building embraced the three branches above referred to prevailed so widely that, until lately, drains were thus kept quite in the background. The few professional men bold enough to face this state of matters were apt to be steered clear off. But the money that ought to have been spent at the beginning had eventually to be produced, nearly always with a considerable addition thereto.

The workmen who laid the drains that would not nowadays be passed did not do so with intent to bring harm upon their fellow-mortals. They were not accustomed to do otherwise. The men who lent themselves to laying a drain devoid of any outlet, or of another whose level rose and fell in accordance with the ease the track could be excavated, were, of course, on a level with criminals. But those who joined the pipes in a well enough cut track, may be without a thought of their being watertight, simply did as they were wanted. If they were the means of causing future trouble on that account, it was through no wilful neglect on their part.

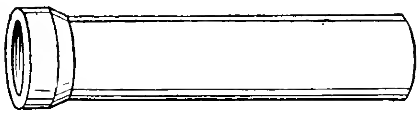
But matters are fortunately on a different footing now, and drains are being constructed on fixed principles. A drain worthy of the name is a watertight underground channel of regular gradient or gradients. The making of such means the possession of suitable materials, and the expenditure of both time and trouble. These conditions imply money, so that nowadays drains rank as an important item in building. We are not content now with a neatly pointed joint round the top and sides of the junctions of the pipes, while the undersides, which are out of sight and not easily got at, are left unfinished. To make sure that all is right we allow no pipes to be covered over until the whole length of the drain, or sections thereof, have been thoroughly tested and otherwise inspected. We are not speaking, be it remembered, of field drains.

Two Sets of Drains required at the Homestead.

Two complete and distinct sets of drains are required at the homestead. There must be one to carry away the rain-water from the roofs and courtyards, and another to lead away the liquid matter and swillings from the various buildings occupied by live stock.

The Drain-Pipes and Method of laying them.

It is common to provide an ordinary field-drain tile or pipe for the rain-water, but in our opinion both drains should be laid with socket or spigot and faucet glazed fireclay pipes. Fig. 90 shows what we mean. The wide-mouthed part *a* is the socket, or faucet, and the opposite end of the pipe *b* is the spigot. The spigot of one pipe is inserted into the faucet of another. There is sufficient room between the two to admit of a packing of cement being inserted. But previous to the insertion of the cement packing, a round or two of ropeyarn is forced home with a caulking iron. The ropeyarn is intended to prevent the soft cement mortar gaining admittance to the pipe. And further, it serves to keep the centre of one pipe in line with the centre of the other, and so leave an equal space all round between spigot and faucet. The cement mortar, composed of, say, one-half of cement and one of sand, is then pressed in all round below as well as above, and the joint neatly pointed and left to harden against the time of testing, and so on with each pipe until all are laid. The faucet ends of the pipes are kept up the hill, which necessitates their being laid from the low end upwards. This arrangement is obviously of less importance in the case of a thoroughly jointed pipe than with one laid in the happy-go-lucky manner referred



a Fig. 90. *b*

to above. In the first, liquid matter has no choice of outlet: it must emerge at the one provided for it. In the other, when pressed, it finds relief at the several joints. But pressed or not, it is easy to see that when flowing towards the faucet end of the pipe instead of away from it, the tendency is for the liquid to spread out there and to escape more readily than it could when being delivered into the mouth of the faucet from the spigot of another pipe. The impetus given to the liquid in its narrower channel helps to tide it over the critical junction. But when the liquid is coming the other way its flow is hindered by the ends of the spigot and other obstructions due to defective jointing, and it is led aside, to escape by the widening-out part of the pipe represented by the faucet.

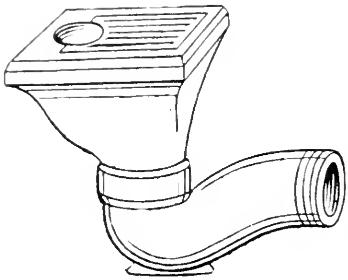


Fig. 91.

The Rain-Water Drains. The rain-water drain should be led away clear of the homestead entirely. There is not half the puddle and mess about a steading that is completed in this way in comparison with another whereat the rainfall is left to its own resources to find a way downwards. The best arrangement is to lead the rain-water conductors directly into Hart traps, or some other contrivance of the same description, taking care to have these in positions likely to be out of the way of carts. The drain need not of necessity be close against the wall. Connections have to be made, at any rate, between traps of the kind referred to and the drain, and these require room for themselves. Figs. 91 and 92 represent one of these Hart traps. The end of the conductor, it will be noticed, is continued beneath the level of the grating. This prevents any water being spilt on the surface, whether by wind or on account of obstruction at the grating. The trap cuts off connection with the drain proper, and what is of more importance in this assistance, it arrests sand and other matters that might interfere with the efficiency of the main channel. It can be cleaned out at any time. When the grating is removed the trap is easily accessible to the hand. An arrangement of this sort is ship-shape, is easily kept in order, and is not costly. This trap is also made in one piece, but when in two it is more adaptable to wayward conductors. Figs. 93 and 94 represent traps of a similar description.

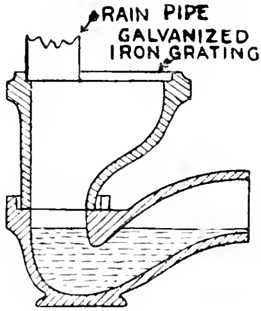


Fig. 92.

A sufficiency of inlets is required to absorb the water from the courtyards. These need to be big in order to swallow with ease the results of heavy downpours, and to be strong enough to bear up carts and heavy implements. The gully traps and gratings that are used in streets are the best for the purpose. Fig. 95 shows what we mean. The trap is of fireclay, is thirty inches deep, eighteen inches in diameter, with the sides a proportionate thickness. It gives room for a large quantity of sand, stones, &c., before its outlet can be interfered with. The heavy iron grating (Fig. 96) which covers it is capable of resisting very rough usage. With enough of these distributed about the steading there is little fear of flooding taking place even at the times of violent thunderstorms. It is too true that as a rule it requires occasions of the latter kind to tell us when the traps want cleaning out. But it is impossible, as already we have so often hinted, to make things about the homestead quite automatic. The occupier must be left to do a little himself in this way. Many would prefer to have no gullies, but to let the drain swallow all and take its chance. It seems as though they would rather have one final cleaning up when the drain had become packed full than be bothered with the periodical attention to traps. It is wonderful, however, how long-suffering in this way drains are. And when the worst has come to the worst, the landlord or his agent may in the end have to father the business.

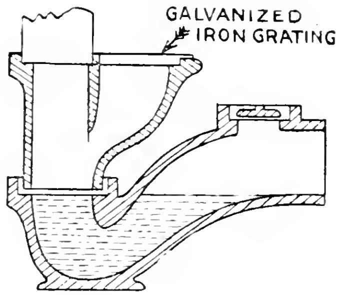


FIG. 93.

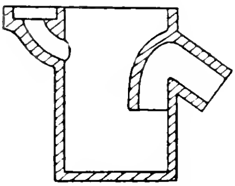


FIG. 94.

A six-inch drain may be large enough to cope with the requirements of the homestead in this respect. But all depends on circumstances. A nine-inch pipe, and even a twelve-inch one may on occasion have to be laid. Nothing under six inches should ever be had recourse to. Four-inch connections between the various traps and gullies and the parent drain are ample when there is no very severe call upon the drain. Where, however, the demand on the gully is apt to be greater, a six-inch connection is requisite. A four-inch connection serves at any time for the Hart trap.

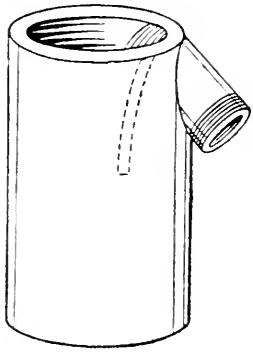


FIG. 95.

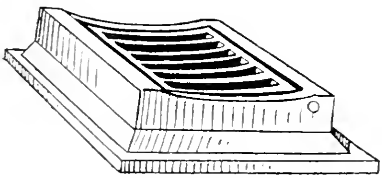


FIG. 96.

It may happen that circumstances necessitate the storage at the homestead of all the available rain-water. Only that obtainable directly from the roofs is permissible of use. No one would think of storing what had first fallen upon the ground. Of this method of obtaining water we shall have more to say under the head of water supply. But where it becomes a necessity in laying our drains, we have to separate the roof water from the surface-water, that which has collected on the surface of the ground. The various Hart traps at that rate, instead of being connected to the main drains, lead into branches that converge towards and feed into a large underground watertight tank. They have no connection with the drainage system proper other than the overflow of the tank they supply is led into some part of it.

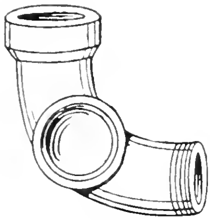


Fig. 97.

The different branches of the drain ought so far as possible to be cut in straight lines. Whenever the line diverges an inspection eye should be fixed at the angle. This simple contrivance, arranged as in Figs. 97 and 98 by carrying a branch of the drain upwards at right angles to its course, enables us to tell with little trouble what is going on in the main. It need not be carried up the whole length to the surface. It may be stopped three or four inches beneath. The mouth can then be securely covered with a flag, with gravel or earth above to bring it to uniformity with the surrounding surface. Or the place can be marked by a "toby," as a cast-iron cover such as we see set over an underground tap or valve is called. With inspection places such as these at our command, it is an easy matter to locate an obstruction should such at any time occur at any part of the drain. It is well worth while, indeed, to have two or three such as Fig. 99 displays inserted here and there on the straight sections of the drain.

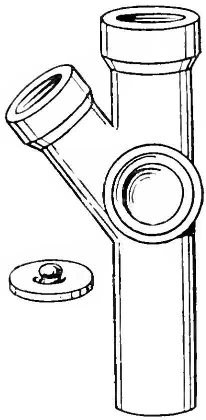


Fig. 98.

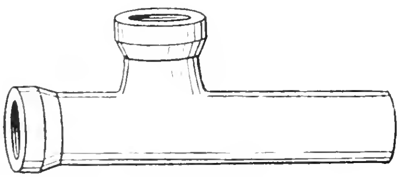


Fig. 99.

These precautions to provide for inspection are even more necessary in respect of the drain that has to carry off from the buildings the liquid excreta of the different animals. It is advisable, indeed, when dealing with them to have manholes instead of simple expection eyes built in at the angles of divergence in the course of the drain. These can easily be so constructed that while offering no resistance to the discharge of matter through the drain, they afford us a ready means not only of inspecting the drain, but also of clearing out obstructions in any section between two manholes. The several sections being straight, it is an easy matter at any time by placing a light at one end and holding a mirror at the other to obtain a view of the interior from end to end of that part of the drain.

These manholes require to be constructed either of brick and cement mortar or of concrete. Three feet long by two feet or even eighteen inches in width affords a very convenient size for a man to get down into and to move about in. The foundation or base of the manhole is of concrete, and a channel worked in this continues the drain and leads it off in the direction it requires to go in the next section. There need not necessarily be many of these about the homestead. But all depends of course upon the natural features of the site of the steading, and the arrangement of the buildings composing the same. Seeing that access to the manhole is not often wanted, it, like the inspection eyes referred to above, may be finished off before reaching the surface. A good thick flag is needed for service as manhole cover, which may be blinded as before with gravel or soil. Some mark, however, ought to indicate its position. These matters are quickly forgotten at the farm as elsewhere. Not exactly forgotten, perhaps, but changes are constantly taking place, and the few who knew the whereabouts of these arrangements pass away without handing on the information. A distinctive mark on the nearest wall is the best method of recording information of the kind. We see this done in towns with regard to indicating the location of hydrants and valves of various sorts.

Where a branch joins the main at some other part than the manhole, it is a good plan to have an inspection eye on the former quite near to the junction, as in Fig. 98. This reveals to us the condition of the drain close up to its junction with the main, and the main we already have the means of inspecting thoroughly.

The Sewage Drains.

There must be no drains led into any of the buildings. Surface gutters must do the work of affording an easy way out for the different kinds of liquid matter. These we shall refer to more fully when we enter into detail with the different buildings they bear relation to. Outside the building gullies must be provided to receive what issues therefrom. For the byre we know of nothing better than those we have already described. Some persons may consider them too large for the purpose. It is not uncommon to see a much larger pit of unknown shape—covered with an old door, perhaps—doing duty. Oftener we see a small, roughly put together brick gully, capable of holding but a small quantity of what it is there to retain, were it able to do so, either minus a grating or with one utterly unsuitable. In one of the kind we have been recommending we have a strong receptacle that can hold a considerable quantity of matter, guarded by a strong grating easily removable when the gully has to be cleaned out. At those places where the gully has little chance of being cleared until it has become so charged with solids that it refuses to take in more semi-liquid it is advisable, if the drain will admit of it, to dispense altogether with the gully and leave the whole stuff to find its way as best it can to the outlet. In short direct lengths it may safely be left out. But where the drain has far to go, or has to pass through a manhole, the gully is indispensable.

So little fluid emerges from the stable that there is scarcely enough at times to keep the gully trap efficient. On that account care should be taken that some surface-water finds its way into the gully connected with the stable. Not very much, however, else we shall bring about over dilution of the liquid manure. Hardly any escapes from the horse loose-box. It seems all to become absorbed by the litter. There is not much use therefore in carrying a branch to these places.

The pig-house—that is to say, the dairy-farm pig-house—is a fertile source of supply to the liquid-manure tank. The gully trap might almost with safety be dispensed with here, although to make matters sure it is better to be present. Whey and butter-milk are so liberally dealt out to the pigs that a constant dribbling goes on. The non-absorbent floor forces the speedy exit of the liquid drainwards.

The size of pipes to be selected for this department of the homestead drains, as with the other one, depends of course on the configuration of the ground on which the buildings are erected and the distance to be covered. A six-inch pipe all through will be ample in the majority of cases. In others it may be needful to enlarge the main, as it draws to a finish, to say a nine-inch pipe. The proper terminus of the drain is a good-sized watertight liquid-manure tank—the "aidle" tank of the Scottish West Country farmer.

The Terminus of a Sewage Drain to be either in the Dungstead or in a Liquid-Manure Tank.

It is practicable occasionally to lead the liquid-manure drain directly into the manure pit. But even where this can successfully be accomplished it is, we consider, doubtful policy to act on that principle. If the farm be devoted to dairying, the contents of the dungstead will be sappy enough without the addition thereto of more liquid matter. It may answer on a farm where cattle-keeping is the leading industry, and straw is plentiful. Much of the latter, almost unpolluted, finds its way to the midden at a farm of that sort. In these instances the addition of liquid manure to the contents of the dungstead, when it can be accomplished in a satisfactory manner, may be an advantage. It is difficult, however, to accomplish this satisfactorily. The drain, to begin with, must have its outlet above the high-water mark, so to speak, of the midden, in order that it may be always free. It is not sufficient afterwards to leave matters altogether to the course of events. If arrangements be not made for distributing the liquid in a sort of uniform manner over the dungheap, it will simply form a pool near to the exit of the drain. If the whole heap is therefore to receive somewhat equal benefit from the effluent, something must be contrived whereby it can be run to different parts as wished. There is not much trouble implied in the performance of this, one would think. A movable wood or iron runnel serves well enough to distribute the stuff over the length and breadth of the midden; but then, where labour has to be economised, it is these odd jobs that are constantly being left over till a more convenient season.

The Liquid-Manure Tank. The better plan is the one we started with—to construct a tank. The best position for this is somewhere in the neighbourhood of the dungstead. Situated there, it is convenient for the stuff being occasionally pumped up and distributed over the dry midden. The latter has a better chance of profiting from the liquid when applied to it in this way than in the manner just referred to. Adjoining the midden it answers, too, as a catch-basin for the overflow therefrom, should there be any such. Such there is likely to be at times from the dairy-farm dungstead, especially if it has no roof, which it rarely has.

The proper place for the tank is, we consider, alongside the outer wall of the dungstead, as ticked in on the respective Plans. We have it long and narrow, as in Fig. 100, which gives a section thereof. The narrower it is the more easily and securely can it be covered over. Its depth and length must be governed by the circumstances that apply to it—the depth more in accordance with the nature of the material to be excavated than with the amount of stuff available; the length, on the other hand, entirely by the latter condition. To get full benefit from the tank it would require, as hinted above, to be so constructed as to act the part of overflow receiver to the dungpit; therefore its surface would have to be fixed in accordance with the overflow point of the pit. Built at the same time as the dungstead walls, it would be part and parcel with the same, and one wall would be mutual to the two.

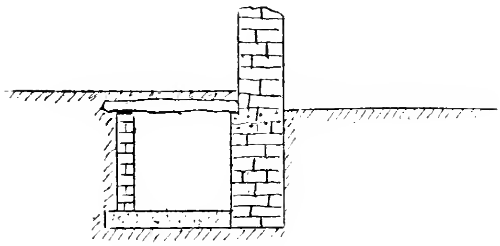


FIG. 100.

The bottom would be of concrete, and the outer and end walls of brick and cement, floated afterwards on the inside with cement. The mutual wall would be of the same material as the remainder of the dungstead boundaries. The cover would be of strong flags as depicted on the section. The flags, in turn, would have a covering of soil or gravel. There would be little use for an overflow exit, but some means of telling how much stuff was in the tank at any time would be required.

In connection with the tank there would be fixed up a chain pump by means of which the contents thereof could be pumped on to the midden or into a barrel or tank on wheels for removal direct to the fields.

CHAPTER VI.

Doors, Windows, and Ventilators.

The Door Styles and Lintel.

The doorway is nearly always bordered with wood. That up the sides forms the styles, and the top piece the lintel. In brick partitions the styles and lintels of doorways are fastened together and placed in position previous to the erection of the brickwork. The bricks are then fitted closely to the framework as the building proceeds. The door lintel is not strong enough in itself to support the superincumbent bricks. To make matters secure here the bricks must either be arched over the doorway or a sufficiently strong lintel must be built in to bridge over the opening. In this way the weight of the building above the doorway is prevented from bearing upon the door lintel, and the latter is left free to perform its own duties. These are simply to help in keeping the styles in their places, and together with them to afford a close-fitting frame above and at the sides for the door. At the bottom the door is bordered by the steps and the floor.

In outer doorways, as, indeed, with those generally that lead through stone walls, the styles and lintels are inserted after completion of the buildings. In forming these openings wood lintels serve for those in the inner walls. They serve also for the inner portions of the tops of doorways in the outer walls. But we have already dealt with these points under the head of "Walls."

The outer face of the top of the ordinary doorway in side wall or gable is almost always of stone, so that the attacks of weather may be withstood. Stone is too brittle to act as lintel over a wide doorway. Five feet is about as wide an opening as it is safe to bridge over in this way with stone. As we remarked when treating of walls, once the building has set together—once the lime has hardened and bound the several stones as one in its embrace—the burden of supporting the building above it has been withdrawn from the lintel, and it can be dispensed with. Were it not then wanted as a neat and strong border or finish to the ragged edge of the rubble work, it could safely, so far as danger of the wall collapsing is concerned, be taken out. But, then, this binding of the walls is only slowly brought about, and meantime the stones have to be held together.

The Arch stronger than the Lintel for the Doorway.

It is of narrow openings we are speaking. When it comes to those from nine to twelve feet or so wide, matters are different, and we are straying beyond the bounds of safety. To spring an arch over an opening of this nature is, as regards strength, the correct method to adopt, but this is not in every case practicable. Generally there is not height to spare, for the arch takes up a good deal of headroom. It can best be got in either at the end or the side of a building that is open to the roof. But it is not suitable to every one of these, even. In fact, the cart-shed is about the only building to which the arched doorway or opening can be applied. It would be as applicable to the root-store or manure-shed. These, however, unlike the cart-shed, require to be supplemented with doors, and doors are both awkward to fit to arched openings and not easily kept in repair when there. At first thought one would be inclined to recommend arched doorways as the proper thing for the barns, but that is the worst kind of opening that can be selected for a passage to admit carts laden with either sheaves or straw. If the cart is not kept directly in the centre of the opening, the stuff is unceremoniously brushed off. Extra height prevents this, but it leads to other annoyances related to the matter of unmanageable doors and suchlike.

The upper floors, where existent, entirely rule the height we can go in the forming of arched doorways into the ground flat of two-storeyed buildings. And so, of course, does the height of side wall in the single-storeyed ones. In the gables of the latter we can get what room we want. Assuming that the side wall is nine feet in height, there is very little margin here for the construction therein of a suitable arched opening. We could not have much more than six feet of headroom where the arch sprang from at each side. That would never answer, except, as we have said, in the case of a shed that is meant for the protection of the farm carts from weather.

Our use of the arch in the erection of the homestead being limited to the cart-shed, and even then not being entirely suitable, we are obliged to fall back on the lintel. This method of bridging the openings, if neither so strong nor so elegant, gives us at any rate the full advantage of the doorway. The same height from side to side, it allows the square-topped load of sheaves, straw, or hay to pass out and in unscathed. Stone, we have satisfied ourselves, while being strong enough to bridge the usual single-door openings, so to speak, is too brittle to do the same by the wider ones.

The Wood Beam as Lintel.

Wood is the usual material had recourse to for the kind of lintel we are discussing. But it is a trying position for wood to act as an outer lintel exposed to sun and rain and other severe conditions due to weather. If the best of stuff be obtained to begin with, it may last an indefinite time, as we see exemplified in the old lath-and-timber houses of the Early English style of architecture still to be met with here and there in different parts of England. But such material is hardly to be got nowadays; at least, it is never looked for. A red or a pitch-pine beam is as far as the builder is asked to go in search of. Either of these, if well seasoned to start with and duly kept painted thereafter, will be there during many changes of occupancy: but these are conditions uncertain of fulfilment.

The Iron Girder as Lintel.

In these days, when either iron or steel beams are easily obtainable, we would advise their use in the position referred to in preference to beams of wood. There is no fear of dry rot, neither of fungus, nor of weevil, where they come, and sun and rain have but small effect upon them, if kept painted. They need not, however, be exposed to the latter influences. It is not at all impracticable to keep them in from the face of the wall in such a way that they can be faced with stone, and so be kept completely immune from weather influences. We show in Fig. 101 how this can be done without much trouble. The outer girder is so shaped that it holds the stone facing in position by affording it a ledge to rest upon, and sufficient depth at back to enable it to be packed in mortar. The inner girders may be of any shape considered best. Wood may, of course, be used for inner lintels, but our preference is for iron wherever practicable in this connection.

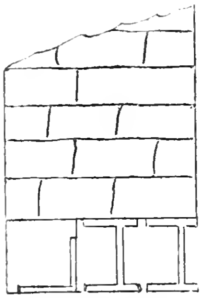


FIG. 101.

Fitting up the Doors: The Hinged large Door.

As a rule, the large doors are too heavy to be hung by means of hinges in the ordinary way. The common plan is to fix them up in two halves with iron straps stretching well over the door and having at the heels or bases eyes that fit over supports which are either firmly batted with lead into the rybats of the doorway or are fastened to the styles as in Fig. 102. This method obliges us to keep the door almost flush with the face of the wall if we want it hung so that it will open out and fold back against the side of the building. No other method of opening the high doors is, in fact, satisfactory at the steading. It would never do to have the doors of any of the places made to open inwards. Neither would it answer to have them standing out at right angles to the walls when opened up to the full. If not constructed so as to be capable of folding back flush with the outer walls when required they are constantly in the way, and sure to come to grief when carting is taking place in connection with the house.

The Door on Wheels.

The best plan of all with regard to hanging the doors at the homestead is that in accordance with which they slide backwards and forwards suspended from wheels that run on a rod or flange attached to the wall. Doors fitted up in this way are easier both on themselves and on the walls than others are when hung from the sides. Unlike the latter, they are never the sport of wind that one minute blows them open and the next slams them back. What with banging against the walls on one side and on the checks against which they shut on the other, they have more at times to withstand than they are fitted to resist. The door that is hung from the top escapes all these

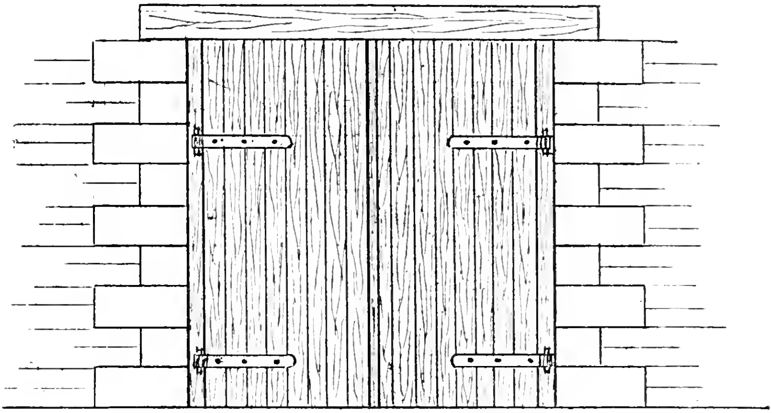


Fig. 102.

ordeals. It is proof against the wind, because it never can be banged about. It can be pushed aside wholly or in part, just as we wish the size of the opening for the time to be, and it will remain so in spite of wind as long as we choose. It is the more expensive method of the two to start with, but it is much the cheaper in the long run, as well as by far the most convenient at all times.

Hanging the Smaller Doors.

Reverting to the smaller doors, those up to four feet or so wide, that are hung in the ordinary way to the accompaniment of styles and lintel, these latter are not complete without the stops or checks indicated on Figs. 103 and 104. These stops *a*, as their name indicates, are there to afford something for the door to shut against. Were they wanting, the door, if one that opened inwards, would project beyond the building because nothing was there to keep it back.

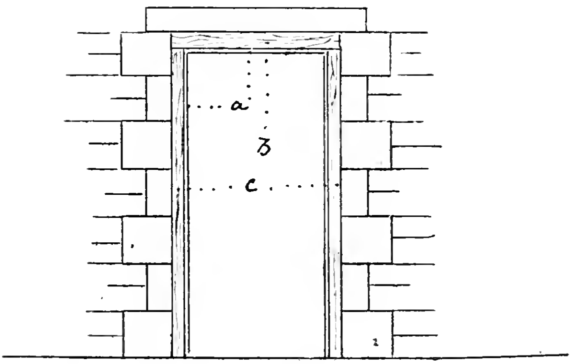


Fig. 103.

The hinges would, to a certain extent, but their attachments would be too weak to hold the door in check. The leverage of the door would put too strong a pressure upon them. The ordinary size of lintel and styles, *b* and *c* in the figures, for a single door is five inches broad by six inches

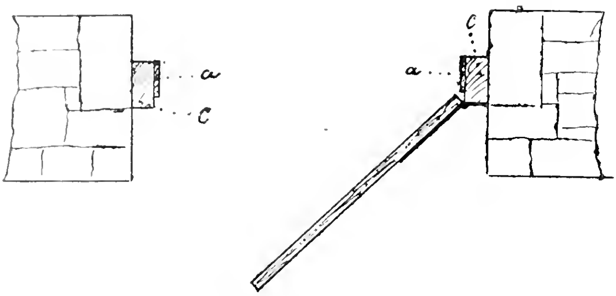


FIG. 104.

thick. The styles are nailed to plugs of wood, driven into the sides of the doorway. The Scottish tradesman speaks of these plugs as "dooks." In place of driving in these plugs, which is at no time a commendable practice, blocks of wood are occasionally built in the wall for the purpose. In brickwork pieces of wood of the same dimensions as a brick, termed "belgates," are built in as the work proceeds. These are all right for inside work, but for an outer doorway they are not suitable. It is common to see these bricks of wood at the sides of an outer door rotting away, and the styles quite loose. It is not so convenient, however, to build wood blocks into the sides of the doorway when this is built of stone, and in the generality of cases the plug has to be called into requisition.

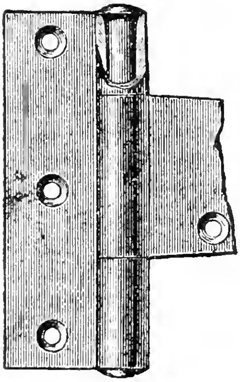


FIG. 105.

Half an inch is a sufficient thickness for the stops. Their width is governed by the thickness of the door. If the door is flush with the edge of the style, the full breadth of the style minus the thickness of the door will be taken up by the stop. The stop, it is evident, is fixed upon the sides of the opening, contrary to the direction in which the door opens.

A usual kind of hinge is the one represented in fig. 105. It is known as the batt-and-band, or T hinge. The band, which is not shown to its full extent in the fig., stretches well across the door as we see in Figs. 102 and 104, helping thereby to distribute the strains pretty uniformly. Occasionally, however, stronger made articles, but of the same type as in Fig. 106, known as the hook-and-band hinge, are set to do service.

The hook is attached in various ways, as the Figs. from 107 to 109 show. These indicate attachment to wood, but when styles and lintel are dispensed with, the hooks are attached directly to the rybats if these are present, or to the scuntion stones, if these are placed suitably for the purpose—being run in with lead. This, indeed, is the rule rather than the exception with regard to byres and stables. The doors of the stores, granaries, and the inner ones relating to the barn, are always of necessity mounted on styles. A closer fit is required at these places than serves at the houses occupied by animals. The latches, or "snecks" for fastening the doors are of all manners of type, one being peculiar to one district, and some other to a neighbouring one. Fig. 110, the Norfolk latch, is a usual pattern for the style-fitted door.

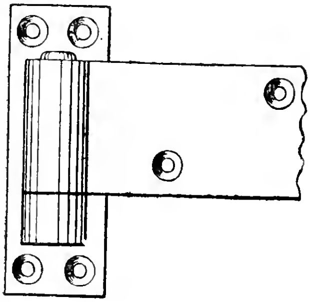


FIG. 106.

Mounting the Sliding Door.

Simpler than any of these is, as we have said before, the door that is hung from wheels. In Fig. 111 we represent the elevation of a door hung in this manner, showing the position of the wheels and the rail upon which these move from one side to the other. This system of door-hanging is equally applicable to small doors as to large ones. The rail and the wheels at the top, two guides and a stop in the ground at the foot, a handle at the outside edge to slide the door open with, and a catband or catch inside to fasten it therewith, are all the fittings a door of this description needs. Fig. 112 is a section showing the nature of the rail that supports the wheels. The latter have, it will be seen, an uninterrupted run from end to end of the rail. The sort of girder or plate of which the rail is a part juts out from the wall far enough to protect the top of the door from rain. The whole affair, it is needless to say, requires to be firmly attached to the face of the wall. Where a beam is doing service as lintel, this is not such a difficult matter. The lintel does not

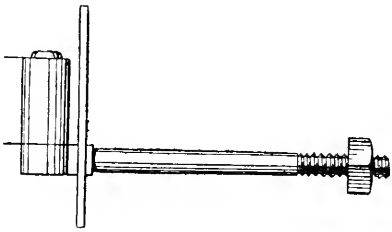


FIG. 107.

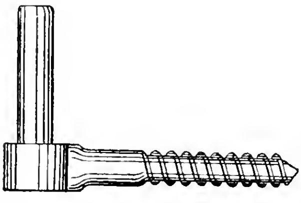


FIG. 108.

FIG. 109.

stretch the whole length of the plate, otherwise the latter would be firmly fastened to it by means of large "wood" screws. So far as it goes, however, the wood lintel can in this way be taken advantage of. Beyond its stretch it is needful in order to make sure of a proper grip that bolts be passed through the wall and be screwed up tight inside, as in Fig. 113. Where no wood is present bolts of this kind alone can be used. Not many are needed, however, seeing they are so effective. To save after boring of the walls it is sometimes practicable to leave provision for the bolt-holes at the time of building. This can be done either by building in stones already bored or that can be easily done afterwards, or as the work proceeds building in rods that can be substituted by the proper article when the time comes for fixing up the plate. The iron lintels need, of course, to be bored before they are put up. The suggested stone facings of these would necessarily be bored at the time of their application.

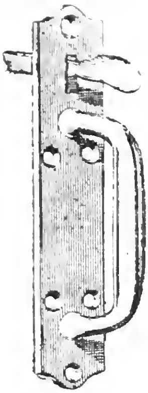


FIG. 110.

Three wheels may be required if the door be a very large one. As a

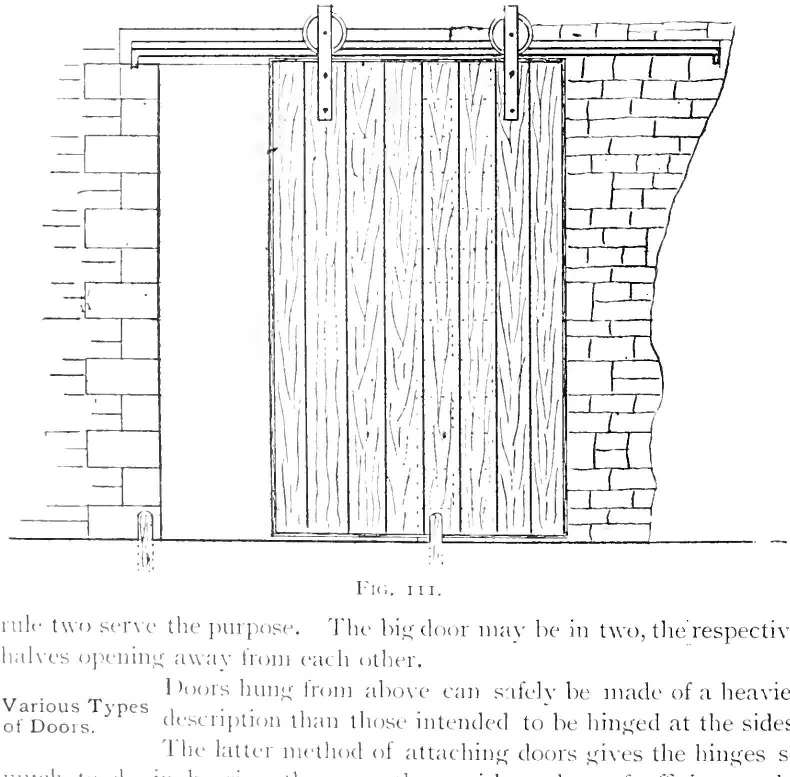


FIG. 111.

rule two serve the purpose. The big door may be in two, the respective halves opening away from each other.

Various Types of Doors.

Doors hung from above can safely be made of a heavier description than those intended to be hinged at the sides. The latter method of attaching doors gives the hinges so much to do in bearing them up that, without loss of efficiency, the lighter they can be made the better. There is no danger on this head, however, when the doors run on wheels. The ordinary hinged door is constructed according to Figs. 114 and 115, the first portraying the front and the second the back thereof. It simply consists of flooring-boards held together by being nailed to the cross-bars at the back. The boards are usually 3 inches broad by $1\frac{1}{8}$ inch thick. The bars, either three or four in number, oftener three, however, are from 6 to 9 inches broad and 1 inch thick. The exposed edges are chamfered more or less. The face boards are nailed firmly to these cross-bars and the door is completed. For the sliding doors a frame has first to be made, and on the face of this boards as before are fixed. The larger we make the door the greater care we have to take that it will be stiff and unyielding. To accomplish this struts have to be introduced here and there. From Figs. 116 to 119 we give some examples of how these doors are put together. It is usual to finish the framed door with a thin beaded edging as shown in the figures.

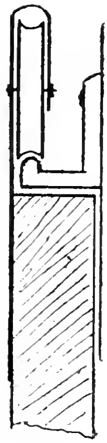


FIG. 112.

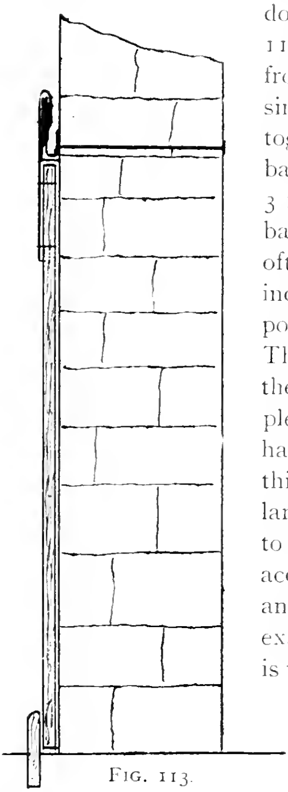


FIG. 113.

It is not a good plan, in so far as the welfare of the big door is concerned, to make a smaller one therein. So many more joints are caused thereby—and these are so many extra attacking points for weather to seize upon—that the door is certain to suffer on that account.

The Sliding-Door Rails.

The rails for small doors can be cast in a single piece. Those for larger ones can be cast in sections. This makes them easier to handle, and if carefully put up, by no means interfere with their efficiency. The ends of the rails, it will be noticed from

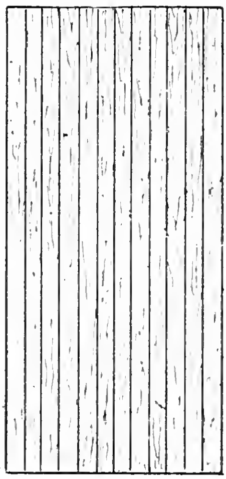


FIG. 114.

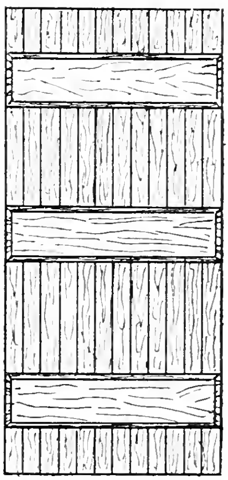


FIG. 115.

Fig. 111, are turned down at right angles for two or three inches. The object of this, it is easy to understand, is to check the further

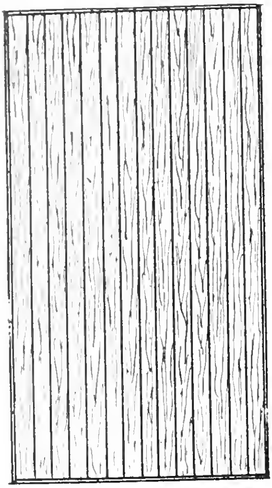


Fig. 116.

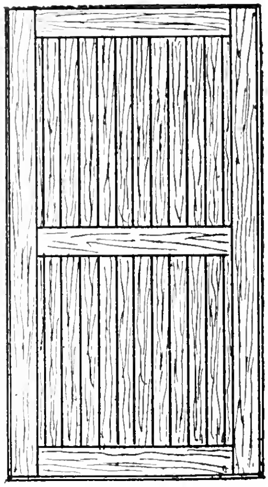


Fig. 117.

progress of the door when it has cleared the opening. Care has to be taken that the door when erected hangs plumb, otherwise it will either grate on the wall or, on the other hand, tend to keep away from it and rub hard on the guides at the foot. If plumb, however, it will run easy without rubbing on the wall behind or the guides in front, and still be near enough to the building to afford proper protection to the opening. To further the latter aim, the chief end of the door, the door has to be made wide enough to overlap the doorway at least three inches on both sides.

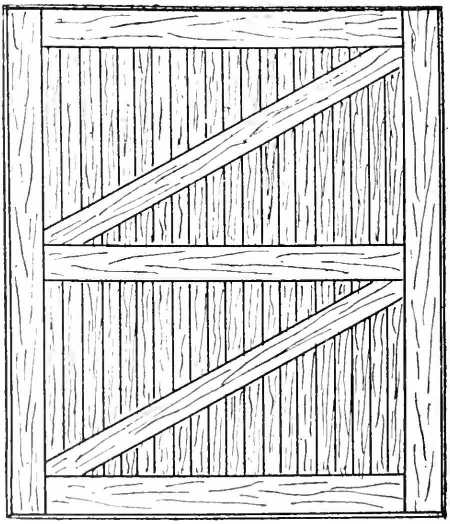


Fig. 118.

Other Fittings of the Sliding-Door.

A strip of iron about an inch broad and a quarter of an inch thick, rounded off at edges, may with advantage be screwed to the face of the door about an inch or two from the bottom. It will help considerably to resist the wear and tear of the door due to any friction between it and the guides. The latter may be either of wood or stone. One of these at each side of the door and another near to the point which the off side of the door reaches when pushed aside to its full limit, as on Figs. 111 and 113, are sufficient for ordinary sized doors. Large ones may need more, for these are the sole checks against their being pushed out at the bottom. But these are details that have to be faced as each special occasion arises.

It is a good plan when screwing home the plate to insert some plaster, lime, or cement and sand between it and the wall. This makes a

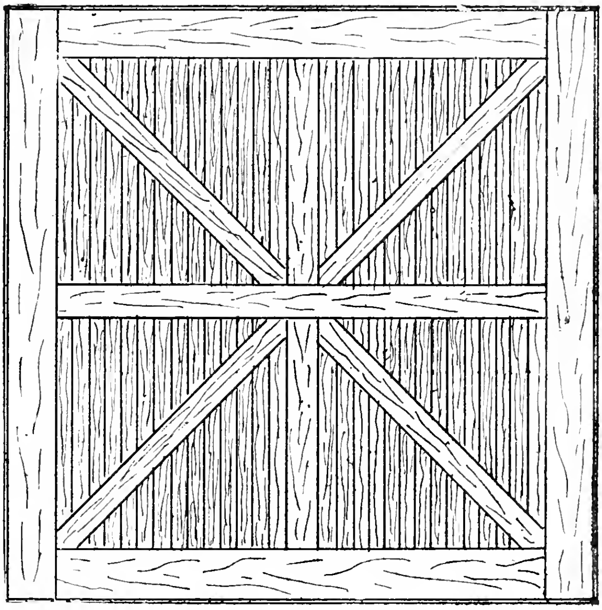


FIG. 119.

watertight joint, preventing water getting in between the two and down upon the door-head.

It is no uncommon occurrence to find sliding doors fitted up with the wheels undermost. The arrangement may be cheaper, but it is in no way so satisfactory as the previous one. The rail must be small if it is not to constitute a constant nuisance; but being on the ground level, even a thinnish rod gathers rubbish at each side. Obstructions to the free run of the door are in this way frequently happening, and occasionally the door gets derailed, when it may come down with a flop, at the risk of harm to itself, and it may be to man and beast as well. And anything in the form of a rail laid on the threshold of a house is not conducive to its being thoroughly swept out.

Modifications of the Door.

The door of the loose-box is generally divided into two parts horizontally, as in Fig. 120. The upper half is the smaller, so that the animal which is confined in the house may have the liberty of projecting its head, but nothing more, from the interior, to breathe fresh air and see what is going on outside. When small doors were commoner in connection with the barn these also used to be in two parts horizontally, about equal in this instance. The arrangement originated, perhaps, as much through a desire for light as on any other ground. In the days when much hard labour had to be performed—thrashing, winnowing, and so on—in the barn, light was admitted by way of the half-open door, or, more strictly speaking, the

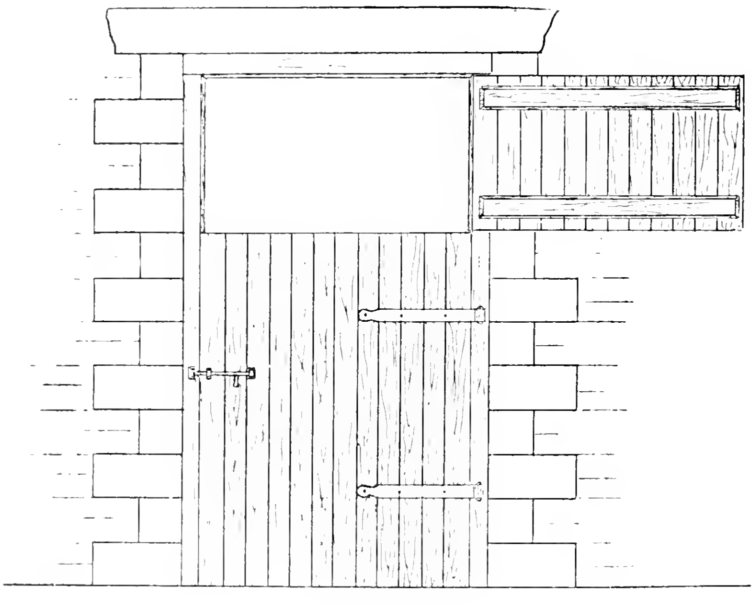


FIG. 120.

door with one half open. Light came in, as we said, by the open upper half, while the closed bottom half kept hens and prowling pigs from gaining admittance.

Where hinged doors are fitted to stables and byres they are often in halves, vertically this time, however, as in Fig. 121. This is done to prevent the door getting too far into the inside of the building. Or, towards the same end, they are hinged up the middle as well as at one side, as in Fig. 122, so that they may cling close to the wall. Both contrivances are clumsy, however. Neither is so handy or so safe as the sliding door. The latter cannot, like the one or the other referred to, or like the ordinary hinged door, ever be blown to just as an animal is emerging and thus induce a catastrophe. There is risk even, with any one of these, of a horse's harness pulling the door shut as the animal is passing through the opening, with disastrous results. Nothing of this kind can take place with the sliding door. No animal will seek to pass through until the doorway is sufficiently clear to allow its head and neck, at any rate, to get through. It may stick there, without suffering much harm, if it cannot get any further. The probability would be, however, that its struggles would widen the opening. Whatever took place, it is evident that the door would not tend to lessen the opening; it would slide away from where the pressure was, and although most of the force would be exerted outwards, some of it would be sure to bear sideways.

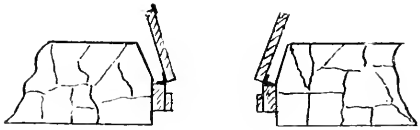


FIG. 121.

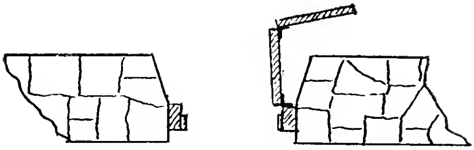


FIG. 122.

Handles, Latches, Locks, and Bolts.

Care has to be taken that the handles, latches, and locks or bolts which we apply to the doors of stables, loose-boxes, and byres are not of such construction that harness can catch on to them, or that they can harm animals knocking up against them. A combined latch and handle, such as the one represented by Fig. 123, would afford no point to which harness could attach itself, or that could tear or otherwise hurt an animal. The handle folds to either side and then becomes almost flush with the door, and there is no projecting thumb-piece as in the ordinary Norfolk latch we have depicted in Fig. 110. The thumb-piece is, it will be seen, substituted by a push-in knob. There could be no disparagement of this latch for the byre door; and for the stable, if a safer thing were wanted, we have it either in Fig. 124, or in Fig. 125. A plain handle, such as in Fig. 126 or in Fig. 127, is all that is needed for the outside of the sliding door. If anything of the kind is required on the inside of the door, it must be sunk in flush with the surface.

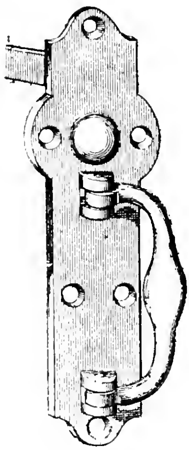


FIG. 123.

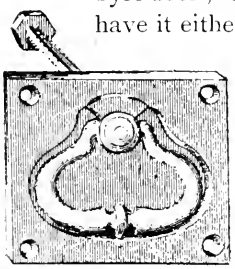


FIG. 124

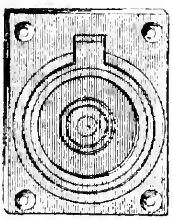


FIG. 125.

Windows. Coming to windows, we have not much to say on that head. We have already expressed our preference for roof lights, and given our reasons therefor. It is hardly practicable, however, to have all the lights at the homestead distributed amongst the slates. There are bound to be places at nearly every group of farm buildings in which side windows are a necessity.

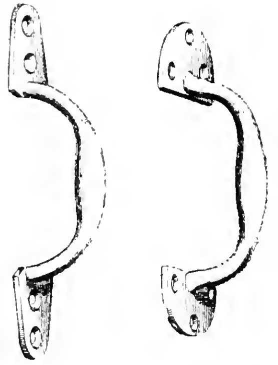


FIG. 126. FIG. 127.

The ordinary Sash Window rather at a Disadvantage at the Homestead. Few realise what an important work of art on the part of a joiner a common sash window really is. In the South casement windows are the rule. These are hinged at one side, and open and close in the same manner as an hinged door. North of the Border, however, the sash window prevails. It is in two halves, which slide up and down in side grooves. One half—the upper one—slides in front of the other parallel to it, separated by the bead *a*, in Fig. 128, which is slipped into the side of the window frame or case. This bead or slip is termed the "parting bead"; it does not pass through the case, neither is it nailed to it, but is fitted neatly into a square groove sunk a quarter of an inch or so into the side of the window frame. It can be easily taken out, and when it is removed there is then nothing behind to hold the outer or upper sash in its place.

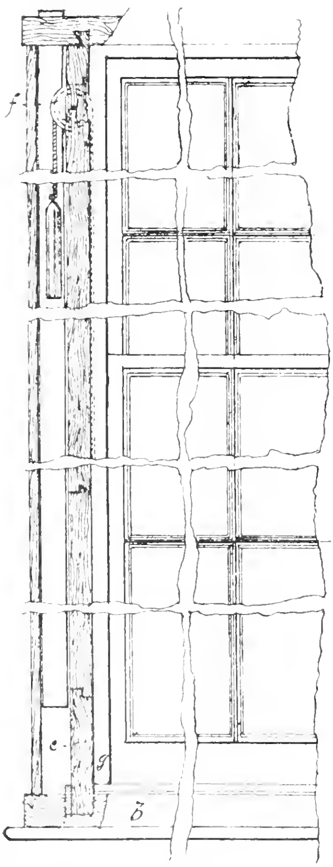


FIG. 128 A.
Elevation of part of interior (the inside lining having been removed).

If we turn, however, to the different divisions of the figure, and take note of the window as a whole, we can better understand the several parts that constitute a sash window, and the relation they bear to one another. The sill *b* is the thickest part of the case; the sides *c* are mortised thereto. At right angles to these side pieces are, so to speak, the wings (the facings) *d* and *e*. When the window is in position these three pieces—the side and the wings—together with the wall bordering the window opening, form a sort of well or recess, in which the weights that balance the sashes move freely up and down. The ropes connecting the weights play over the pulleys *f* that are inserted into the side of the case. The outer wing projects half an inch or so over the side of the case next to the window. The upper sash plays between this projecting part *g* and the bead *a* already referred to. The under sash in turn plays between the latter and a movable batten, *h*, which is screwed to the inner edge of the window case. This batten is the key of the situation; without its removal neither of the sashes can be unshipped. It holds all in place. In splayed openings the inner wings of the case are broader than the outer ones, thus giving it the wedge shape necessary to fit closely into the space. The upper surface of the sill is bevelled out, the better to free itself of rain, the under edge of the inner sash being bevelled in to fit close to the sill. The two sashes fit together when each is home. The top part of the frame of the lower sash is so much thicker or broader than its other three sides, as well as the four sides of the frame of the upper sash by the thickness of the intervening slip bead *a*, that when both sashes are closed the parts that come into side contact are close against each other. These two parts, the top bar of the under sash, and the bottom bar of the upper sash, are together called the "meeting-rail." Were the frame of the lower sash of the same thickness throughout, there would be a vacant space equal to the thickness of the slip bead *a* between the

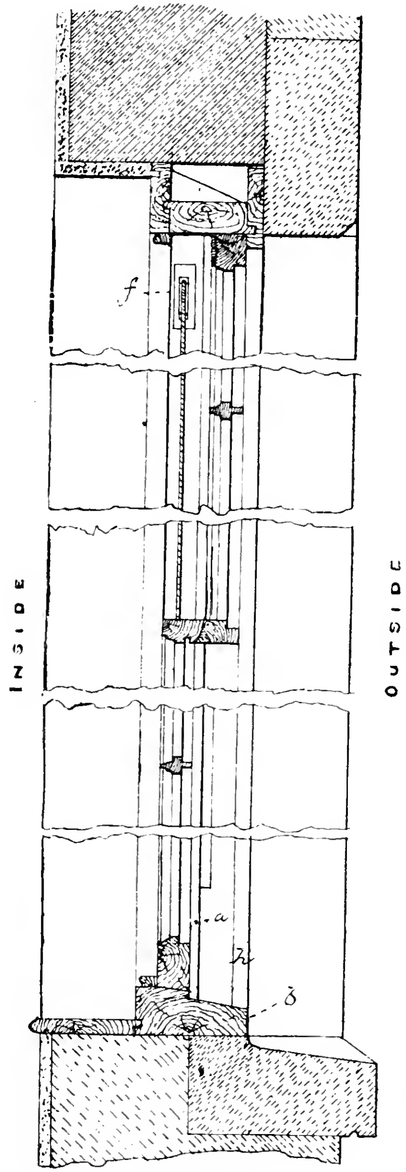


FIG. 128 B.
Vertical section.

sashes where they adjoined, but the enlargement of the sash referred to obviates this. Sometimes this extra breadth is divided between the two. The sashes are divided up into panes by means of wooden divisions termed "astragals," moulded and so checked as to retain the glass on their inner sides, and to hold putty in front.

Hardly any other portion of a building so soon betrays the fact that unseasoned wood has been used in its construction as do the windows thereof. To begin with, the wood, if unseasoned, swells when it is affected by damp. All wood, of course, does; but unseasoned wood is more readily affected by this cause. Before the house is occupied, then, the windows, if made of improperly seasoned wood, have begun to swell. Comparatively dry when they left the joiner's shop, their after subjection

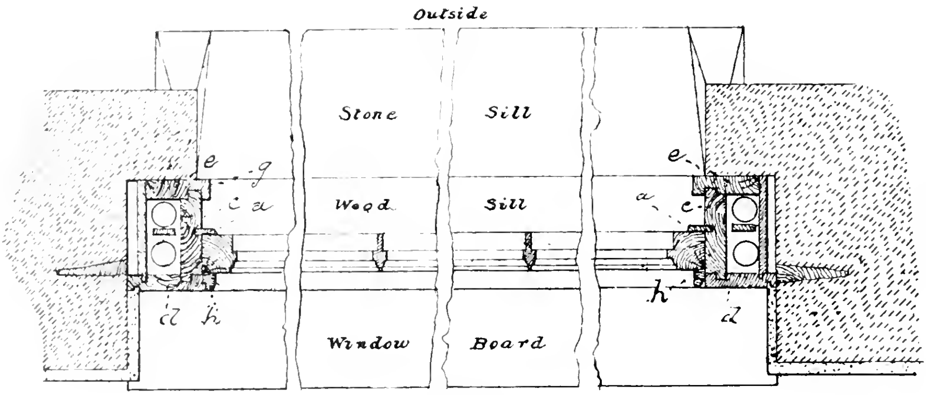


FIG. 128 C.

Plan.

to the damp emanating from the newly-plastered walls causes the wood to expand, and the sashes get jammed. By-and-by a shaving is taken off the sides of these with the plane. As time goes on the building becomes dry, a condition which eventually tells upon the windows. The sashes, in common with the other parts, shrink, and in the end become too loose. Most of us know the annoyance, due to this, of rattling as well as draughty windows. Had the wood been well seasoned to start with, it would not have expanded so much as to interfere with the sliding of the sashes. No planing would then have been called for, and planing in the instance above assumed was simply paving the way for an aggravated state of matters. When shrinkage set in the misfit would be all the worse on account of what wood had been stripped from the sides. Moreover, with the properly prepared wood, when the circumstances conducive to shrinking set in, the window would be comparatively little affected. At any rate, it is open to easy conception that a piece of work such as a window with so many separate pieces taking part in its constitution must give very much better results when made out of sound, well-seasoned timber than with raw stuff, if we may use such an expression.

The window serves further to bring home the ground for our already often repeated objection to the making use of appliances or parts of the buildings at the homestead that have to depend on the frequent application of paint for protection against weather. With its many corners and joints into which rain is ever ready to seek an entrance, once these begin to open, decay is certain ere long to make its appearance. Paint alone, frequently applied, can keep the window in a sound condition.

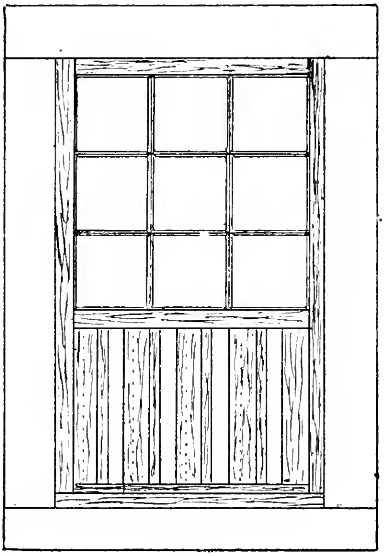


FIG. 129.

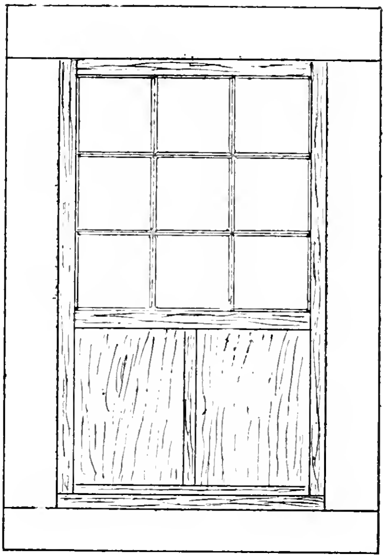


FIG. 130.

Even the putty, as we mentioned when speaking of roof-lights, cracks and falls away when paint is denied the window. But painting at the homestead is by no means a frequent proceeding. The less, therefore, there is left about the place to paint the better for all concerned.

Casement Windows.

Once the windows have room to rattle, there is little chance of a remedy. With casement windows there is little or no rattling. They are easier of construction, and cheaper. But then, they are not so convenient. They require too much room in opening and shutting. And, further, unless made to open outwards, which is not always desirable, it is difficult to keep them watertight if they are exposed to pelting rains. It seems a little strange, all the same, that the simple, easily constructed casement window should so seldom in Scotland be substituted for the more complicated sash window.

But the windows such as we have been referring to come more under the head of Houses and Cottages than of the buildings proper to the homestead. Still, as already remarked, there are places here that require one or more windows of the kind just discussed. There may be a bothy about the homestead that requires a window of either sort; or the harness-room may be so situated that such a window is the proper one under the circumstances. But if unsuitable in the cottage the sash window is less so here.

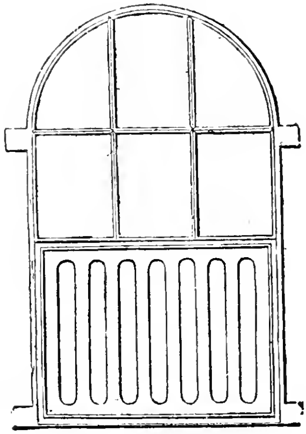


FIG. 131.

Other sorts of Windows in use at the Homestead.

As regards the stable and other buildings, the windows of which are not wanted to be so well finished as are the two classes above referred to, the kind of window—half window and half ventilator—shown in Fig. 129 is a common one in this connection. The glazed upper half is fixed; so, indeed, is the whole frame. But behind the fixed vertical laths or spars of the bottom half is a similar series of spars, the frame of which is slideable to the extent that the openings can be covered in whole or in part or left entirely open, just as one wishes. A somewhat similar window is that in Fig. 130. Instead of the "hit-and-miss" arrangement of spars characteristic of the window in Fig. 129, two doors or shutters, each hinged at the side and folding against a centre upright, take its place. Neither of them, however, is a long liver, and, therefore, not to be recommended.

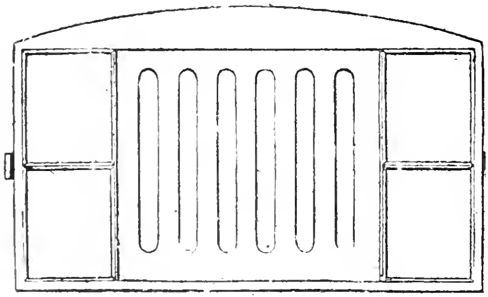


FIG. 132.

Iron-framed Windows.

Iron window-frames seem never to have gained ground at the homestead—perhaps on account of their being thought very easy of fracture and difficult in replacement. But they can be no more liable to fracture than wood frames, and we seldom see accidents of this kind happen to windows. As to replacement, articles of this class are only made by the leading founders. They are in a position to store their patterns, and at any time to produce articles listed in their catalogues which they do not happen to have in stock.

Iron side windows are, perhaps, more suitable for brick than for stone buildings. Still, there is nothing to hinder their satisfactory application to stone-built houses. In fact, a very good job, both neat and strong, can be made of them with brick facings in a rubble wall. Sills, rybats, and lintels can be dispensed with when bricks properly moulded for such openings are available. If the sill bricks be laid on a bed of cement, and be closely jointed and pointed with the same, a perfectly watertight ledge is the result, and this is about all we look for in the free-stone sill. If we dispense with the lintel, we are obliged to build the bricks in the form of an arch. Most of the catalogued homestead iron windows are of the arched pattern. In Figs. 131, 132, 133, and 134 we give examples of these. A window of arch shape at the farm may seem incongruous to some: but it is only a matter of prejudice. A "flat" arch is handsomer than a square-topped opening. The brick facing is checked all round the sides and top two or three inches back from the face. The inner casement, faced with cement, fits close into this, where it can be firmly wedged. The sill dips outward from a slight check for the base of the window to rest against; at sides and top the check is in front of the frame; at the bottom it is behind it. The inner part of the opening can be finished off with cement plaster. Completed thus, we have a window which, if a little out of the ordinary run where North Country notions are concerned, is both cheap and strong, and, better than all, one capable of holding out in the midst of neglect. Very little paint serves the turn of the iron frame. Very good windows of this kind are represented by Figs. 134 and 135. They are to be had square-topped as well as arched. They are fixed against the interior of the wall. Either is suitable for any

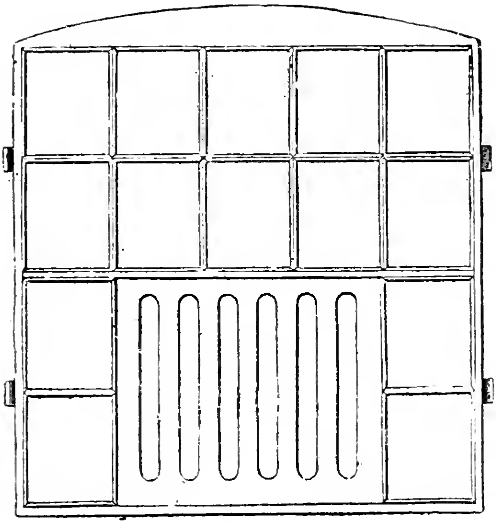


Fig. 133.

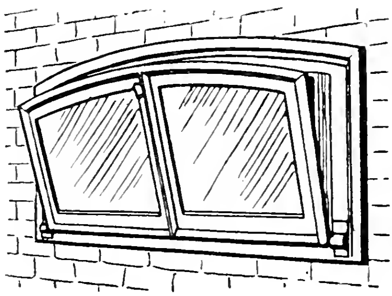


Fig. 134.

stable, loose-box, or byre, where side light is considered preferable to that derived by way of the roof. The former is not very large, but on that account all the more of them can be used. It opens nearly to its whole area under a simple and easily controllable arrangement. Fig. 136 shows a larger window of the same description suitable for the buildings that require windows more after the ordinary type. The opening part is regulated on the same easy principle as obtains with the other two. Besides these there are, of course, endless varieties of others.

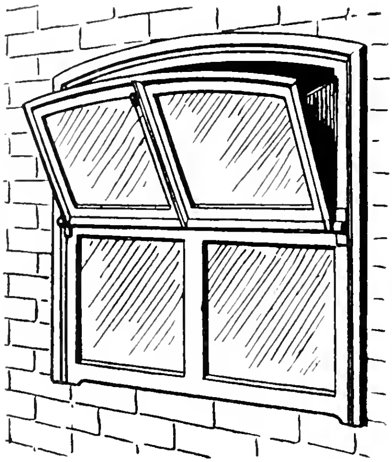


FIG. 135.

Ventilators: The common kinds at the Homestead.

The commonest sort of roof ventilators, where such form a part of farm buildings, is the louvre-board lantern affair, Figs. 137 and 138, something like a small dog-kennel, placed on the ridge, and the arrangement as in Figs. 139 and 140, whereby a part or parts of the roof are tilted up a little above the general level and open spaces made in this way. Neither is very satisfactory. The first, being usually of wood, very soon gets out of repair. Wood is placed in a trying position in this instance. Exposed on the outside to all extremes of weather, and the inside parts subjected to warm, moist air, it has more to withstand than it can really be expected to bear for any length of time. Even with frequent administrations of paint, a thing of this description cannot be expected to last long. It is but a makeshift, in fact. Occasionally we come across them made of iron, but so small as to be rather ineffective. But iron, also, is in too trying a position when taken in this connection. Paint would keep it right, no doubt, but that is not always forthcoming.

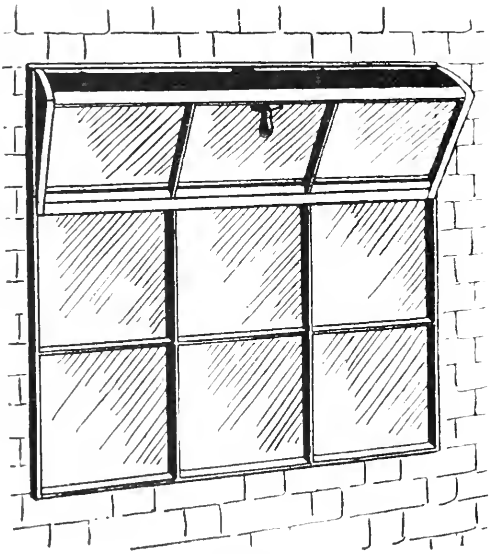


FIG. 136.

The slit in the roof, when properly made, is free of these objections, but it is not so effective as a ventilator. The lantern sits clear of the interior of the building altogether, and foul air that reaches it is at once swept out between the spars at one side or the other. It is bound, therefore, to be a better means of withdrawing or extracting the spent air of the building, or of allowing it an unobstructed exit, than the slit, which is some distance below the apex of the roof. The air may get locked, as it were, under the latter arrangement. It cannot, however, with the lantern. As it fills into this it is virtually mixing directly with the outside air.

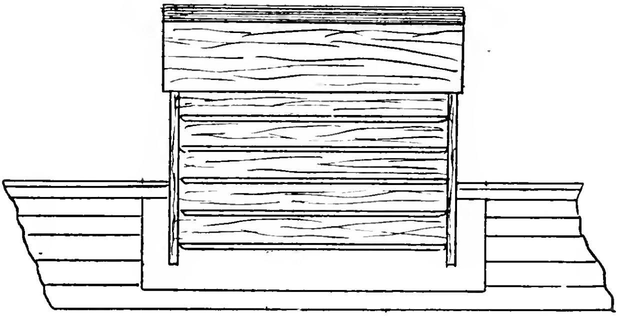


FIG. 137.

A fault common to both, however, is that birds are free to come and go through the openings. This is no fault, indeed, when the welcome swallow is the one that takes advantage of these passages. But when the sparrow is the intruder he becomes a nuisance, especially if he elect to set up house in the ventilator itself. He and his partner are slovenly builders, and having to make up for want of neatness with increased quantity of material, they soon interfere with the usefulness of the opening.

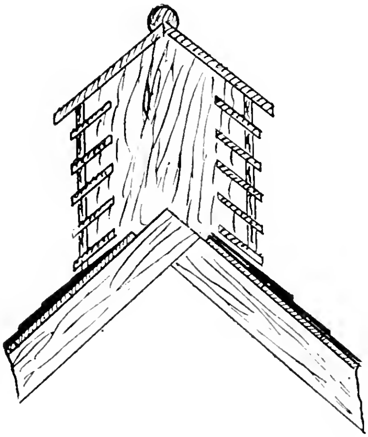


FIG. 138.

But, worse than the sparrow, both kinds of ventilators admit drifting snow. They are easily constructed so as to forbid the entrance of rain, but wind-driven snow sails in with ease. This may not often happen; but a building that is liable to allow such a state of matters is imperfect as a shelter for stalled animals.

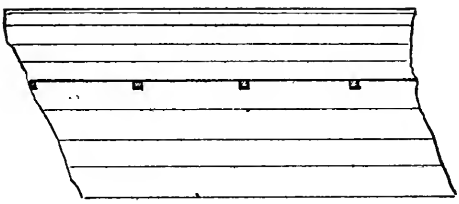


FIG. 139.

The double-horned Zinc Ventilator.

Better than these, in our opinion, is the double-horned zinc ventilator shown in Fig. 141. It is simplicity itself. Nothing about it can go out of order. No painting is needed where it comes, zinc being capable of resisting the attacks of weather. Rain cannot gain admittance through its openings; neither can birds, nor snow. It may, however, be hardly so effective as the louvred lantern. It stands like the latter, above the level of the air within: but, on the other hand, unlike the lantern, there is the downward curve in it that must to some extent retard the free exit of the inner air. But when it is fitted with the diaphragm, or division, the position of which is indicated by the dotted line on the figure, this obstruction or retardation of the outward passage of air is considerably obviated. The circulation of air through the ventilator goes on freer with the passage divided into two than it does with the opening left as one. The air is apt to be locked in the undivided ventilator, similar to what takes place with it in the slit-in-the-roof arrangement.

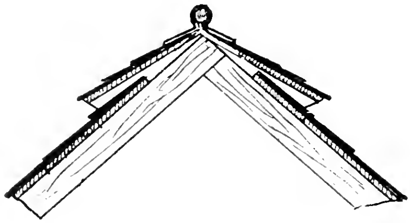


Fig. 140.

A roof fitted up with one or two of these ventilators insures a good circulation of air within the building it covers. More are, of course, required in a building that contains live stock than in one set apart for other purposes. One or two will do in barn or granary, while thrice as many may be needed in a byre of the same length. And fewer will keep the stable comparatively well aired than can do the same with regard to the byre, the horses, though larger, being less closely packed together. They are not expensive to begin with, and their maintenance is a small item. They are easily fixed, and not liable to be thrust out of position. As the figure shows, they have lead flanges, or aprons of lead attached. These are made to suit the pitch of the roof, and to cover a sufficient area all round the opening into which the shaft fits to make sure that no rain can gain entrance. The shaft passes into the interior of the building far enough to clear the roofing boards. There is little use in inserting it further. The shorter distance it dips into the interior the better will it be able to draw off the spent and heated air that seeks the inner apex of the roof. Air in that quarter that might be slow of exit through a single opening is, as remarked above, set

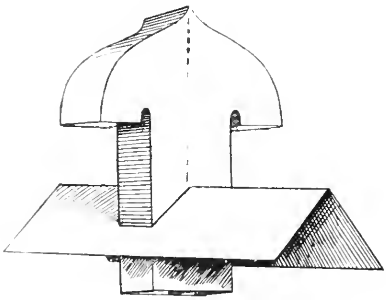


Fig. 141.

agoing more briskly if the opening be divided into two. The cold air may be struggling to get in from above while the warm air within is at the same time pressing up from beneath, both, in this way, being hindered the free use of the passage. But when the passage is divided each gets a road to itself, and the exchange of the air from without for that from within can go on without let or hindrance. The division in the ventilator acts like mounted police or cavalrymen when slowly patrolling the centre of a street crowded with people going in opposite directions, to make sure of keeping each current in its own channel. Were the crowd left to its own devices, a block would ensue, and little progress could be made; but so long as those desirous of proceeding in one direction were kept to one side of the street, the other being left for those bent on going the contrary way, all confusion would be avoided.

The roof ventilator is generally supposed to be constructed for the purpose of allowing foul air to escape, openings whereby fresh air can get in being made lower down in the building. This holds good with the louvre board lantern. And so it does with the slit in the roof referred to, although in lesser degree. No doubt the same can be said of the horned ventilator. But the construction of the latter, which necessitates a curve downwards at each exit, retards, as we have said, the outward current. The heated air seeks to rise, and its progress outwards is sure to be hindered where it has to dip downwards a little before it can escape from the building. Besides, however, acting almost solely as a discharger of used-up air, as happens with the lantern and the slit, our double-chambered affair serves likewise as an inlet for fresh air. Cold air gains admission by one opening, helping, as we explained above, to make easier the exit of the heated and already breathed air within.

Acting thus, as it were, in two capacities, a ventilator of this kind is admirably adapted for the granary and similar places. In these, while there is little call for a constant replacement of the air contained therein, all the same, there is need for a certain amount of circulation of air within the building. Where air is stagnant as well as damp, which it is bound at times to be in an unfired building in our climate, moulds and fungi thrive, and most of its contents grow mouldy and musty

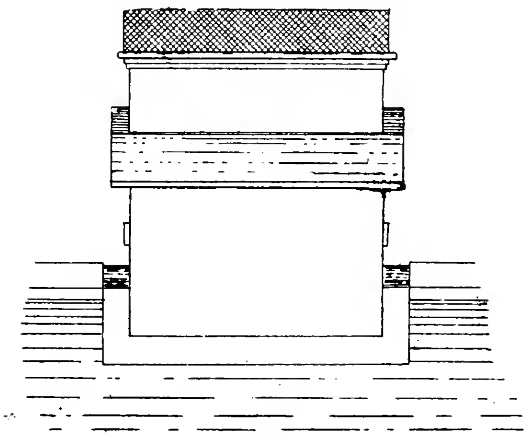


Fig. 143.

preparatory to decay. But if the air is kept moving, there is even at the dampest times of the year not half the harm likely to arise from these promoters of decay. A ventilator such as we are speaking of answers well, therefore, to keep the atmosphere of the buildings referred to in wholesome condition. One or two in the roof of each keeps the air within the building in close touch with the atmosphere itself, at the same time keeping at bay the rain and snow that are every now and again emanating from the latter. The advantages of this in connection with houses the doors and windows of which are seldom open are surely too obvious to require further dwelling upon.

It is none the less suitable either as a circulator of air within buildings of which horses or cattle are the occupiers. If it does admit air with one hand as well as withdraw it with the other, matters are thus made all the more satisfactory, for as a rule the fresh-air inlets are in no wise satisfactory.

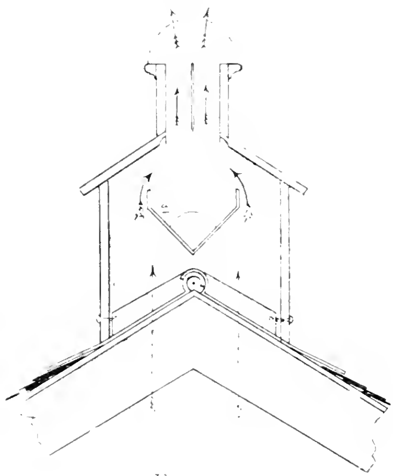


Fig. 144.

There are, of course, many patented ridge ventilators in the market. Most of them, however, are rather too complicated, or, at any rate, too expensive, for the simple requirements of the homestead. Those on the system of Boyle's patent might suit the steading. They are simple, having no movable parts likely to go out of order, and being made of zinc, need little attention of the kind we have so frequently hinted at. Their underlying principle is that of automatically maintaining a constant movement up the shaft of communication between the building and the outer air. But they are more expensive than those we have been recommending, and we question if they are a bit more effective. Moreover, they are not so simple in construction, therefore not so easily kept in repair. In fact, those we advocate approach the primitive type—the more primitive the better, however, so long as they perform their part.

Craig's Ventilator.

A really good ridge ventilator is the one patented by Mr. Craig, Langbank, Port Glasgow. It has all the advantages of the louvre lantern without possessing any of its defects. Mr. Craig has been so long connected with landed estate work that he knows well what is required of an article of the kind that has to do duty at the homestead. His ventilator is constructed either of cast-iron or of wood covered with zinc. At top it opens clear to the outer air without let or hindrance. In Figs. 143 and 144 we represent this ventilator. It shows a diaphragm dividing the shaft proper into two, as we have adopted in the case of the zinc one above referred to. Any rain that gains admittance at the top as well as what snow gets in there is caught in the tray or trough *a*. The latter leads to each end of the ventilator, and passing through it a little, delivers its moisture on the roof. The top is covered with wire netting in order to prevent sparrows from making a convenience of the thing. It is both serviceable and effective, and can be easily fitted up. Although made of iron as well as wood, there is nothing to hinder the former being galvanised if wished. Its effectiveness in affording a free communication between the air without and that within enables one to do the work of two or three of the kind we have spoken of as favoured by ourselves. They are rather too

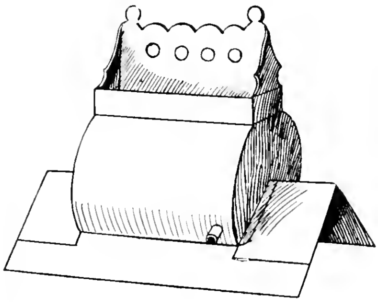


FIG. 145.

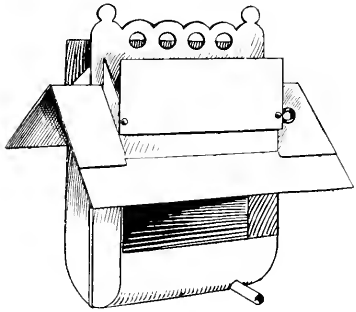


FIG. 146.

effective for being put to service in barn and granary, but for byre or stable they are eminently suitable.

Taylor's Ventilator. Figs. 145 and 146 represent a somewhat similar type of ventilator to Mr. Craig's. It is patented and manufactured by Mr. Taylor, Nether Leask, Ellon, N.B. We cannot speak of it from experience, but from the appearance it seems to follow the lines we advocate.

Fresh Air Inlets. Fresh air inlets are generally made somewhere towards the level of the wallhead. They would be more effective, perhaps, were they constructed nearer the foot than the head of the wall. But there are difficulties in the way at the bottom of the wall that do not apply at the top, and on that account the upper part of the wall is chosen in which to make the necessary openings. The nature of these differ with the district. In some places a series of vertical slits widening inwards like the loopholes of old do duty. At others mere round holes are formed in the wall. At many places there is nothing of the kind, fresh air being left to find a way in for itself.

It is becoming common now to build glazed fireclay pipes in about the top of the wall. These make neat and unimpeded channels for the passage of air. When they are built in with a slant upwards, rain cannot beat through, and, in addition, the inward passing air is given a current upwards and impelled well into the building and made to mix more uniformly with that already in the place. The probabilities are that the incoming air, when introduced in this manner, will have a better effect than it would if allowed to blow directly in through the ordinarily constructed inlet. If it blew in, it might indeed clear the animals that were near to the opening, but draughts would be induced rather close to the floor level. These, if they did not interfere directly with the comfort of the animals, might in the end come to hurt the health of many of them.

Danger to the health of the animals is one of the strongest arguments against admitting outside air at the level of the floor or thereabouts. It is almost impossible to admit air by way of openings in the floor itself without causing draughts that will affect the animals. And if this difficulty be overcome, we are met with the other of how to keep these inlets in the floor clear of obstruction. How is it possible to sweep the floors without allowing matter to get through the gratings? In the act of carrying straw about or pushing it along the floor in front of one, both straw and chaff will find their way down the grating. Little better is it to have openings at the foot of the wall so much above the floor as to avoid risk of impediment to the free action of the passage. These, unless on a principle rather complicated for the somewhat primitive practices of the majority of the occupiers of our homesteads, could not be placed at the heads of the animals. On the other hand, if placed in the wall behind the animals, the latter are certain to feel the effects of the draughts that must arise therefrom.

If we cannot make sure of these side openings when placed in the floor itself or in its vicinity, we may as well at once place them near the wallhead where they are out of all risk of obstruction and are quite effective enough for ordinary purposes. They may as well be there, at any rate, as at the head of hollow pilasters against the wall which act as conductors up the side thereof from openings leading to the exterior at the base of the wall. These only take up room, and are for no other use than by way of ornament, which, it is needless to say, is at a discount in the byre and stable of the economically conducted estate, whatever the farm may be.

The Fresh Air Inlets ought to be controllable.

With air inlets in the shape of pipes at the wallhead, and the zinc ridge ventilators we have been saying so much about, or those of Craig's, we have at our command a simple method of maintaining a change of air within our byres and stables. It is rather a crude system, perhaps; still, it is one that answers the end in view. It is fairly automatic, a condition that is, as we have so often repeated, greatly in favour of any arrangement that applies to affairs at the homestead. But unless the wallhead openings are under the control of the attendants upon the animals, or of the overseer or the farmer himself, our arrangement is little better than what constitutes the ordinary state of matters—some holes in the side-walls, with may be openings in the roof and may be not.

With some simple and ready means of regulating the size of the wall-head openings at our disposal, we can suit these to the conditions that rule either outside or in. When it blows a gale we can close entirely those at the weather side of the house and leave open those on the lee side as much as we think necessary. On a still, frosty night when there is no movement in the atmosphere, and the air within the building can hardly be stirred, we can open the inlets to their fullest extent and so induce some slight draught through the place. And if the occupier of the farm be far-seeing, he will, on occasions of this kind, have the opening roof lights in such a condition that he can press them into service as effective aids towards the circulation of air within the building.

Without the means of controlling the action of the side openings the farmer is in the position of having his building so constructed that its ventilating properties are a fixed quantity. Its ventilating capabilities are devoid of adaptability, and yet they have to face the weather that is embraced between the fierce, cold blasts of winter and the occasional mild breezes of spring. All that can be done to mitigate the piercing winds of January and March is to stuff the most exposed openings with straw, and there it remains blocking up the passage when it may be wanted in a time of calm and a high barometer. Before the offensiveness of the air of the house has made itself manifest to the men or women who look after the animals, these, which have been breathing it continually, must surely have felt oppressed.

A simple Method of accomplishing this.

In Fig. 147 we represent a cheap, simple, and easily workable arrangement for regulating the admission of air by the wallhead openings. It is simply a round piece of wood, or, to speak more definitely, a circular board, *a* on the figure, large enough to cover the inner mouth of the opening. To this is fastened the long leg or lever *b*. The whole moves on the pin *c*, which acts as a fulcrum as well as the point of attachment. The lever is worked by means of the string *d*, hanging from its free end. When this end is pulled down, the circular board clears the opening. When it is released, the board, being heavier than the handle, tends downwards, obstructing the opening. It is arrested by the stud *e* when the opening is completely covered over, and there it remains so long as it is not interfered with. To open completely or in part, all that one has to do is to pull the string attached to the lever until the desired size of opening has been attained, and secure it to a nail or cleat put in the wall for that purpose. To shut up the hole entirely nothing more is needed but to free the string and let the end of the lever go up.

This is surely simple enough viewed either as matter of cost or as a saver of trouble. No one with such an arrangement at hand can say, what is so often true in this respect, that he is powerless to adapt the provision for ventilation that his buildings are supplied with to the almost daily changes that take place in our climate. It affords him a ready, as well as fairly effective, means of coping with changes of weather without having recourse to complicated arrangements for ventilation, which in nine cases out of ten at the very least would if fitted up never be appreciated, not to speak of their receiving due attention.

If to be under control in the way we have suggested, we can safely make the wallhead openings of a much larger size, or make more of them than usually happens. We are then in a position to aerate the house fully during spells of anti-cyclonic weather, as we are to close our port-holes in times of storm and stress. But how often do we see the side-walls of stable and byre, instead of being left free to serve their original purpose, turned to account as the back wall of some lean-to building. It is folly to speak of holding control over the air of the

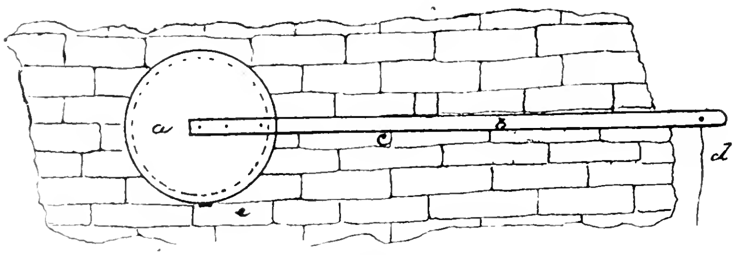


FIG. 147.

building when this is the case. Each building of the kind should stand free from others. It matters not about the gables, but the side-walls should be free of all encumbrances in the shape of sheds of any kind. The wall alone, if we are to be free in our simple way to supply fresh air to the animals within, must be between them and the outer air. More complicated methods can, no doubt, be adopted irrespective of the position of the buildings, but simple methods alone are justifiable at the homestead.

How the Ridge Ventilator may be controlled if considered necessary.

We have made no mention of applying control to the ridge ventilators. That, we consider, is hardly necessary. Assuming, for instance, that all the side openings were closed, what air did enter the building by its roof openings would in all probability under these circumstances be no more than was needed. If this be correct (it is at least reasonable) we can, by regulating the side openings, indirectly control those on the roof. But should direct control of these be desired, its accomplishment need be no very difficult matter. Zinc flaps could be hinged to the internal openings of the ventilator shafts, and by means of a pulley and a cord each flap would be under separate control. But all this means so much likely to go out of order, which is a condition of affairs strictly to be guarded against at the homestead. We see the principle applied to the ventilator in Fig. 146, but in this case at the top instead of the bottom.

CHAPTER VII.

Sanitation at the Homestead.

What Sanitation at the Homestead implies.

Here, as obtains somewhat similarly elsewhere, sanitation is the twofold art of so dealing with the members of the microscopic world, that they are kept from working harm on the farmer's stock, either live or dead, and of insuring that the air within the various buildings is so far as possible kept in a wholesome condition. The former comes under the head of Cleansing, and the latter under that of Ventilation. Cleansing is carried out by means of drains for the conveyance of liquid matters, and with broom and shovel the solids—the dung and the soiled litter—are removed; and to ventilation we have to look for the maintenance of a due standard of atmosphere.

Out in the open, and well away from populous places, as nearly all homesteads are, there is little need to bother about such matters, one would naturally think. With sun, rain, and wind, each free to make its influence fully felt about the place, why trouble about sanitation? They are the best sanitarians; and their services are free. But the animals must be kept warm when in winter quarters, and rain and wind must be excluded to make sure of this. As we hinted towards the end of last chapter the wind is usually so thoroughly excluded from the farm buildings that a proper exchange of air from without inwards is rendered all but impossible. Coupled with this we have, when the drains are defective and cleanliness is not otherwise well observed, a condition of matters that indicates on the part of both proprietor and occupier ignorance of the first laws of sanitation. When, for instance, along with the warm, impure air of an unventilated byre, we have a large proportion of excreta ever present in the building, and this placed under the most favourable circumstances for rapid decomposition, the occupier of the place would seem to be courting disaster upon his animals. But one can with impunity do in the country what he cannot in this connection do in the town. Isolated in the country, he is removed from the reach of the more harmful microbes. These are either gregarious themselves or like best to be where the big numbers of the animals they most effect are congregated together. At any rate, they are more virulent under these conditions. And even into the most insanitary country places a fresh whiff now and again gains admittance and turns the balance.

The two Classes of Live Stock that suffer most from defective Sanitation.

Notwithstanding the penalty that is certain to follow any breach of the law of sanitation, as well as of other sciences, it is wonderful how long farm animals when in winter quarters evade the consequences of infringing the dictates of sanitarians. Only the cows and the horses, however, run any great risks on account of improper observance of sanitary laws. They are kept so long as they are fit for duty, and in consequence have recurring periods of these adverse circumstances to go through, while the other classes of stock, such as the pigs and the beef-producing cattle, are despatched from the homestead before the ordeal has had time to show its influence upon them.

Why the Cows are apt to be the greater Sufferers.

Of the two classes of stock most liable to suffer from the cause we are discussing, the cows feel its effects in the greater degree. The horses, if half suffocated by night, in their stuffy stalls, are out nearly all day under the vault of heaven, breathing the purest of air. But not so the cows. From October until May not only are they housed by night in their very often noisome houses, they are there all day as well. Towards the beginning and the end of that period they are, of course, out of doors for a good part of the day, according to the state of the weather. In the dead of winter, however—in December, January, February, and March—they are little out of doors except for a short run to water and back. What is more, they, unlike the horses, must be out of condition muscularly, or bodily. The horses are kept in good condition because they are hardly ever completely off duty for longer than one or two days at a time all the winter through. But the cows have not even exercise during many consecutive months of the time they are housed. In summer their exercise is not to say of a very thorough description. Still, the work of finding and of cropping their daily supply of grass implies no small amount of muscular effort, which, together with their walk to and from the steading to be milked, and their endeavours to keep insects from alighting upon them, is sufficient to keep them in good tone physically.

How the Seeds of Bovine Disease are spread in badly-ventilated Byres.

It is during winter that the cows run the risk of the seeds of tuberculosis being imbibed into the system. The annual recruits to the company are rarely found to be affected with the disease previous to their joining the ranks of motherhood. They are more in the open air during their first year or two of existence, and less crowded together. At any rate, they have more freedom and exercise. And if they are packed closely at times, it is in company with fellows showing a clean bill of health. When it comes, however, to their taking place with their elders the danger begins. There are bound to be one or two cows in the house so far advanced in the disease as to be centres of its dissemination. And the conditions under which the animals are housed are such that there is hardly any chance of their escaping the malady. With little room, as we have pointed out, in which to move about in—pilloried, in fact, in a row of others—the animals are under constant bodily constraint. Never free to stretch body or limb, as they are at liberty to do whenever inclined at pasture, but kept to one position almost, the additions to the herd must at first feel the effects of their close confinement and restrained position. Neither able to lick nor to scratch themselves as they are wont when untied, and not even able to lie down exactly when they want, are, one might conjecture, conditions by themselves enough to place the youngsters at the mercy of those germs that take advantage of lowered vitality, even of a temporary nature, to gain hold of the constitution.

But to conditions of this kind the junior cows seem soon to grow accustomed, their apprenticeship of former years having prepared them to a certain extent to face these with impunity. They can stand all that without serious harm apparently. It is to the noisome state of the atmosphere they are subjected to that one has to turn his attention as the most dangerous medium of inducing the contagion of this form of lung disease. Hot, moist, and laden with emanations from lungs and skin, together with the odours from excretal matter as the air of the average cow-house is, little wonder many of the young animals soon fall victims to tuberculosis. Having to breathe an atmosphere of this sort almost continuously for months at a time is certain to lower their vitality. Such an atmosphere is of the most favourable nature for the transmission of the disease germs from affected to healthy animals. Once these enter the system of an animal placed under the conditions we are describing, but hitherto immune, there is small chance of their being thrown off. They are not so difficult to resist, we are told, when the animal is in the field most of its time. The infecting germ may then be destroyed in the system before it has had time to implant itself where it can increase and work harm.

Much depends, as we have hinted, upon the condition of health of the animal at the time the disease germs gain admission to its organisation. If strong and vigorous at the time, the ill-sown seed falls on stony ground and has no effect. But if out of sorts or down in condition at the time the germs come its way, the seed falls on deep ground and returns a bountiful crop. Both states, as is generally believed, are further ruled somewhat by the general constitution of the animal. One may be so constituted that it is more susceptible to the disease—it affords a more congenial soil to the germs—than others of its kind happen to be.

No matter, however, the degree of susceptibility inherent in the respective animals that are annually introduced into the cow-house, every one of them is placed in circumstances which almost inevitably brings it into the clutches of tuberculosis. The affected animals spread around them abundance of the germs. They cough them up and scatter them about in the saliva with which they beslabber whatever comes in their way. A turnip may be lying on the road as she goes to water. This she makes a snatch at, biting a piece off perhaps. Whatever she leaves behind of that she has mouthed in this way is now sufficient to infect the next healthy animal that gets hold of the remainder of the root. The same is, of course, liable to happen in the pasture-fields. Grass at places may be rendered dangerous in like manner. And it is common to see one cow, when the needs of her stomach have been attended to, helping another in toilet matters. On occasions of exchange of courtesies of this nature there is every likelihood of the disease germs being passed from one to the other. But at grazing time the animals are, as we have said, under conditions less liable to render them susceptible to the seeds of the disease.

We do not often, however, see such a good understanding existing between seniors and juniors as to admit of so much familiarity. The matrons are bullies of the first water, and show no mercy to those who shrink from them. But the juniors have ample opportunity of meeting the disease half way without actual contact of this kind with their elders. It may so happen that the young cow may, on admission to the ranks in the byre, be stalled with an aged one that has contracted the disease. If this be the case, there is little chance of her escaping the malady. Although the animals are tied up in such a way that they cannot assail each other with hoof or horn, still, the individuals of each pair can reach with tongue to the edge of each other's trough. And portions of the food belonging to one may be pushed aside within reach of the other, which she will avail herself of before consuming her own share. Her neighbour on the other side of the travis is so near that she may cough almost in her face. On both sides, therefore, is the hitherto unaffected young cow liable to be subjected to contagion when introduced to the amenities of cow life in winter-time.

Even if her neighbour on either side should be clear of the disease, the stance taken up by the young one may previously have been occupied by one that was victim to it, which, under ordinary circumstances, is about as bad a state of affairs as being alongside diseased animals. The usual kind of byre with the wall in front of the cows, rough and full of holes and crevices—at any rate, not pointed and smoothed as it might be—affords lurking-places in which the disease germs find safe harbourage. Deposited inadvertently by the diseased animal, and becoming dislodged thereafter in front of the newcomer, the latter gets opportunity of absorbing them into her system; or they may issue from crevices in the travis or from about the troughs.

In these and in many other ways have the young cows to run the gauntlet of the disease on admission to the byre. The atmosphere of the place is, as we have been endeavouring to make plain, conducive to the dissemination of the seed thereof, and also is favourable to the preparation of the soil for its reception. Warm, moist, and charged with organic matter, it favours the spread of the germs of the disease, while, on the other hand, it lowers the tone of the animals that have to inhale it, and makes them more receptive of the germs, and a better field in which they may flourish. With good air to breathe the animals would not so easily fall under the bane of tuberculosis; neither would the germs thereof be so freely spread about in a purer medium than usually prevails in our cow-houses. We should endeavour to bring the air of these places near to a par with what we find in the open.

Our Atmosphere.

Our atmosphere is a vast gaseous sea of unknown depth, enveloping the land and water that constitute our globe. Unlike the fishes, which are free to ascend and descend in their sea, we are obliged to confine ourselves to the bottom of ours, which is its densest part. But although the fishes elect the waters for their habitat and we the dry land, both of us exist alone by reason of making use of the oxygen of the atmosphere—they obtaining it from solution in the water, and we direct from the air itself. If one of either of these representatives of animated nature be deprived of oxygen, it ceases to exist.

Oxygen, as nearly all of us know, but are nothing the worse for being reminded, is the great instigator and supporter of life. It is due to the endless pertinacity of this chemical element that life goes on; but for it no manner of vital force could ever exert itself.

Its Composition.

The atmosphere consists almost entirely of a mixture of the two gases nitrogen and oxygen, four parts by bulk of the former to one of the latter. Nitrogen is as loath to combine with other elements or combinations of these as oxygen is ever ready to combine with them separately, or to have a finger in any pie that may be concocted of these. Thus we have one of the most active of the elements mixed with one of the most inert. No other, however, could serve so well to dilute the virulent oxygen. Ordinary combustion is but the oxidation of the substances being consumed. New combinations are formed, some of them gases and others solids. The gases escape in the atmosphere, the solids remain behind as ash. Much the same occurs in our individual organisms. Heat and force are developed therein by oxidation of the bodily tissues. The waste due to this constant combustion is made good by the food we consume. Our food is the fuel that keeps the fire going. We inhale diluted oxygen into our lungs; this is passed on to the different parts of the body by the blood as it circulates through the system, and it keeps the fire going as it proceeds. The waste products of the fire find their way into the return stream of the blood, eventually to be cast forth as excreta, or given off as gaseous emanations from various parts. And not only is this marvellous machine self-stoking— both as regards replenishing with

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fuel and the removal of the resulting ashes—but it automatically regulates the degree of heat to be attained, and guards against any marked variance therein.

Oxygen.

Pure oxygen would be too strong for life as at present ordered on our globe. Were we to be exposed to it we would probably be burned to cinders in a very brief time. Most of the elements take fire spontaneously in an atmosphere of undiluted oxygen. Iron filings thrown into it emit an intense light due to their combustion. A glowing ember inserted into it blazes forth at once. But Nature has enshrouded it in a thorough wet blanket: this everlasting busybody is severely effaced by the extremely negative nitrogen.

Nitrogen.

Nitrogen, notwithstanding its slowness to move, is a most important element where life is concerned. It is an essential element in all the most vital tissues and organs both of plants and animals; no cultivated plant can thrive unless there be abundance of it at its disposal in the soil. It does not suffice for them, however, that it be there in its simple form; plants can make no use of it in that way. It must be in combination with other elements before they can turn it to their own purposes, and even then as one certain compound—as a nitrate, one of the salts of nitric acid. In its elementary form plants are all their lives waving in the midst of it, yet unable to avail themselves of any. There is air, too, about their roots, and consequently nitrogen is within reach of these organs as well as of the leaves and stems. But they also are helpless in regard to laying hold of nitrogen, although it is by way of their roots solely that plants obtain their needed supply. If the soil be devoid of nitrates, plants may therefore starve in the midst of plenty.

Nitrogen is among the most plentiful elements in nature, but nitrates, as most of us know, are dear. Nitrogen in this form costs the farmer about sixpence a pound—and all on account of the exclusiveness of this element. Nitrogen is too coy for oxygen to induce it into partnership. Stronger influences than oxygen can put forth alone are required to bring about such a consummation. It goes on steadily all the same, steadily but imperceptibly. Under the influence of electricity the two are brought together to form the oxides of nitrogen, and then in time, with the addition of water, to form nitric acid. The latter finds its way to the soil, to serve as an important plant food.

If the plants are unable to make use of the free nitrogen of the air, we are less so. We cannot even turn the nitrates to account as suppliers of the nitrogen we need to maintain our bodies with. They must first be built up by the plant to the more elaborate substances which are embraced under the head of Albuminoid Bodies. The plant stores up these in the organs that are in future to serve as propagators of the species to which they belong.

Other Substances contained in the Atmosphere.

These two, then, the optimist oxygen and the pessimist nitrogen, form the great bulk of the atmosphere; but there are important substances present along with these in fresh air. The atmosphere is, of course, the great receiver of all evaporation and emanations that arise from sea and land, but only those are suffered to remain therein that are natural to it. Over populous places the atmosphere is bound to become the recipient of many gases and vapours and more dust particles than ascend into it from places in the country or away from the haunts of man. But these, unless of the kind that are characteristic of air, are soon returned to earth. Oxygen lays hold of any that are susceptible to its influence: rain carries the bulk of them back to mother earth. Eventually the air is cleared of them, either on account of the solvent powers of rain or of the action upon them of oxygen. The latter may cause those it has any influence over to assume a semi-solid state and settle out as a sort of precipitate; or it may render them more soluble. At any rate, the air soon clears itself of all impurities that reach it in this way. As the sea maintains its characteristic composition because it is obliged to stick to the more soluble of the stable substances that water from mother earth brings to it in solution, somewhat in the same way but inversely does the atmosphere maintain its standard composition by a process of rejection. What is not natural to sea-water, what cannot be held in permanent solution, is precipitated as a solid at the bottom; what is unnatural in the composition of the atmosphere is washed therefrom by rain or deposited as dust on the surface of the earth.

Next in importance, from a chemical point of view, to the two gases above mentioned as contained in the atmosphere are carbon di-oxide, commonly called carbonic acid, and ammonia, together with the oxides of nitrogen. There are present, too, the vapour of water as essential to the economy of life, and such wayfarers as microbes and dust particles. As compared with nitrogen and oxygen, carbon di-oxide is present in small quantity, from three to six volumes of it to ten thousand of the mixed gases being the accepted standard. This seems a small proportion relatively, but actually it forms a large quantity. This is the source whence vegetation derives its enormous supply of carbon. Fully half of the combustible matter of plants consists of this element. Coal is the fossilised remains of dense vegetation, overwhelmed and buried under sediment borne along by water ere ever the organic matter therein contained had time to decompose in a natural manner under the influence of oxygen. Shut off from the action of oxygen by the accumulating strata of rocks under which the coal seams now lie buried, the carbon stored up by plants in these remote ages has thus been reserved till the enterprising man of recent times began to understand its value as a heat and force giver.

Plants depend, we have said, on the atmosphere for the carbon with which they build up their tissues. Slowly but steadily they absorb it from the air that laves their leaves and stems. This they are able to do under the influence of sunlight. If the rays of the sun are denied them, this faculty is paralysed. By night it is in abeyance entirely, and instead of the plant then making use of the carbon di-oxide of the air, it is giving off that substance as the result of changes taking place in its constitution. Only slightly, however, does this retrogressive progress go on. Plants, unlike animals, are independent of internal heat, and using up tissue on their own account is therefore unnecessary as regards their internal economy.

In the animal system, as we have seen, the internal fire is never quenched so long as it holds together. Carbon is the fuel proper to the machine. We are consumers, not producers, of the commodity, and to plants we look for the needful supply. We put to waste in this way what they slowly and laboriously build up. They lay hold of the carbon di-oxide of the air, assimilating the carbon and letting loose the oxygen. The carbon they introduce to hydrogen and oxygen, which they derive from water, and the three unite in varying proportions to form woody fibre, starch and sugar, and the innumerable compounds allied to them. The wood warms us externally when we set it on fire; the starch and the sugar support the internal combustion of the individual. Heat is given off whenever chemical union between bodies takes place. In both cases instanced the result is the same—the carbon, which is so largely represented in wood, is being oxidised or converted into carbon di-oxide, and so with the carbon in both starch and sugar. In each instance the carbon is uniting with oxygen, or *vice versâ*, seeing the general aggressor is in question, and heat is being evolved. In both cases, too, the resulting carbon di-oxide is returned to the atmosphere; in the one directly from the glowing wood, in the other along with the exhalations from the lungs, and in lesser degree from the skin, the carbon di-oxide of the burnt tissue entering the blood that is returning to the lungs, there to be got rid of along with the excess of moisture. In this way is the balance of carbon di-oxide contained in the atmosphere maintained. Plants absorb it therefrom and animals in the act of developing heat and force return it. Every act of combustion, either slow as in imperceptible oxidation, or violent, as in fire, means the return of carbon di-oxide to the atmosphere. And so does all splitting up of organic matter — the remains of animals and plants—whether by reason of ferments or microbes or under the direct influence of oxygen. In their case, however, the contained available hydrogen is also oxidised, water this time being formed. So, of course, with the hydrogen in the starch and sugar already instanced.

It is wonderful how closely the proportion of carbon di-oxide in the air is observed by Nature. Out in the open it is found almost unvarying. It is different, of course, with the atmosphere which envelops towns and cities. There, many men and many fires are giving off much of this gas. Where the wind gets free play the polluted stuff is soon wafted away, to be replaced by air of a normal nature. But for all that, numerous are the nooks and corners that interrupt the air-currents and form eddies in which the foul air is at times free to lurk awhile. If this be so outside of houses, matters must be worse in places enclosed by walls and roof. There, of course, wind is not so free to replace the air that may be overladen with carbon di-oxide as it is to sweep the same out of street or court when it gets a chance. Besides, the building depends on street or court for its supply of air, which, under the existing circumstances, may not be altogether fresh.

Ammonia and the Oxides of Nitrogen.

Ammonia and the oxides of nitrogen as components of the atmosphere are, like carbon di-oxide, of more importance to the vegetable than to the animal kingdom. They serve no useful end so far as the animal economy is concerned. Indeed, there is so small a quantity of either of them present in the air as to be imperceptible to our senses except on the rare occasions mentioned below. It is from these, however, that soil in a state of nature receives its supply of nitrogen. Rain washes them out of the air and carries them to the soil. There, under the influence of oxygen, they are eventually converted into nitric acid, which, with lime or other base, forms the nitrate that yields nitrogen to the plant. Fixed nitrogen has, in this and other ways, been accumulating in soil that has never been disturbed by man. At the start it had no other means of obtaining nitrogen capable of acting as plant food than what came to it in the rainfall. Gradually, however, it became the receiver of fixed nitrogen, resulting from decayed plants that had been borne on its surface. A little would also be derived from the remains of animal life that in some way or other found a location therein. As time passed, when circumstances were suitable, tracts of soil in these ways grew rich in nitrogen. To all, however, whether spendthrift or saving, came, as it still comes, the annual supply from the atmosphere. The late Sir John Bennet Lawes, of Rothamstead, in his time the great British authority on such matters, tells us that the soils of England annually receive from the skies about fifteen pounds of fixed nitrogen to the acre.

Ammonia is a compound of nitrogen and hydrogen, while the oxides referred to consist of nitrogen and oxygen. Electricity gets credit for thus bringing the free nitrogen of the air into the latter of these forced companionships. The great heat of the electric fluid as it passes through the atmosphere forces the union. The peculiar smell one sometimes feels after lightning is due, it is said, to the presence of these oxides. Some ammonia may be formed in this way, too, but the most of it ascends from the surface of the earth. All decaying organic matter that has nitrogen as one of its component elements gives off ammonia. Soil absorbs what of it is set free in its midst, but what is given off from matter on its surface escapes into the atmosphere. The constantly recurring evaporation of water is also supposed to be responsible for some of the ammonia of the atmosphere.

Moisture.

The vapour of water—that is, water in its gaseous form—is the last of the special substances characteristic of the atmosphere. Although last referred to here, it is one of far-reaching importance. Water is in this form drawn from the oceans and carried away on the winds of heaven, to be dropped again by-and-by, and thus give vegetation a chance of receiving moisture. At sea level the weight of the atmosphere is equivalent to a pressure of 15 lbs. to the square inch. Were this weight removed, water would be free at once to change from the fluid to the gaseous state. Applying heat to water, and so raising its temperature, we bring it to a point at which its internal heat enables it to cope with the pressure of the air. While maintained at this temperature, 212° F., it continues to go off as gas until all has become vaporised. This is known as the "boiling point" of water. At this stage the vapour escapes violently in little bubbles of gas set free from the points of application of the heat. But at all stages, from this one down to its ice-forming stage, water is constantly, although imperceptibly, being absorbed into the air as vapour.

It cannot be so, however, without first assimilating to itself the amount of heat necessary to maintain it in the gaseous form. Heat impels the molecules of matter to assume the active form they reveal when it is in the gaseous condition. They are comparatively dormant in the solid, rather sluggish in the fluid, but full of restless energy in the gas. Both cold and pressure, on the other hand, force the molecules into a state of quiescence. Such a strong natural tendency has water to escape into the atmosphere as a gas, that in order to do so it will rob all surrounding objects possessed of heat of as much of it as they are capable of yielding. When after a wetting we feel chilly in our damp clothes, this is due to the water evaporising at the expense of the heat of our bodies. In the same way are wet and undrained soils kept cold. When they do become dry it is mostly under the influence of evaporation, which can only be accomplished at a certain outlay of heat. The necessary heat must either be derived from the soil itself or at the expense of heat that the soil would be free to apply to its own benefit were there not an undue amount of water contained in it ready to lay hold thereof. Wet soil can derive little benefit from the genial sun-rays so long as the surplus water it holds in its embrace claims to be first served.

The amount of water contained in the air is ever varying. The warmer the air the more moisture is it capable of absorbing. Air is said to be saturated when it holds the full amount of the vapour of water it can absorb. As the temperature of the atmosphere is constantly changing, it follows that there is considerable range in the atmospheric moisture. It is constantly running up and down the scale—at one time free to expand without limit, at another squeezed close to the critical point and on the verge of the fluid state. A current of warm air encountering or passing through some cold strata has its temperature lowered, and in consequence its retaining power over vapour is lessened. All excess of moisture is then obliged to resume the fluid state and fall earth or seawards. The warm air of the Tropics absorbs an enormous quantity of water as vapour from the sea. Much of this moisture-laden air is driven into colder latitudes, where as it begins to lose heat the then superabundant vapour condenses to form either rain or snow.

In a warm, moist atmosphere we feel languid and oppressed. Exertion becomes difficult because our energy grows dull. The fully charged air is slow to accept of more moisture, and we can hardly get rid of our bodily moisture that seeks escape in evaporation. This disturbs the balance and throws the bodily machine out of gear, giving one organ the work of some other one in addition to its own. In a badly ventilated building, whether occupied by men or animals, if filled to its capacity, the vapour of water is usually present in excess. This alone is not good. But when we add to it the other drawbacks we previously hinted at as being characteristic of the byre—the excess of carbon di-oxide, the gaseous emanations from the animals, the smell of the excreta, and relative nuisances—matters are bad indeed. They may not directly cause harm, but together they cannot but tend to the detriment of the animals that are for long stretches of time subjected to their influence. If nothing else, they together lay the animal open to become, as we said above, an easy seed-bed for the germs of disease-causing microbes that are apt to abound where crowding takes place.

Microscopic Organisms and Dust.

These microscopic organisms deserve more than a passing notice in this connection. The substances we have just been describing are inseparable constituents of the atmosphere. Excepting the two fundamentals nitrogen and oxygen, the proportion they bear to the whole may vary in accordance with circumstances. The amount of water, we have seen, varies in accordance with the temperature of the air and that within a considerable range. The proportion of carbon di-oxide varies perhaps least of all among these fixed accompaniments of the atmosphere. Ammonia and the oxides of nitrogen are more largely represented in the atmosphere of tropical countries than of the temperate and cold parts of the world. Where the sun has the greater influence, atmospheric disturbances are more frequent, as well as more violent and decided, and in consequence the substances referred to are more in evidence. But coming to the more adventitious constituents of the atmosphere, such as the germs and dust particles, we find the quantity of these varying considerably. These, as one would expect, are the most plentiful nearest to where cities and manufactories are situated. Away from mankind and their various works the air is comparatively free of them. Nature herself, however, occasionally acts as a pollution in this respect. Volcanoes emit immense quantities of gases and dust. It is wonderful how far such dust is carried on the air. Out in mid-ocean it can be detected by means of proper apparatus. In the same way as dust particles are spread abroad in the air, the germs of living microscopic organisms are disseminated far and near. Nansen tells of the presence of microbes in the pools of melted snow or ice as near to the North Pole as he was able to attain. There, if anywhere, we would be inclined to regard the atmosphere as absolutely pure. But the atmosphere is never stagnant. No bulk of it can ever be at peace for any length of time; one portion gets chilled and therefore reduced in volume and in outward pressure; the surrounding air presses in to restore the balance. A stratum next the warm earth expands under the influence of this heat, and thus becoming lighter, rises, its place being taken by streams of colder air ready to move in as it finds room. In ways like these arising from such causes is the atmosphere being continually stirred up and its contents, whether natural to itself or accidentally added thereto, pretty well distributed out over the face of the globe.

Although dust and germs are plentiful in the air at all parts adjoining the earth, it is not to be inferred that the latter are every one of a virulent or disease-causing order. The germs found free in good air are of the harmless sort so far as man and animals are concerned. Many of the everyday processes of life with regard to both plants and animals are supposed to depend for their proper fulfilment on the organisms of which these free germs are either the seed or the representatives. In fact, we are only becoming alive to the all-important, if not vital, part the microscopic members of the world play in promoting the welfare of the more visible members of creation. Not a few, as we know too well, fulfil their own ends at the expense of our lives, each species of plant and animal having apparently one or more that are specially adapted to make it a world to themselves regardless of the consequences to their supporters. But it is the minority (the more specially developed ones), it would appear, that bring harm in this way to their hosts. The widespread organisms are common to groups of beings, either plant or animal, and work for their good rather than their ill. From these we have nothing to fear.

Those of evil omen, if no less virile in themselves, are fortunately unable to let loose germs so tenacious of life as are those that drift about in the atmosphere. Once established in a congenial soil, they increase at an enormous rate, but the seed is not capable of withstanding circumstances that act adversely to it. Sunlight and fresh air are both detrimental to it. Filth, either semi-solid or liquid, and foul air are good nurseries for propagating these, to us, harmful little foes. Thus it is that in badly lighted, unventilated, and crowded places we find the disease-producing micro-organisms thoroughly at home. In house, stable, or byre, it is all the same. Not only, therefore, as we have seen, do places of this description lower the vitality of animals for long confined therein, and thus lay them open to attack by their insidious foes, but they serve to propagate these foes and to conserve the germs or seed thereof under circumstances most suitable to the purpose.

The woodwork of the buildings in which the air is suffered to remain in the condition just referred to is also severely tried thereby. The heat, together with the excess of moisture, is badly against the keeping powers of the wood. Matters are worse if it has not been well seasoned to begin with. Any remains of the sap that have not been got rid of will, under the circumstances we are dealing with, be sure to decompose and induce disintegration of the woody fibre.

Fresh Air in many ways essential within the Farm Buildings.

There are, it will be seen, many interests at the homestead demanding that some attention be paid to maintaining the air within the several buildings as pure as it is practicable to accomplish. We could, of course, easily maintain it about as pure as it is outside by simply leaving enough of openings for currents to play throughout them ; but then, the animals have to be kept warm as well as dry. Neither of these conditions could be attained under such circumstances. In the open air one can stand without inconvenience a degree of cold that he cannot face when wind is an accompaniment of the low temperature. A calm frost, even when intense, is often pleasant, but a blizzard never. When the air is calm the heat of our bodies radiates more slowly than it does when wind blows upon us. In the first instance, we are consequently parting with our heat slowly: in the second, it is snatched from us almost before it reaches the radiating points, and we are "chilled to the marrow" in a brief time. That is why we house our cattle in winter. The food they would require to consume in order to replace the heat necessary to maintain the temperature of life against the vicissitudes of weather we wish them to devote to the laying on of beef or the production of milk, and provide them with shelter accordingly. But in doing so, and thereby subjecting them to restraint and crowding, we cannot avoid subjecting them to a more or less polluted atmosphere, with all the evils that follow thereon. Neither man nor animal, as we have been endeavouring to point out, can breathe the same air repeatedly without risk to health.

Air that is breathed and rebreathed gradually loses the proper proportion observed between its respective constituents. Both carbon di-oxide and moisture gradually increase in quantity, both chiefly emanating from the lungs of the animals. But they emanate, too, from the pores of their skins. What proportion of carbonic oxide in air beyond the natural one an animal can inhale with impunity has never, so far as we know, been discovered. By itself, the gas is a deadly poison to the animal constitution. The choke-damp of mines is none other than carbon di-oxide. Perhaps it would hardly be possible to so pollute the air of an ordinary building such as we find about a homestead with this gas emanating from the animals as to reach the danger point to life. Doors and windows are never so tightly fastened but what some change of air takes place within the house. But there is slow poisoning as well as the quick process, and a long course of dilute poison may kill in the end as certainly as a dose of the concentrated stuff. At any rate, we find it oppressive to breathe air that has done service frequently. How much more offensive this becomes when accompanied by animal odours and the gases from decomposing excretal matters one is not long in discovering should he happen some bracing day in midwinter, after a turn in the fields, to enter directly into a byre of the ordinary stamp. In some instances it is literally appalling to feel the contrast between the two. After a while, if the case is not extreme, one becomes a little accustomed to it. But how different an effect must the one—the clear, crisp fresh air—have on the animal organism in comparison with the other, the one that at first taste gives an impression of foul suffocation impending over his head! That the animals do become accustomed to their surroundings and evidently thrive therein, so far as rapidly becoming fat or yielding milk amply may be held as thriving, can hardly be denied; but this does not imply that such is taking place under healthy influences. If placed under the latter, it is reasonable to suppose that the results would be even better.

The Difficulties in the way of providing this.

The difficulty, however, is, as we have already stated, the reconciliation of a free circulation of air throughout the house with the maintenance of a proper temperature within the same. If we let in much fresh air, which in winter is certain to be cold, we are bound either to let out much heat, or, what is the same thing, lower the temperature of what it mixes with. And warm either cow or fattening beast must be kept if we are to derive a full return for the food administered to it. And it has to be remembered that only rather primitive apparatus, such as described in last chapter, for facing the difficulty with are at our disposal. But even with these we hold that at the expense of a little care and watchfulness on the part of the attendants a medium may be struck whereby a comparatively sweet atmosphere can be maintained without undue sacrifice of the heat of the place.

The problem is hardest to solve with regard to cows giving milk. It is asserted, and the belief is almost universally acted upon by dairy farmers, that in order to get the most out of the cows the temperature of their house must be steadily maintained at about 60° F.—at least, it must not be allowed to fall below that. This can only be done in a smallish place, and then by reducing as much as possible the several openings in the walls and roof—carefully excluding fresh air, in fact. But there are many changes in the weather within a week, if not in a day, and what, as we observed previously, may suit one kind of weather will not another. The house can hardly be so situated as to be altogether cut off from outside influences. If the beasts within are comfortable when the blizzard rages without, what must they be in the muggy November nights, when fogs settle down and stifle all air movements in their embrace? Little wonder tuberculosis is rampant when such a favourable field is placed at its disposal.

Artificial Heat recommended by some Sanitarians for application to Byres.

Some of the leading sanitarians, with a notable disregard of the practical side of the question and of ways and means, advocate the introduction of hot-water pipes into the byre. But where the pipes, if forthcoming, could be stowed away in the buildings as we know them would puzzle most folks. Every ordinary byre would require to be remodelled ere room could be found within for the pipes and a suitable place obtained for the furnace and boiler connected therewith. Neither the cost of fuel nor the amount of labour necessary to keep the heating apparatus at work would be much felt by the tenant. These he could provide without any strain; but unless he attended to the matter himself he might perhaps have difficulty regarding the steady, if slight, care and attention that is needful to keep such an affair in order. In the case of a byre fitted up with a heating apparatus such as we refer to, one would certainly be at liberty to promote a freer circulation of air between the house and the outside than would be advisable in one where the heat that radiated from the animals required to be conserved.

This only admissible, however, in the case of Cows yielding Milk.

It is only the cows giving milk, however, that need to be coddled up in this manner during winter. Those in calf can, with benefit to themselves, be subjected to a more Spartan treatment. But in order to make matters right for the few that happen to be yielding milk, the others whose turn of motherhood has not yet come have to undergo all the inconvenience and risks to health above referred to. They may have to be semi-suffocated and nearly parboiled for weeks on end for the sake of the few. If the milk-giving matrons must be kept extra warm, it is surely bad policy doing so to the hurt and detriment of the remainder of the herd housed along with them. The way out of the difficulty is to have an artificially heated house constructed and set apart for the cows in milk during winter. It need not be large, because it is the exception for many of the cows at the ordinary sort of dairy farm to be brought to calve in winter-time. Where winter milk-selling is a practice of the farm the place would, of course, require to be larger. But holdings where this is observed are generally near towns, and rather out of the run of the usual type of homestead.

No need for it where other classes of Stock are concerned.

With the actual milking stock thus provided with heated quarters where air is freer to come and go than can be permitted under prevailing circumstances, we can deal more liberally in the matter of air supply with those they have been parted from. The latter, not now requiring to be put in purgatory for the sake of the few that are being treated something like invalids, may be dealt with in a rational way. They can do with a cooler atmosphere; therefore, a freer exchange of air can be permitted in their house of detention.

The same applies to the fattening cattle. Some managers believe in keeping them in almost as warm a temperature as we quoted in connection with the milk cows. This is surely unnecessary. It is bad management, on the other hand, to subject them to cold. But there is a happy medium in this as in other things, and it can be obtained without shutting up every crack and crevice in the walls of their house. Many a good beast is turned out of the sheltered cattle courts during the season. These get air at first hand; but then, unlike their stalled fellows, they are, of course, free to move about at pleasure and assume almost any attitude they choose. Those confined in the covered boxes come between the latter and the tied-up ones as regards the degree of heat adapted to their comfort and well-being. They too are free in the matter of attitude, and to move about, although in a far more circumscribed space. They are too much restricted in movement, however, to be left without some attention being paid to keeping them warmer than they would be if left outside.

But the stalled oxen or heifers, which in common with the cow have barely enough room in which to stand or lie, not to speak of being able to move about therein, need to be in an atmosphere at a temperature between 50° and 55° F., if food is not to be wasted in keeping them warm. A pretty liberal exchange of air can safely be allowed without interfering with this arrangement—a freer one, at any rate, than can be permitted with regard to the byre containing cows in milk. Even with it, however, some of the heat radiating from the animals has to be conserved for the purpose of keeping the air of the house warm. What suits the requirements of the fattening animal is, we maintain, sufficient for the interests of the cows in calf until their time of crisis arrives, when they can be relegated to the heated house above suggested unless the season be so far advanced that this is hardly worth while.

It amounts to this, therefore, that the in-calf cows, the fattening animals, and the juniors of the two classes, all of which, when confined in byres, thrive under a moderature temperature, may be allowed a liberal supply of fresh air. This can be given to them without fear of making their enforced quarters too cold. And with the simple arrangement we propounded in last chapter for enabling the attendants to govern the admission in accordance with atmospheric conditions fitted up, there is not much excuse for some degree of regularity not being observed in the aeration of the buildings that contain those classes of cattle.

The usual Condition of the Atmosphere within the Stable.

Coming to the horses, it is very common to find them in an overheated atmosphere in the stables. Unless the stable be wide and lofty and freely ventilated, the animals, if confined therein for a few hours, soon render the air of the place both obnoxious and warm. There is no necessity for keeping the horses unduly warm in the stable. Farm horses are seldom clipped and their coats in winter are heavy. If during the night their house becomes too hot, they perspire, and by morning the pores of their skins are relaxed and their coats damp. When morning arrives they are taken out in the face of hard frost, pouring rain, or it may be the cutting east wind. It requires a horse with a strong constitution to face circumstances of this nature very long with impunity. Much healthier are those horses which are stabled in roomy buildings wherein air is comparatively free to circulate. They turn out in the morning better fitted to face the weather, whatever it may be, whether cold, wet, or windy. The Vet. is seldomer in evidence about stables of the latter than of the former description. The arrangement recommended for aerating the byre answers equally well with respect to the stable.

County By-laws with regard to Farm Sanitation.

Officialdom has begun to concern itself over the matter of fresh air for the animals of the farm when housed. It does so directly in the case of cows connected with the milk supply of the public, because the owners of these come under the provisions of the Milk Shops Act. And indirectly it is beginning to gain a more comprehensive control on account of the right of interference that County Councils, through their health officers, now have in respect of farm buildings. These men in authority cannot enforce their by-laws at farms that do not come within the scope of the Act referred to, unless, of course, the homesteads are a menace to the health of the people about the place, and a nuisance generally; but in one or two counties advantage is being taken of statutory powers, and no building can be erected or alterations made in existing ones, without plans of the same have been first submitted to and approved by the health officers of the Council. This departure, when it becomes general (for it can be universally adopted at any time), is bound to tell its tale. But knowledge of what is needful under such circumstances, as well as the use of common-sense and tact in expressing the same, will be needed on the part of those who are to have such large discretionary powers if heart-burning is to be avoided and much money prevented from being wasted.

Why the Central Authorities have sought to regulate the Size of Cow-Houses.

Hitherto the central authorities in such matters not being able to enact any system of ventilation which would serve for universal application, and further make sure that when in force it would be attended to, have been obliged to content themselves with providing that byres devoted to milk-cows shall be of such and such a size. So many cubic feet of air space must be set apart for each of the cows, the amount, however, being left to the discretion of the respective County Councils. But this has not improved matters very much. It does not imply that because one byre embraces more space within its walls and roof than another of equal accommodation, but neither so wide nor so high, that the air of the former is always the purer of the two. Indeed, it is often the other way about. Here as before heat is the crux of the question. The air within the larger place will be the more difficult to keep warm, and in order that this may be done as effectually as possible, there must be the very minimum of outside air allowed entrance. The tighter closed all openings are kept the warmer will the interior of the house be. More or less fresh air may be admitted into the small building, but it must be jealously excluded from the large one in the endeavour to maintain some degree of heat therein.

Some of the Anomalies which have arisen out of that Interference.

It is apt to be inferred, because we generally feel the atmosphere of the larger place less offensive, that it is the purer of the two. When it is less obnoxious, the true cause is usually due to its being lower in temperature. Used up or polluted air of the kind referred to is less offensive when cold than when warm. We can put up with a tighter closed bedroom in winter than we can in summer. We are using as much air too in the winter—in fact, more, on account of the greater demand on oxygen to promote the increased internal combustion to cope with the greater loss of heat through radiation from the surface of our bodies.

To begin with, the animals in the larger byre are assured of more air than those in the smaller. But air is not like more material substances that can be consumed part by part, the last remaining unchanged until its turn to be made use of comes round. Once a beginning is made to inhale it whatever comes forth in the succeeding exhalation is diffused at once throughout the bulk of what is being started on. This property of matter when in the gaseous condition distinguishes it entirely from fluids and solids. Solids reveal no trace of it, and fluids hardly any. Different fluids do show a tendency to form a homogeneous mixture when brought together, and when a solid is dissolved in a fluid it inclines to affect the whole medium into which it merges, but all the same the fluid tends to settle in strata or layers of different densities. From this there can be no such continuity of substance in a mixture of fluids that is found to obtain in a mixture of gases. When two or more of the latter, no matter their difference in density, are brought together and left free to commingle, each at once begins to lose itself among the others, reaching to the farthest limits that bound the whole. This law is known as the diffusion of gases. No two gases can be brought together without each losing itself in the other, the eventual mixture being thoroughly homogeneous in all its parts. This is, of course, the prime means whereby the atmosphere maintains its original character under all circumstances. It is no doubt helped, as already pointed out, by the various phenomena that cause currents and disturbances in the aerial ocean that envelops us all. There is thus no reserve of absolutely fresh air possible in either building. The air of both alike begin to be polluted when the first breath is taken in either. It is simply a matter of degree in the rate of the pollution. And once the air of the larger place has become spent (if such a word may be used here), or obnoxious, the initial advantage over the smaller one possessed by this building in its being able to hold more air at the start and so take longer to become offensive is lost, and the beam turns against it over the matter of temperature. Communication between outer and inner air must now be rigidly cut off if a due amount of heat is at all to be maintained in the place. But with the smaller one, even in times of storm and stress, an occasional sniff may be allowed in without much heat being lost, while at ordinary times a fair amount of circulation between the pure and impure may without fear of the consequences be permitted.

It follows, therefore, that while the larger place must necessarily be the colder, it by no means holds good that it is the better aired of the two. If our reasoning be correct, then it must be waste to go to the expense of building byres beyond a medium size. We may make them large, and at the same time be free to ventilate them without stint, if we fit them up with hot-water pipes, but the "if" here presupposes what cannot be got over in conditions where sound economic principles prevail. The landlord would be spending extra money for which there was no call, or at least from which he could hardly expect to receive any return; and the tenant would be put to extra outlay that might be dispensed with. A medium-sized house, such as we shall afterwards describe when we discuss the byre more in detail, fitted with the simple contrivances for regulating the circulation of air, can, as argued above, be made to answer the purpose effectually, especially if it be supplemented with the casual ward referred to for the use of the animals giving milk.

In the department of ventilation we have been dealing with, one would think that we have been treating the pure outer air as a thing to be avoided on the whole, and, as it were, kept at arm's length and only allowed access to the houses in small quantities at a time. So indeed are we almost obliged to act with regard to the animals when in winter quarters. With the dairy buildings, on the other hand, we are free to flood them with fresh air. This is partly in order to keep down the temperature, but principally to prevent stagnation of the air anywhere within the buildings. Stagnant air, as we have already remarked, is conducive to the well-being of moulds and other lowly organisms, all of which are inimical to the products of the milk-house. The dairy worker is more alive to promote the interests of the microbes that act on his behalf. The best of these, so far as he is concerned, thrive most in surroundings where the air is pure and free to circulate. About this we shall have more to say when dealing specially with the dairy premises. In the other buildings composing the homestead we ventilate for the purpose of keeping the air moving on, and avoiding the evil consequences that follow on its non-observance.

CHAPTER VIII.

The Water Supply—In Theory.

Good Water, and plenty of it, essential at the Homestead.

It goes without saying that good water, and plenty of it, is essential at the homestead. It must, like Cæsar's wife, be above suspicion so far as contamination from what proceeds out of the abodes of men is concerned. But this is no easy matter even in country districts. Where the land is chiefly pastoral, man and his works are less in evidence, and there is not so much risk in this respect. Scarce and well scattered, however, comparatively speaking, as are men's habitations in the strictly arable parts of the country, there, little as the novice would think, one has to be wary in selecting water that has to act for domestic purposes. The burns or streamlets are liable to receive drainage matter from cottages, either on the farm which the homestead serves, or from others on neighbouring farms situated on higher ground. Should they escape contamination of this sort there is still the risk of what may have been added to the ground in the way of manure to be faced. And where police manure—the sweepings of streets, contents of middens and ash buckets, and so on, mixed together—is put to use in this manner, the danger is no imaginary one. Wells that are independent of surface water and far enough removed from houses to be out of reach of any manurial matters that might thence find their way in are the safest source of supply. No well is independent of surface water, of course, seeing that the water all comes from above as rain. But the source of a well can be deep enough to be independent of the immediately overlying surface for its supply of water. The latter may be drawn from either a widespread or remote area, the water having to descend far ere it can affect the well in question. It is this indirect connection with the surface, therefore, that makes for the purity of the water. It has to pass through much earth or porous stone in its way to the well, which means that it undergoes the process of filtration. Should it be polluted or contaminated to begin with, it becomes purified as it percolates the earth. In losing the one form of impurity, however, it is almost sure to take on another, but one that it is not at all vital such as the other is liable to be. To understand this it is necessary to make clear what pure water is.

Absolutely pure Water not met with in Nature.

Absolutely pure water is not to be met with in nature. Rain, before coming in contact with the earth, is the nearest approach to it we have. But we saw in the preceding chapter what rain is apt to wash out of the air as it condenses therein. It brings with it to the earth dust of various kinds and several gases, air itself in small quantity, together with those we mentioned as being natural to the atmosphere, and occasionally others that find their way there either as the result of man's work or of some abnormal terrestrial conditions. And once the earth is reached its original comparative state of purity disappears. The distilled water of the chemist may be accepted as almost pure. In the process of distillation the water being dealt with has the gases that are dissolved therein driven off as the heat is applied to it. At boiling-point the water passes away as vapour, to be cooled down and condensed again into fluid, this time rid of all extraneous matter that was previously mixed up with it, the gases returned whence they came, and the solids left behind in the vessel wherein the water was boiled.

The Composition of Water.

Water pure and simple is composed of the two elementary substances, hydrogen and oxygen, the former as well as the latter being, when free and subjected to ordinary circumstances, a gas. This time the busybody oxygen is completely disguised in the fluid. Water is a chemical compound, not like air, a mixture only. In the compound the substances which take part therein lose their identity—the individual merges in the state. In the mixture each is as it was before the mingling took place, although in looser union and, consequently, diminished force, on account of the watering down due to the crowd of strangers in its ranks. Oxygen is still oxygen, although, as we know it, in the air it is pretty well smothered by the wet blanket nitrogen. But oxygen as a component of water has totally parted with its individuality. Another property thoroughly marks off the compound from the mixture. The components of the mixture make no demonstration when shuffled together, but the components of the chemical compound, when brought in contact, go through more or less violent disturbance, heat being always concerned in the business. Heat is made manifest when the bonds of the compound are being entered into, and conversely the application of heat is required to break the compact and liberate the parties thereto.

Two volumes of hydrogen go to one of oxygen in the formation of water. All gases are physically built up of molecules of equal size, like as sandstone is built up of grains of sand. But the grains of sand are stable, while the gaseous grains—the molecules—of the gas are mobile and restless. The molecules of a gas are for ever striving against pressure. The slighter the pressure they are put to the more do they expand; and this will go on until the last degree of tenuity—whatever that may be—is reached. On the other hand, the pressure may be made so great that the molecules of the gas, being squeezed into so small a space, can no longer hold out against it, but are driven to take up the fluid state. Fluids yield comparatively little in bulk under the influence of pressure. In proof of this we have the steady, enormous force that is available in hydraulic machinery, which is simply the turning to account at one point the pressure exerted on enclosed water at another. The molecules of the gas rendered liquid are still freer to move in the mass than in the solid body, although more cabined and confined than they were before being squeezed out of their original condition. Increased pressure, it is evident, will not coerce them into the sluggish state they pass into when the solid form has to be assumed. But lowering their temperature will. If we reduce the temperature of the molecules in water to a certain degree, they can no more hold out against this than could the molecules of the gas against the critical degree of pressure. Reducing the temperature of water to the freezing-point brings the molecules thereof to the torpid state they are driven to in the solid.

The three physical conditions of Water.

All matter, whether simple or compound—whether consisting as one of the elementary substances by itself, oxygen, for instance; or made up of two or more of these to form a chemical compound, as water, by way of example—takes on in accordance with circumstances the three states of solid, liquid, and gaseous. Few elements or compounds assume the three forms under everyday sort of conditions, the bulk of them having a wider range between the various stages than is included between the extremes of even our variable climate. Water is one of the substances that does. At all temperatures between 32° and 212° F. water remains fluid. The pressure of the atmosphere due to its weight is sufficient to withhold the molecules from bursting forth unfettered in vapour. True enough, water is always emitting more or less vapour into the atmosphere in accordance with the condition of the latter. But what escapes in this way is little in comparison with the water yielding it. If we place water in a vacuum the pressure of the air is removed from it, and the molecules are freed and the fluid takes on the gaseous form. We do something equivalent when we heat water up to boiling-point. The heat puts energy into the molecules sufficient for them to cope with and overcome the resistance to their liberty caused by the pressure of the atmosphere, and to burst forth as steam or gas in spite of this.

At 212° F. water passes into the liquid form of matter; cooled below 32° F. it solidifies into ice. These figures refer to sea level and average atmospheric pressure, conditions which speak to a pressure of fifteen pounds to the square inch. As we rise above sea level the pressure decreases, the air becoming less dense as we ascend, and in consequence water will boil at a lower temperature on high ground than it will at sea level. Not so long ago this fact was turned to account in measuring the height of mountains.

Neither oxygen nor hydrogen by itself can be forced so easily to take upon itself the three forms of matter at the will of man. It is only recently that either could. Both enormous pressure and a most excessive degree of cold are together required in the accomplishment of these feats in chemistry. But water (the two combined) we see can be put through these phases by means compatible with ordinary workaday conditions.

Latent Heat, as exemplified in the case of Water.

Water when at the point of passing from the solid to the liquid form—from ice to water—absorbs a large amount of heat of whose presence it makes no sign. One pound of water at a temperature of 144° F. added to one pound of ice is just sufficient to turn the ice into water, without, however, raising it to a higher temperature than 32° F.—that of melting ice or water at the point of freezing. But add a pound of water at 144° F. to another pound at 32° F., then the temperature of the mixed water will be 88° F., or the average of the two. What then has become of the 144° F. of heat in the first instance, which is absorbed without revealing any outward trace of its effect? It has gone to give the molecules of water the energy necessary to enable them to maintain against external pressure the state of fluidity. All the heat beyond that amount received by water becomes apparent to our senses in its rise of temperature. If heat be steadily applied until a temperature of 212° F. is attained, another disappearance or absorption of heat takes place. This is the point at which water takes on the gaseous form.

But water when about to pass from the liquid to the gas drinks up much more heat than is lost sight of when passing from the solid to the liquid. About one thousand times the amount of heat required to raise a pound of water one degree in temperature is needed to fortify the molecules in that weight of water in assuming the free state represented in the gas. It takes nine hundred and sixty-seven thermal units to convert one pound of water at 212° F. to steam at the same temperature. In other words, if to be had, one pound of steam at 967° F., if added to one pound of water at 212° F., will give us two pounds of steam at 212° F.

The heat that in both instances thus disappears is termed latent heat. But although latent or hidden, this heat is by no means lost. Every portion of it is duly returned when the reverse processes take place—when the gas returns to the fluid and the fluid reverts to the solid. A knowledge of these facts regarding the physical properties of water brings home to one's understanding the important part that is taken by this homely substance in the economy of nature. The heat of the tropical sun draws, as we have already mentioned, enormous quantities of water from ocean surfaces in the form of vapour, to be wafted far and near throughout the atmosphere. Wherever this vapour is condensed to rain, gaseous water is being changed into fluid and the latent heat shed abroad in the surrounding air. Every inch of rainfall means a hundred tons of rain to the acre. In each inch of rain, therefore, let loose from the atmosphere, there is liberated in that medium about a quarter of a million heat units. Water thus serves to distribute the heat of the sun more uniformly over the globe. We find it of great use in our concerns as a carrier of heat. It rises readily in temperature, and parts steadily with its heat between the range of its minimum and maximum points of fluidity. But nature is able to deal with it in the highest phase—the wholesale one, as it were—and get the advantage of the bigger deals.

Falling snow, as most of us will have observed, is warmer than sleet, because snow is not robbing the surrounding air of heat to anything like the extent that sleet is. As regards the latter, it is half-way between the solid and the fluid, but tending towards fluidity and hungry for the heat that will enable it to rise in the scale. The snow, on the other hand, is not so grasping of the heat of surrounding substances, and they are not called upon to pay tribute to it so much as to the sleet in its search for the necessary heat wherewith to subsidise the greedy molecules it contains.

Water in its solid form also plays into our hands on occasion. It slightly contracts as it decreases in temperature until within a few degrees of the freezing-point, when it begins to expand until it passes into the solid. On this account ice is lighter than water, and freezing takes place at the surface instead of the bottom of any sheet of water. Were it otherwise, mundane matters would not go on as at present arranged. It is in accordance with this law whereby water expands on freezing that frost ameliorates our soils and weathers down rock surfaces in preparation for fresh soil-making material.

Water as the universal Solvent.

It is, however, with water as the great solvent that we are here most concerned about. It is on account of this solvent property of water that there is so much difficulty in obtaining it pure. Before it reaches the earth it has, as we pointed out, laid hold of the gases of the atmosphere—air itself, carbon di-oxide, ammonia, some of the nitrogen oxides—and of the dust and other suspensory matter that may happen to be floating therein. But with all this it is comparatively pure when it touches earth. Indeed what it has picked up from the atmosphere increases its solvent powers. The carbon di-oxide it absorbs in passing from the air to the earth enables it to dissolve solid matters of the universe on which it would otherwise have little effect. No sooner, therefore, does it fall upon the earth than it loses the comparative purity it came with.

Next in purity to rain-water comes the water of lakes, and following it that of rivers. Running water has more matter in suspension than lake-water. The one has time to settle and let fall to the bottom any fine matter it may have held in this way. But the ever onward course of river-water prevents its loitering by the way to clear itself of what it is bearing along. Rivers that form lakes as they lead their waters to the sea emerge from the lakes purer than they entered, just because their course has therein been arrested for the time and the suspensory matter given a chance to gain the bottom of the water.

The Suspensory Matters in Water.

This suspensory matter, it has to be borne in mind, is entirely different from the matters held in solution by the water. The dissolved substances, whether solid, fluid, or gaseous to begin with, lose themselves for the time being in the body of the water and take part with it in the various phases it may have to pass through. But although they lose their identity to this extent they still make their influence felt. Different substances have different points at which the physical changes in matter take place. So long, therefore, as these relating to water and what it holds in solution do not clash, the two act in unison physically while each is free to exert its own peculiar influences. In the distillation of water, for instance, we get rid of what it contains by acting in accordance with these simple principles. The air contained in the water to be purified in this way is driven off as the water begins to boil. Other gases may also then go. For a little time, therefore, the water may be allowed to boil and the vapour to escape without our seeking to condense it. In the latter process we simply lead the vapour into a cooling pipe or chamber and collect the resulting water. We rob the vapour of its heat and oblige it to revert to the fluid state. Those substances dissolved in the water that do not vaporise or pass into gas at 212° F., the point at which water does, are consequently left behind when all the water has been boiled away. Were some other fluid dissolved in the water taken to be distilled it would, if its vaporising point were lower than that of water, have escaped before the water began to boil, but if it happened to be higher, then it would remain as part of the residue in the vessel wherein the water was boiled.

There is, however, no such firm bond between the matters in suspension in water and the water itself as exists between water and what it contains in solution. The right relations between the latter two are in fact not yet clearly understood. They are not in direct chemical combination, but that there is some slight approach to this is evidenced by the heat that is evinced when some substances are dissolved in water. Dissolved matter is difficult of withdrawal from water. The separation of the two has to be attained in roundabout ways, taking advantage of the laws that bear upon chemistry; but the matters in suspension can directly, by simple mechanical means, be removed from water. What will not settle down of its own free will when water is allowed to remain undisturbed and gravity is given a free hand to assert itself, can easily be abstracted by filtration. If water be allowed to drain through porous strata of some kinds, the solid matters it contains are arrested as the water penetrates, they being unable to pass through where it can. This fact is turned to account in the artificial filtration of water. On the large scale water is filtered by passing it through layers of gravel and sand. We see the chemist doing the same thing in a small way by letting water soak through a sort of porous paper resembling blotting-paper. The filter has no effect whatever on the matters that are dissolved in the water. They go with the water to wherever it penetrates.

What happens to Rain when it touches Earth.

It is evident that rain-water, with its great solvent powers, no sooner comes in contact with the earth than it rapidly picks up matter and carries it along either in solution or in suspension. The rain that does not immediately enter the soil makes at once along the surface in search of a way to seek the level of its parent, the sea. In many cases this is a long and troubled journey. At one time the way may be gradual and unobstructed: at another precipitous and in a channel both tortuous and jagged. The raindrops unite in the ground, and as they accumulate their combined weight becomes sufficient to urge them on in obedience to gravity till equilibrium is gained in the ocean. The nearer they get to their journey's end the larger the stream of others they fall in with, all bent on the same errand of returning whence they started. They left empty-handed, but they return laden with spoil, some of it bound closely in solution and some merely held in suspension. The stronger the velocity of the converging streams the more of the latter there is likely to be. But a good deal depends, of course, on the nature of the district watered by the streams for the quantity as well as the quality of both dissolved and suspended matter contained in the seaward-bound water. If the earth and rocks be of a friable nature, a great deal of matter is borne along by the running water. In the same way, if, for instance, the district traversed by the water is one where limestone predominates, the water will have dissolved much lime during the time it took to collect and pass on.

When the sea is reached the stream slows down, and the suspended matters begin to fall. The heaviest material is dropped first and the finest last, the interval between being taken by the intervening grades. Geologists tell us that the earth's surface is being slowly reduced through these two actions on the part of rain-water—its solvent action and its action of carrying along with it loose matter that is unable to resist its power when brought within its reach. It is the latter action, however, which tells most in wearing down the earth's crust, and tending to bring all under the surface of the sea. It gets credit amongst scientists for having to a great extent moulded the surface of the earth as at present revealed. Dreadful contortions, upheavals, and subsidences have undoubtedly often put new shapes on the earth's surface when adapting itself to changing pressure due to the more rapid cooling down than now takes place; but rain is allowed to have, in recent geological times, done more in eating away the uncovered crust of the earth than all other agencies of the kind put together. It has eaten out the passes and valleys, and slowly rounded off the rugged outlines of hills, and cut deep furrows into the mountain sides. This action of rain tends to level down the crust to a more uniform outline, if not to carry all seawards. But the crumblings of the elevated peaks do not all get the length of the sea at once. The bulk of them go to raise or at least extend the lower-lying lands. They, too, however, are constantly paying tribute to running water, and paying with one hand as much as they are receiving from higher lands in the other. The process is a long and almost imperceptible one, but steadily the sea is gaining mastery of the land and reducing it down to its own dead level.

What the Sea receives back in the Rain-water it gives forth to the Atmosphere.

The sea gives off into the atmosphere its moisture in the form of vapour, much of which falls upon the earth as rain, more or less of it returning once more to the sea. But it brings to the sea, as we have said, matters dissolved from earth and rocks and others worn therefrom, which, though unable to dissolve, it is capable of bearing along with it in its descent to the universal level. What it carries mechanically it lets drop when it reaches the sea. And what it brings with it in solution the sea absorbs, if able to retain the same. If not of a kind over which sea-water holds a permanent sway, it will be rejected from solution, and it, too, will find a resting place on the sea bottom. But the sea will hardly reject what river-water is capable of holding in solution. The salts of sodium, calcium, potassium, and magnesium are the leading chemical substances that rain-water robs the earth of, making the sea the resetter. Neither river nor sea-water holds such solvent powers over other earthy matters as over these, consequently the salts referred to are the substances that characterise sea-water. Common salt—chloride of sodium, formed by the union of hydrochloric acid with sodium—is the predominant substance in sea-water, and the one which gives it the characteristic taste we all know so well. It is this selective power on the part of water over what it will hold in solution that enables sea-water to retain its distinctive character without appreciable change. Sea-water, taken on the whole, is bound to be growing salter. Enormous volumes of fresh water are ever pouring into it, but that water originated from itself, leaving it pure, while it returns with other substances in its grasp. A point there is beyond which water can absorb no more of any separate substance, the point in question varying with each. That point is the point of saturation of water with regard to any of the soluble substances. When it is reached, no more of the special substance can be dissolved. Ordinary sea-water is as yet far from saturation, and therefore still has room in its embrace for much of the salt of the earth. In the Dead Sea, over which evaporation is freely exercised, and into which little or no river-water finds its way, the point of saturation is near at hand. From similar causes the sea-water under the tropics is salter than that near to the poles. At the one place evaporation is constant and rapid; at the other there is little evaporation, while snow and ice, unsullied as regards contact with the earth, though derived from atmospheric moisture, are steadily returning to the sea-water almost as fresh as the vapour that escaped therefrom under the heat of the nearly vertical sun.

What Surface-water generally contains.

What is picked up by water as it runs along the surface of the earth, or percolates by short cuts underground to appear at lower levels, is not as a rule harmful to man. In the first case is included brook, river, and lake-water, and in the other that of springs and deep wells. The water of the former class is characterised by the foreign matters they contain being more in suspension than in solution: that of the latter, on the contrary, being almost wholly in solution. The reason is plain enough when we consider that the one journeys along amongst loose material and open to whatever is wafted its way by the wind or is dropped from cliff or bank as it is impelled onwards: and that the other, as it seeks downwards through earth and rock, while offered many chances of dissolving such earthy salts as those above referred to, has no opportunity of carrying away solid matter in suspension. The matter beneath the surface is too well packed to admit of much being abstracted in this way. It may encounter strata which if by themselves and exposed it could successfully attack and disintegrate, bearing the fragments with it; but when these are sandwiched between others of stronger cohesion and are but part of a group, water is able to affect them by means of its solvent powers alone.

The big continental rivers, long ere they approach the sea, are discoloured by the matters they are bearing along in suspension. So, too, are our rivers in their times of flood. It is not to these, however, nor to lakes, that homesteads ever have to look for their water supply. When surface-water is the source of supply, it is usually among the tiny tributaries to the parent stream of the district. The water in these has not travelled so far as to be so smirched from contact with the earth as to be unacceptable at the homestead. Where artificial filtration is practicable the matters in suspension, provided the water is good, are no obstacle to its use. They can be readily removed by this process. But at the farm it is not practicable.

Filtration not very practicable at the Farm.

It is an operation that requires close attention by men experienced in the work. An ill-kept filter, especially such a one as we should be likely to find at the homestead, is more dangerous than unfiltered water — the water is safer before than after it has been passed through. The water supplies of populous places are always filtered before use, but this is done on a large scale and on fixed principles such as can hardly be observed at the ordinary homestead. It is wise, therefore, in selecting a supply of water for the homestead, to fix on a source the water from which is sufficiently free of suspended matter to render filtration unnecessary.

Water from deep-seated wells needs no filtration. When one of these is available to get the water handy therefrom, it is a fortunate circumstance for the occupier of the farm. He is then sure of water of a clear character. It may, indeed, have much matter in solution, but there will be little, if any, in suspension. The water will have had to percolate too far for any matter of that kind to have been able to accompany it. Surface wells, like open streams, are apt from their situation to receive all manner of loose material, and, what is worse, drainings that bring with them deleterious matters either already dissolved or ready to enter into solution. The nearer the surface we come we get more into the part of the ground where waste vegetable and animal matter is undergoing decomposition, and thus water that lies in that position is almost certain to receive more or less of the matters resulting from this never-ceasing process of decay.

Dissolved Matters more to be considered than Substances in Suspension.

It is not, however, usually the matters in suspension in water that we have to be on our guard against. Those in solution are the aptest to render water dangerous to mankind. But as a rule it is only those matters, whether suspended or dissolved, that can be traced back to man himself that render water containing them dangerous to his fellows. It is in the fact that water which has been in direct contact with man, or has been the recipient of matters that have been derived from him in some way or other, may contain germs of various diseases, where lies the danger of its use by others of his kind. Even if it has kept clear of these dangerous guests, the other matters it is likely to contain on account of its connection with man and his doings make it a favourable nursery-ground to these should they at any time effect a lodgment therein. Organic matter derivable from man and his doings is, therefore, the worst kind we have to do with in water. But organic matter being represented either by the decayed fabrics of bodies that have been quickened by life in some one or other of its phases, or the result of the waste of these while alive, it follows that the vegetable as well as the animal kingdom has also a considerable hand in the contamination of water. Organic matter, however, which is traceable to animal life is, as we have been saying, more than the other to be feared in relation to water that has to be turned to account by man. The effective filter is capable of removing these dangerous substances, that is to say, those in suspension, be they derived from animal or vegetable, and disease germs as well if present. The filter, however, we maintain, is not practicable in connection with the homestead.

If we can manage to avail ourselves of a source of supply that is well removed from dwelling-places, or otherwise free of contamination therefrom, we have little to fear from the danger of disease germs peculiar to mankind; and further, if the burn, well, or spring be comparatively free of matters in suspension, we are fortunately situated as regards water for man as well as for beast. We may, without fear of evil results, use it as we find it, and be thankful. It will of course contain, in accordance with its opportunity of picking up the same, more or less of the earthy salts and other matters that water derives from the soil and rocks. Rarely will it contain any that render it dangerous. Its solvent powers may, in consequence of what it already has assimilated, be slightly impaired. The more matter it already holds in solution the less will it be inclined to add thereto as it keeps pressing on to find a resting-place. It will seldom, however, have its solvent powers affected to the extent of seriously interfering with its usefulness.

Lime the most abundantly represented of Dissolved Matters.

Among the earthy salts already mentioned as those most likely to be dissolved in water that has percolated far underground are those of lime. Very seldom do any of the others put their stamp effectually upon water. In the rare instances they do, they render the water offensive to taste, and sometimes to smell, and therefore useless at the homestead. Neither man nor animal will, unless hard pressed, face water that either tastes decidedly or smells of any matter that it holds in solution. And if water be unpalatable in drinking, it will never answer for cooking. Iron is, in many districts, a frequent cause of rendering water unfit for domestic purposes. It is present in nearly all water that has been much underground, but only in exceptional cases to such an extent as to be a nuisance as far as our wants go. Well-water, as we all know, is more sparkling and palatable than either river or rain-water; and this is by reason of its containing more gases as well as earthy matter in solution than either of the other two. Rain-water is almost devoid of the earthy or mineral matters referred to in the instance of spring-water, and it is extremely insipid to the taste. Lake and river-water come in grades between the two just mentioned. They have neither had time nor opportunity to pick up what the spring-water has, both as regards gases and salts; but they have improved on the chances of rain-water in this respect. So long, therefore, as spring-water is able to observe a due proportion in what it abstracts from the soil—nothing of this, of course, being dangerous—and no substance is so prominent as to assert itself over the others, we have the most palatable of all waters at our disposal. It may not be the best one theoretically, seeing that its solvent powers are already so well exercised, and the place of water in natural economy being the great solvent agent. But spring-water is hardly ever so well supplied with dissolved matters that it has not a considerable reserve of its solvent powers left intact.

Much depends, we need hardly say, on the geological features of the district for what the spring-water of any place is likely to contain. Where one or more of the substances are so prominent as to make their presence easily felt, we are in touch with the so-called mineral springs.

Hard Water and Soft Water.

We speak of one sample of water as being hard and another soft. A soft water is one containing comparatively little mineral matter in solution; and on this account rain is the softest natural water at our disposal. Starting from rain-water as the bottom of the scale, therefore, we go through the various degrees of hardness in lake, stream, and lastly spring-water, in which kind of water we find, as we have said, the largest amount of mineral matters dissolved. Rain-water, being the softest of all, is dear to the heart of the housewife. Its high standard as a solvent makes it the best of all water as a cleanser. Its use saves soap as well as much hard rubbing on washing-day. Hard water, on the other hand, will not dissolve sufficient soap to penetrate thoroughly among the fibres of the material being manipulated in the washtub. We know for ourselves how much easier it is to wash hands and face in a soft than in a hard water. In the latter it takes some trouble to raise a lather; in the former the trouble is to get rid of the soap from our skin when the wash is completed. No rough-and-ready test as to the degree of hardness of a water is so decided as the effect soap has upon it. On sea-water ordinary soap has no effect whatever. It is impossible to obtain a lather therein. There is so much mineral matter dissolved in sea-water that it cannot dissolve so much of the soap as will give any appreciable effect.

Rain-water, however, is insipid to drink. It ought, one would think, to be more effective when imbibed than a hard water can be. The hard water is pleasanter certainly both to sight and taste, but it is hardly likely to be more acceptable otherwise to the animal economy. It is hardly questionable that soft water is the better assuager of thirst.

Temporary Hardness and Permanent Hardness of Water.

The salts of lime are, we repeat, the most prominent of the earthy matters contained in ordinary spring-water—spring-water, we mean, that is adapted to domestic purposes. It is the amount of these dissolved in the water that rules its degree of hardness. From this it can be implied that the salts of lime may be present in water to a much larger amount without destroying its usefulness where we are concerned, than those of other minerals apt to be picked up by water. The lime salts affect water in two ways. One of the salts, the carbonate, causes temporary hardness; and another, the sulphate, brings about permanent hardness. The temporary hardness is removable—it can be obviated to a considerable extent; but the other cannot.

The Solvent Powers of Water increased by the presence of Carbon Di-oxide therein.

The solvent powers of water are increased when it holds carbon di-oxide in solution. Rain, we pointed out, dissolved this gas out of the atmosphere, and when it touches earth it has other opportunities of gaining more. Aided by this co-partner, water is able to take up an extra amount of mineral matters, lime amongst the number, as it percolates down in the soil. But if the water is forced by any means to part with its share of carbon di-oxide it must also liberate the increased quantity of lime which, by help of the gas, it was able to retain. When water that is temporarily hard is boiled the carbon di-oxide is driven out from it and the extra lime falls to the bottom of the vessel. Most of us know the effect that some kinds of water have on boilers and kettles wherein they are boiled; how in a short time the boilers become coated inside with a mineral deposit, and the tea-kettle in time becomes so encrusted with the stuff that water can hardly be poured from the spout. A marble is, in many houses, a not uncommon inmate of the kitchen kettle. It is there to keep the flocculent precipitate of lime from settling down to form a scale on the metal. As it rolls about it stirs up the sediment, giving it a chance to escape by the spout when the last of the water is being drained thereby; at the same time it is probable that the marble gets coated in turn.

By adding a little lime-water (water with lime dissolved in it) to a temporarily soft water, we can fix the free carbon di-oxide contained in it, and, as before, liberate the carbonate of lime it was able to hold through the agency of the di-oxide. We shall then have two precipitates, the one we have already been discussing, and the new carbonate, that due to the combination between the added lime and the carbon di-oxide dissolved in the water but otherwise isolated from the other substances it happens to be in close relationship with. For a somewhat similar purpose the experienced housewife adds a pinch of bi-carbonate of soda to the contents of the teapot when the water is hard. She knows that hard water is not well suited for tea-making, and has learned that a little soda improves it in this respect. The soda serves, no doubt, to fix the carbon di-oxide that has not been driven off during the heating of the water, and thus let free some of the lime: and in this, as well as in other ways of a similar description, to render the water softer.

Permanent hardness is due, as we have said, to the presence of sulphate of lime in the water. This we cannot remove by the same methods that enable us, as we have just seen, to get rid of much of the carbonate. Other salts there are, of course, that induce permanent hardness in water. Common salt (sodium chloride), for instance, will, but then, as we have been seeking to point out, waters with other salts than those of lime predominating therein would never be selected for supplying the homestead. The lime salts are those that least deteriorate water as it affects man and animals. Were it not on account of the hindrances it places on the solvent properties of water its presence would be rather acceptable than otherwise. It has been argued, in fact, that for cooking and drinking purposes it is essential towards the health of human beings, especially when young, that the water at their disposal ought to contain a fair percentage of lime. Much lime is needed in the building up of the animal frame, and if some be available in the water consumed by the growing organism, there is less chance of its being at a loss where to obtain the needful amount.

But to food, not to drink, one ought to look for the necessary supply of mineral matter. Water's place in nature is as a general solvent. In our bodies, as elsewhere, we should look upon its mission as being to that effect. As regards plants, nearly all their mineral food is supplied to them dissolved in water. But our bodies are different. Our complicated digestive apparatus is competent to put before our various tissues matters suitable for their daily requirements as well as for general upkeep, without having to rely upon water for bringing lime along with it. We may as well turn to it as a medium for supplying us with salt. What we want water for is to act as a solvent capable of carrying life-supporting matters from the various organs that elaborate these and send them out for use throughout the body generally; and in addition bring back to the other organs, whose duty it is to get rid of spent or superfluous matter, what the tissues are either done with or have no need of. If this be the case, the purer the water at our disposal the more effective will be the results following upon its use. Let the body be supplied with pure water, it has then at its disposal a proper distributing medium wherewith, on one hand, to send out the matters with which it supports life, and, on the other, to drain off what would otherwise clog up the system and retard useful work in its several branches. Further, let the body have enough of food to keep all going. Let the water be devoted to its own proper end, and the food likewise. There is plenty of lime in milk, meat, and bread, without looking to water for it. The water is wanted in the animal economy for making the food matters in them fully available; nothing further need be expected of it.

So in theory, but in practice we have to take things as they are, and act accordingly. If rain-water be the softest at our command, although we know it be the most serviceable, still it is not the most palatable, and we cannot have two full supplies at the one place. Where other water is to be had, rain-water is never made the source of supply at the homestead. It is always competent to the thrifty housewife to make provision for the storage of as much rain-water as will keep the washhouse going. More than this, however, can hardly be looked for when provision is made for a supply of water from some other source than the rainfall collected from the roofs of the buildings.

The Chemist should be consulted when Doubt exists over a new Water Supply.

It is advisable, whenever there is doubt in the matter, to consult a chemist with regard to water about to be chosen for supplying the homestead. The water selected may be pure so far as one's eyes can tell. It may be clear and sparkling, and yet contain substances both in solution and suspension that render it unsuitable as a chief source of supply, and even it may be positively dangerous to the health either of man or beast. The matters in solution may be such that at one homestead they may have no ill effect, while at another they may render the water quite unsuitable for some important operations at another one. At an ordinary arable farm, for instance, a water highly charged with the salts of iron, say, may be quite acceptable at the place; but at a neighbouring one, where butter-making is the leading industry, a water of this nature may be entirely unsuitable in that connection. At the one place the water might answer all requirements, at the other it would be rejected as being prejudicial in the preparation of the principal commodity of the farm. Hard water, if otherwise good, is acceptable at the dairy.

Taste is a very good guide in some respects. When too pronounced in a sample the source thereof is to be avoided. The salts of lime can hardly be distinguished in this way. Neither can those of sodium, unless present to a large extent. Common salt we mentioned above as being the chief of these. But few of us ever come across an inland spring so strong of ordinary salt as to give the unmistakable taste. Potassium salts are equally difficult of recognition. The salts of magnesium are more readily revealed when present in water. But of the most prevalent substances found dissolved in water the salts of iron are perhaps the most readily recognisable by the tongue. And some of these are the most objectionable among the lot. They give the water a decided taste. Moreover, when allowed to stand in a vessel for some time, it in many cases develops an offensive odour. A scum appears on the surface and a rusty sediment gathers at the bottom. A water of this kind is entirely unsuitable as a source of supply to the homestead.

It will be a strongish water indeed that makes the average man suspicious of it through taste alone, more especially if the flavour thereof is not due to the presence of iron. The others seldom go alone, or, what is perhaps more exact, we rarely find one group of the various salts, excepting that of lime, predominating over the rest to any marked degree. When this is so, we are then, as we said above, dealing with what may be truly termed a "mineral spring."

A rough-and-ready way of gauging the Hardness of Water.

The degree of hardness in a water we can tell approximately by the rough-and-ready method referred to above of trying what effect soap has upon it. Doing so with the water both as it is and after being boiled will reveal to us relatively how much of the hardness is "temporary" and how much "permanent."

But the chemist who is experienced in water analysing will clear up all these matters without further ado, and provide us with a tabulated statement of the principal substances that are dissolved in water. It may be wise, therefore, in every case, whether there be room for suspicion or not, to submit a sample of the water that is considered likely to serve the homestead to be dealt with in the laboratory. For not only will the expert furnish us with full particulars of what the water contains in the way of mineral matters, but in addition he will point out (what we are unable to tell even the existence of therein) the amount of organic matter dissolved in it. This organic matter may have its origin either from vegetable or from animal sources. It may arise from the decay of herbage or from the remains of animals in the soil, in either case washed out by the rain. It may have resulted, too, from matter brought more or less direct to it from where either man or animals were housed.

The presence of Organic Matter in Water to be viewed with Suspicion.

No matter whence derived, however, the presence of organic substances in water is, as stated above, more prejudicial than the earthy substances referred to. The latter cause inconvenience rather than carry danger; but it is different with the former. So long as the organic matters are not acting the part of host to disease-causing microbes, their presence in the water has little or no effect thereon. It is almost alone in respect of their being accompanied by these dangerous organisms that the organic matters present in water have to be carefully watched and kept at bay. The organic matter that arises from decay going on in the soil has a fairly clean sheet in this respect, unless under exceptional circumstances. Instances of these may arise, as already hinted, in the manuring of the land, and in the burial of carcases near enough to the collecting area of the water to affect the same. In these, as well as in many other ways, which will readily occur to the man who knows something of rural affairs, may the water supply be rendered unsafe. Most of them may, however, be guarded against, and the gathering ground of the water be kept clear of danger in this respect. But there remains the fact that should the water by any means come to contain any of the microbes that are prejudicial to the health either of man or animal, the organic matter we are referring to will be favourable, if not to their propagation, at least to their maintenance in the fluid. The less of this the water is known to contain the more security therefore is one justified in feeling that his water supply is beyond suspicion.

But with organic matters derived from the other source mentioned—from the waste of man and animals—we can never have the satisfaction of knowing that they are free from dangerous organisms. And we repeat once more, it is these we have to dread as accompaniments to our water. And what makes the danger the greater, neither the taste, the smell, nor the appearance of the water will reveal the presence of these when it is fully charged therewith. The water may be all that is desirable, and yet be poisonous on account of its harbouring countless organisms far beyond the powers of our senses to distinguish. For all we can tell, they may be abundant in the water at one time and completely absent at another.

It must not be inferred from this that water is ever altogether free of the microscopic life we refer to. No water, unless what has been newly distilled, or that has been sterilised, ever is. We question if even distilled water has shaken off all the organisms that were in the water from which it was prepared. Some of the organisms that live in water can survive a light boiling such as takes place in distillation. But under the process of sterilisation, whereby water is heated to a higher temperature than boiling-point (which can be done under pressure), there is small chance of any surviving the ordeal. On occasion, when dealing with special fluids—milk, for instance—the process may have to be renewed. What will kill the mature organisms may not harm the spores or germs thereof. When these have had time to develop after the cooling down of the fluid, another heating disposes of them; and so on with successive crops.

The analytical chemist may, as we have said, indicate the special substances contained in any sample of water, and the comparative quantities of each. He might be able also to give us some idea of the amount of microscopic life it contained. But even if he did, what would be the good? Water is never free of the organisms we speak of; and the evil-disposed ones may show themselves at one time and not at another. Besides, the work that is involved in the separation, or rather the identification, of the different species of these organisms is out of the sphere of the analytical chemist. It comes under the province of the bacteriologist, with his high-power microscopes and gelatine preparations.

It is enough for us to be told that there is almost no trace of animal organic matter in the water, or at any rate to know what organic matter does reveal itself is in all likelihood derived from a vegetable source. The chemist may be misled on this point, but we who happen to know the physical conditions of the gathering-ground of the water can satisfy ourselves on this head. If the water be out of reach of drainage from hamlet or homestead, and of surface-water that has been in contact with midden manure, and the chemist otherwise testifies favourably regarding its composition, we may accept of it with confidence as a suitable source of supply of water to the homestead.

Specimens of Water Analyses.

Below we give two reports by Dr. Aitken, chemist to the Highland and Agricultural Society of Scotland, on some samples of water submitted to him for analysis.

The first embraces waters from three different sources, which were looked upon as being likely to answer the requirements of several homesteads:—

"PARTS PER 100,000.

	No. 1.	No. 2.	No. 3.
Solids dissolved	26	27	23
Chlorine	1·6	1·6	1·4
Free ammonia	·0048	·0045	·0035
Albuminoid ammonia	·0214	·0300	·0132
Nitric acid	·1	trace	trace
Hardness { Removable on boiling	3·7	8·0	7·2
Hardness { Not so removable	8·1	5·3	4·6

"Waters No. 1 and No. 2 are very similar—they are dull, turbid waters, containing a good deal of vegetable organic matter in solution. It does not seem that the organic matter is either of a kind or quantity to render the waters unfit for use for domestic purposes. They are third-rate potable waters.

"No. 3 is rather better than the other two as being less contaminated with organic matter. It is a somewhat hard water; the hardness is such as to cause boiler incrustation, but I have no doubt of its being quite wholesome.

"A. P. AITKEN."

The somewhat muddy state of the water which is implied with regard to Nos. 1 and 2 was due to the samples having been taken before the water had settled down properly after excavation, and to a heavy rainfall coming on the back of the same.

The next report is with regard to a sample drawn from a well within the precincts of a homestead. It was the only source of supply at the place. It had been complained of for some time, and was gradually becoming worse, at which, judging from the following, there is little wonder:—

"PARTS PER 100,000.

Solids dissolved	116·0
Chlorine	17·0
Free ammonia	·0184
Albuminoid ammonia	·0166
Nitric acid	·6
Hardness { Removable on boiling	26·5
Hardness { Not so removable.	10·5

"This is a sample of very hard water—too hard to be recommended for household use, and quite unfit for a closed hot-water supply.

"It is at present polluted with organic matter, probably accidentally introduced from interference with digging, draining, or working about the works or the pump, or the like that may be there.

"In the absence of all knowledge of the source and surroundings of the water, I am unable to say if the organic impurity is of a kind to make the water unfit for drinking.

"A. P. AITKEN."

Fuller reports than these are, of course, to be had of the chemist, but the foregoing, read in the light of local knowledge, are explicit enough as guides whether a certain water can with propriety be turned to account for homestead purposes.

An undue amount of chlorine present in water is viewed, as we have already said, with suspicion, as likely to arise from the break-up of organic matter. In fact, its presence is suggestive of some connection with excretal matter. And similarly with the two forms of ammonia quoted, and with the nitric acid. The organic matter referred to in the first report, and bearing on samples Nos. 1 and 2, was due to vegetable rather than animal sources, and, therefore, comparatively harmless. The water from each source now supplies several homesteads, that of No. 2 some half-dozen at the least, and at every one the water is most acceptable. In both cases it is clear and bright, and gets no filtering of any kind.

The water involved in the second report had evidently been receiving all sorts of stuff from the subsoil of the farmyard, and its character as revealed by the chemist at once put it out of count. Fancy having to cook with this water, or to wash! It already held so much matter in solution that its solvent power was about exhausted. It had no stomach for more, either solid or liquid.

It is well, therefore, to make certain of a matter of the kind by submitting water over which there is a doubt to the searchlight of the chemist.

CHAPTER IX.

The Water Supply—in Practice.

The Rainfall on the Roofs as a Source of Supply.

The rainfall from the roofs has in many situations to act as the source of supply of water to the homestead. It is one, however, that ought to be evaded as far as possible. There are so many difficulties and drawbacks connected with a supply of this sort that it has always to be treated with suspicion. To begin with, the water requires to be stored so close to the buildings that it is almost impossible to avoid offensive matters now and again gaining admission to the tank. The top of the tank has perforce to be pretty near the surface of the ground, and leakage thereinto is consequently difficult of prevention. And when the tank is sound in this respect there is still the danger connected in this way with the piping that conveys the water to the tank. These may be well enough laid to start with, though to insure this alone the closest supervision of the tradesmen is required. And even when a good job has been secured the pipes after they are covered up are liable to suffer from accidents. One or two may easily be fractured without the waterway being interfered with, or any other indication of the damage being revealed, but these flaws will, until remedied, be a constant source of danger to the purity of the water.

The Construction of the Storage Tank.

But jobs of the kind have to be faced sometimes, and then there is nothing for it but to make the best of the business. Much depends upon the nature of the subsoil as to how deep the storage tank will be. If hard rock comes near to the surface, we may be sure it will not, under this circumstance, be constructed very deep. For our part, we would rather have the tank narrow and deep than broad and shallow. The one is far more easily covered over than the other; and the top is the most difficult part of the tank to construct properly. The walls—the sides and ends—of the tank may be of brick or of concrete. Either can be made thoroughly watertight. The bricks may be built with lime mortar, and afterwards be all faced over inside with a continuous coat of Portland cement plaster; or they may be built with cement mortar and made watertight as the building proceeds. The former method is the more advisable of the two. The bottom of the tank is generally left until the sides and ends have been built. It is practicable sometimes to lay the bottom first, making it both wide and long enough to afford a scarcement for the walls to bear upon. But the walls usually have a sound enough foundation in the subsoil without this being had recourse to. And where water proves troublesome during the excavation, it is necessary to have done with the walls before completing the bottom. If there is much water to contend with, this is often a very troublesome operation. When the water can be drained away from a level below the bottom of the tank matters become easy. But this can seldom be done. If a corner happens to be near dipping ground, a trench may be cut from there down to a lower level than the base of the trench, and so draw the water from where it is in the way. As a rule, however, at those places where tanks have to be made for the storage of rain-water there is not much underground water to trouble one in the construction of these. Were underground water so plentiful as to prove an obstruction in this way, it could surely be turned to account as a supply in itself. If there were abundance of water near the surface adjoining the buildings, there would, in all probability, be plenty available far enough from the steading to be out of reach of pollution therefrom, yet near enough to be readily available thereat. Rain-water would in all likelihood be the only water left to deal with, and it would not be difficult to encounter. At any rate, there would not be any more water to cope with than could be mastered by means of baling with pannikin and bucket.

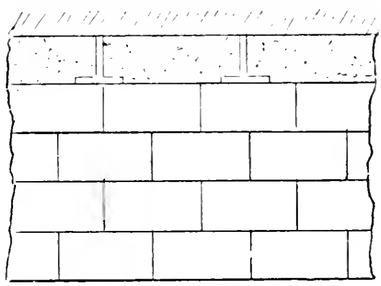

FIG. 148.

The top or cover of the tank is, as we remarked above, the most difficult part of the affair. Arching it over with brickwork as a continuation of the walls makes the strongest job. Where, however, there is not much chance of heavy weights, such as loaded carts, and it may be an occasional traction-engine or itinerant thrashing-machine, a flat cover may do. Here, again, concrete comes in as a suitable material. T-shaped angle iron or steel beams are laid across the tank a foot or two apart, and sheets of concrete laid between, as in Fig. 148. Boards propped up from underneath keep the concrete in position until it sets, after which they are taken out. This makes a capital cover and a watertight one. The flat cover enables us, as a comparison of the last fig. with Fig. 149 will show, to have more water storage for the same depth of excavation than the arch-covered one permits of. The arch takes up more room than the lintel or flat cover, and each must have a certain amount of soil over it. We advocate, as already said, deep and narrow tanks in preference to broad and shallow ones. If it is impracticable to go deep, then the loss in this direction must be made up in length. There is a limit here, too, however. But we can duplicate the narrow tank with another alongside, as in Fig. 150. We may, in fact, widen the tank to any size in this way so long as we have partitions near enough to allow of strength either to arch or lintel. The partition may either be of brick from top to bottom, with abundance of openings therein for the water to pass to and fro, or it may consist of brick pillars with a girder on top; or the partitions may have arched openings therein.

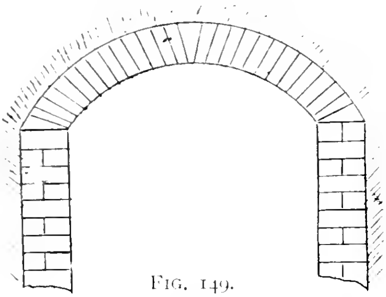

FIG. 149.

Somewhere in the top there must be provision made for gaining admittance to the tank for its occasional inspection, as well as for cleaning it out and repairing it. The sides of this opening ought, of course, to be carried up clear of the ground, completely watertight, and stand a little height above the same and be closely covered over. It must be after the nature of and as effective as a ship's hatch, in fact.

A tank constructed on these lines will be capable of retaining unharmed, so far as it is concerned, the water that may be delivered into it. It will be no cheap affair, however. In order that the water may be carried to it as led from the roofs the conductors or drop-pipes must all communicate with Hart traps in the manner described on page 110. The Hart traps in their turn have to be carefully jointed to the spigot and faucet fireclay pipe drain that leads to the tank. These drains, how many soever there be, must, when laid, be thoroughly watertight from one end to the other—from the Hart trap to the tank. They should enter the tank as near the top as possible in order to make the most of the storage room. To make sure that the drains will be out of harm's way from ordinary traffic overhead, they should have at least eighteen inches of cover; but generally more than this will have to be allowed on account of affording a sufficient cover of soil over the top of the tank.

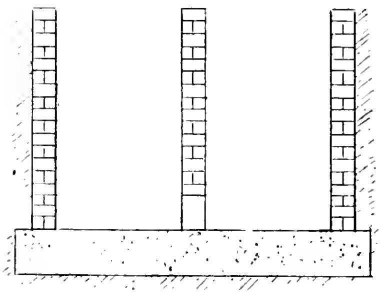

FIG. 150.

Not very practicable to annex a Filter to the Tank.

It is not practicable to fit these tanks with filters that would have any marked degree of efficiency. When the water is delivered into a tank of the kind it is often in such volume that only a filter of the coarsest stuff would admit the water as fast as it came. It is by paying proper attention to the general cleanliness of the various roofs that we can best promote the purity of the water in this instance. If the work be efficiently done on the lines above suggested, all the filter required would be a grating over each of the inlets from the rhones to the conductors. Nothing could get into the water from the ground level, and these gratings would keep back leaves and straws that had found their way to the roofs, the only place left to be guarded against as likely to pass odd matters along with the water that fell thereon.

An overflow drain from the tank is an essential adjunct. If the tank were large, the overflow would not often be called into service; still, the tank could not be considered effective unless provision were made for its relief during a time of pressure. A run-off or scour-drain is, in order that the tank be complete of its kind, even more essential than the overflow. The tank can never in the absence of this be thoroughly cleaned out. Rarely, however, is such a convenience provided. Its construction generally means so much trouble and expense that it is at times rather meanly passed over by those who ought to know better. Once let the contents of the tank become polluted by disease-causing microbes, it is difficult to see how it could be properly cleaned and disinfected failing such effective aid as a flushing or scouring drain affords on these occasions.

A tank of this nature requires to be of a considerable size, else it will often be a source of discontent; it will be found empty at a time when water is most needed. More especially is this so in the dairying districts. In spring the roots have become scarce about the place, the cows have begun to calve, and in consequence much sappy food has to be prepared. That means the use of a good deal of water daily. But this is at the time of the year when the rainfall is light, and the stored rain-water is decreasing rapidly. If the tank be not, therefore, of a fair size to start with, the supply of water from such a source will frequently fail at the time it is most wanted.

Storage for no less than a six-weeks' supply ought properly to be provided. March, April, and May are the trying months. During these, even in times of phenomenal drought, it seldom happens that there are not frequent showers now and again. But these may not be heavy enough to weigh against the daily demand on the dwindling store.

The Size of the Tank.

It is not a very difficult matter to settle on the size of a tank that will hold the quantity of water we have just mentioned. Allowing fifteen gallons a day for each cow, and assuming that there is a herd of fifty to be catered for, this means 750 gallons a day for the cows alone. But there are the horses and the other live stock at the homestead to be kept in view; and there is also the house to be provided for. Say that we allow 200 gallons daily for these inclusive, the total comes up to 950 gallons a day; but let us fix it at 900. We have forty-two days in the six weeks, which at 900 each amounts to 37,800 gallons in all. Now, it takes six and a quarter gallons of water to make a cubic foot of the fluid; consequently we have a tank of a capacity of 6,048 cubic feet to construct. This is no small affair when it comes to be looked into, either on paper or in reality. We can give no rule for the shape of the tank. That must be governed completely by the circumstances of the case, no two of which are alike. If the proposed site of the tank is on rock or other stuff difficult to excavate, or in a place where underground water is apt to be troublesome, or over ground that would need much propping up while the excavation was being proceeded with, depth would have to be evaded and the size made up either in the length or the breatdh of the tank. Suppose it were inadvisable to sink no deeper than would give us a tank five feet deep, then if we made it ten feet wide, it would, in order that it possessed the capacity specified, have to be within an inch or two of 121 feet long. It can, of course, be made wider than ten feet. It may be twenty feet or it may be fifty feet in width as circumstances dictate. But whatever the width, we would make it some multiple of five, in order that the partitions therein were no further than five feet apart. The arch over this space can be kept flattish without loss of strength; and it is not a stretch to test too much the powers of the lintel. Seldom, however, is a tank of this size constructed. Affairs of the kind are too often made on more restricted lines, with the result of an occasional water famine. But when rain sets in, the past inconvenience is forgotten; and the following spring may be a wet one and allow matters to drift on.

When the tank is arched over it is the outside part of the brickwork that needs to be made watertight. There is no chance of water forcing its way upwards through the brick covering, but plenty will leak in if it can gain an inlet. There is little use therefore plastering the inside of the arch in the same manner as we suggested the walls should be done. The inner plastering might be continued for five or six inches above the level of the spring of the arch, but no more is needed. The outer plastering, however, is the better to be carried a few inches down from the level of the wallhead. Finished thus, the tank is capable of retaining what is brought to it by the feeders laid for that purpose, and of rejecting whatever seeks an entrance at other points. The concrete of the flat-covered tank, if laid a little thicker than the depth of the angle iron, so as completely to embed the top therein, will be one continuous sheet impervious to water.

A Pump a necessary Adjunct of the Tank.

It has to be remembered that, unless where it is so contrived that the roof water of any building is set apart for the special use of the inmates thereof, and stored at a level high enough to gravitate to the points at which it is wanted, every drop of water from a supply of this kind has to be pumped up from the tank. That alone is a serious drawback to this method of securing a supply of water. It is little thought of by those accustomed to scarcity of water; but when the water is assured the constant labour implied in having to pump up all that is required for hourly and daily use grows irksome. Unquestionably it is an item of labour which so far as lies in the power of the proprietor ought to be spared the occupant of the farm. But there are situations where it cannot be avoided, and a homestead that is dependent for its water supply on what falls upon the roofs of the houses is one of these. Others there are which we shall touch upon further on.

The ordinary Horse and Duck Pond.

It rarely occurs even at those places where rain-water is turned to account as above described that there is not some pond or other watering-place which in so far as the animals are concerned helps to eke out the main supply. Too often, however, the pond is suffered to become a nuisance. If ducks and geese have free access to it, they help to make matters worse; they stir up the loose sediment and keep the water muddy. When the pond is merely the accumulated surface-water of the surrounding ground it may be empty for long periods, the contents as it approaches ebb being thick mud. But if fed by a streamlet the pond is generally capable of being kept wholesome for most of the year. The outlet of a main drain is often the sole tributary to the pond, contributing liberally in the wet seasons, but not a drop during drought.

Even the pond that is merely a widening out of some passing streamlet dries up in summer. But it is not during summer that the homestead pond is most in requisition. The live stock are then away in the fields, where they are supposed to have water as well as grass to come and go to at pleasure. It is at the time of hand-feeding, from October till May, that the pond is serviceable, and usually it contains water during this period. At the dairy farm the homestead pond, if available, is visited morning and evening all through summer by the cows as they pass to and fro at milking time. It is at the dairy farm, if anywhere, therefore, that the pond must be attended to. If other water is to be had there, the pond should be abolished. So indeed it ought to be elsewhere, if it be practicable to dispense with it, although horses may safely be treated to water which it would be bad policy to present to milk cows. But we are speaking of it here as supplementary to a rain-water supply. The rain-water supply is rather against there being a large trough constructed whereat all kinds of stock can drink their fill without making the water filthier for those who come after them, as they are so apt to do when they have to wade into the pond to get a proper mouthful. When the trough is dependent on the pump for being kept full the arrangement never answers well, and this is the reason why a good supplementary watering pond is a good thing to have in connection with a homestead so situated as regards water.

How it may be turned to better Account.

If, however, the pond is to be an adjunct of the homestead, let it, no matter how fed, be constructed in such a way that there will be a minimum of mud at the bottom and of scum at the top. Let the bottom be of some hard, impervious material smoothed off in such a manner that it can easily be scraped when it comes to be exposed during drought, or for that part at any time it may be convenient to withdraw and divert the water therefrom. Let the banks or sides be similarly of a material that will not crumble away under the influence of every mimic wave that spends itself against them. Constructed thus, the pond, whether filled with surface-water, with the effluent of a main drain, or with water from a passing streamlet, will keep its contents comparatively sweet and wholesome, will be capable of at any time being easily cleansed, and at no time, unless when gross carelessness and laziness prevails at the place, will it ever become a nuisance. Ducks and geese may be left to their own sweet wills in a place of this kind. When the silly mood overtakes them and they rush with flapping wings from one end to the other, one minute above water and the next beneath, the water will be little the worse for their strange evolutions. It will not, like what happens in the ordinary farm pond when "the devil enters the ducks," be left as though it were some spent part of a spate.

In some parts of England, in those districts where the subsoil is pervious to water, and none is to be looked for from that source, great care is taken in the construction of watering ponds. Not only is the bottom of the pond carefully scooped out and made firm and smooth, but in addition it has to be left thoroughly watertight. If it were not capable of keeping the water from passing to the subsoil, none of it would remain in the pond. At most places the subsoil is sufficiently retentive to enable us to dispense with this operation. Were it not so, the farm ponds would, we suspect, be very different affairs to those which the most of us are familiar with.

The Surface Well.

When water other than that from the roofs of the buildings is selected for the wants of the homestead the occupier is nearly always saved the labour of pumping by hand. If the water will not come to the place by gravitation, but has to be lifted from a lower level, then, in the latter case, it will be too far away to admit of hand-pumping, for it would never do to have a well sunk so near to the homestead as that implies. A well, unlike the rain-water tank above described, is not an affair intended only to hold water until wanted. The tank admits no water either at side or bottom; it must come in at the top, without having once touched the soil. But the well is simply an artificial opening underground, sometimes deep and sometimes shallow, into which the water in the surrounding subsoil can drain and collect. The rain-water tank, if well constructed, can be ranged alongside the dungstead without harm to its contents. Were the well put there, however, its contents would be on a par with the liquid manure tank. There would be nothing to hinder the drainings from the dungstead finding their way into the well. The well, therefore, having a "crop for all kinds of corn," is not a safe contrivance to be placed anywhere in or adjoining the homestead. Being no discriminator, but ready to welcome all comers, it is easily seen that the subsoil that comes within the influence of the homestead is no place in which to sink a well. We get an instance of this at the close of last chapter, in the latter of the reports by Dr. Aitken. How near it may be with safety to the homestead is entirely dependent on the circumstances of each case.

Water from a Bore.

It is different, as we mentioned in last chapter, with regard to water derived from a source deep down in the ground. In boring, we seek to tap a supply far beneath anything with which the water in the subsoil at the mouth of the bore has to do. If successful, we have delivered at the surface cool water that has undergone the perfection of natural filtration. Surface-water to begin with, the deep-seated water that rises in the bore as it percolated through earth and rock in its downward course, gradually got rid of all that it carried in suspension. But while doing so it was dissolving substances from the different strata, hard and soft alike, that it penetrated on its way downwards. We may therefore look for the water from a bore to be thoroughly pure as regards matters in suspension, but, as a rule, considerably hard. It will have cast off what solid matters joined company with it in the air and on the ground—dust, microbes, mud, and all: but it will be pretty heavily charged with the various salts of the earth that are unable to resist the solvent property of water.

This will not hold good unless the bore-hole be protected for the first twenty feet or so at the top. If bordered there by the earth or rock alone, unless the latter is dense and homogeneous, then there is nothing to hinder the water in the surface soil from draining into the bore as it does, although in a freer manner, into the cavity of the well. But to guard against this the upper end of the bore, from the surface soil to where the rock, at any rate, is struck, is rendered secure by means of zinc tubes fitted closely therein. This precaution enables the water from the bore to be obtained quite free of contamination from the surface soil.

At this rate the bore could, so far as immunity from contamination therefrom is concerned, be sunk alongside a dunghill. But the bore, if formed beside the buildings, leads, as the well does, to the obligation of hand-pumping on the part of the farm hands. It is not suitable, therefore, to place it there if the farm be large and much water in consequence be required. At the small homestead, however, the bore may be within hand-reach of the kitchen door. We have in our mind's eye two or three instances of homesteads where the bore is so situated, and always ready to respond to the pump-handle with a delivery of clear, sparkling, and cool water.

We have in our mind some others, too, sunk at some little distance from the homestead, and at a higher level, the water from which gravitates in a steady "pirl" day and night all the year round down to the steading without aid from pump or other mechanical contrivance. It is in cases like these where the bore is the most serviceable. It can, when thus situated, with regard to the farm buildings, be made to yield a steady supply without the labour of pumping. The kind of bore we speak about rarely, however, delivers water over the sides of the opening at the surface. The water generally rises no higher inside the bore than the water-level of the surrounding ground. But if the ground in which the bore is sunk be a little higher than the site of the homestead it is no difficult matter to run a drain or lay a pipe from a little below the water level in the bore down to the steading, along which the water can gravitate freely. Although the bore is but a small opening, usually no more than three inches in diameter (generally four from the surface until the rock is tapped and three thereafter), yet, if a successful one, it is in direct communication with water-bearing strata that are ready to avail themselves of the relief that an expansion pipe such as the bore resembles yields to them, and in consequence is almost certain to be kept constantly supplied with water. Hard pumping has little or no effect in lowering the water-line of the bore.

If, therefore, it is competent to get the supply pipe connected to the column of water in the bore sufficiently far below the water-line referred to, we are insured of a steady supply of good, wholesome water. It may be hard, but it will be free of the kinds of pollution that are characteristic of water obtained from the surface of the ground, or from the subsoil not far beneath. Sometimes it answers better to form a watertight tank at the head of the bore and carry the supply-pipe therefrom. This is advisable when the yield of the bore is not very strong as affording a store in advance of the ordinary issue from the orifice. Or, for that part, there may be a receiving tank down somewhere in the neighbourhood of the buildings, with pipes led therefrom to the various points of the homestead where the delivery of water is required. But these are details regarding which there can be no fixed rules laid down, for each case must be dealt with according to surrounding circumstances.

Boring for Water on the small Scale referred to usually rather uncertain in Results.

Boring for water in the small way we have been discussing is, unfortunately, very uncertain work. On the big scale of which we read about it being done in connection with artesian wells there is no uncertainty about the matter. The latter are sunk on principles which are ruled by the geological features of wide areas of country. For every hundred feet we go down, by means of our hand-worked drill, the artesian well sinker, with his efficient machinery, penetrates a thousand, until he taps the locked-up water of some stratum which is ever on the watch for an outlet, and will, when the opportunity occurs, rush up the bore-hole with a force sufficient to lift itself some feet clear of the surface. The pent-up water may be collected in a large hollow or fold in the strata that affects a large tract of country. Nearly the whole of the rainfall that is imbibed by the latter eventually collects in the hollow or fold in which there is certain to be some stratum or other impervious to water, and beyond which it cannot descend. In this hollow, then, the water has to lie, all the relief it is ever likely to get, under ordinary circumstances, consisting in spilling over the edges in the times of plenty. A bore let down into a water source like this is pretty sure of an endless supply of good, pure water.

The geologist can tell when the conditions favourable to artesian well-making exist, and, once assured on this point, the well-sinker has no doubt of water plentifully rewarding his labours. But it demands no great stretch of intellect to foresee that these conditions will not hold good where the rocks of a country, favourably situated otherwise for the purpose, are traversed by fissures or cracks. These would turn our hollows into cracked basins, as it were, and water would not lodge therein. The conditions favourable to this method of water-procuring are, therefore, only met with where the geological formation of the district are either of a comparatively recent origin, and therefore little knocked about, or, if far back in the earth's history, has been but to a slight extent the sport of the forces that have torn and twisted the earth's crust into its present shape.

But the boring likely to be undertaken in the interests of a homestead is a small affair in comparison with one viewed in connection with the lie of the rocks within a wide area. In one case the bore is but a pin-prick to the long probe that affords an outlet to the deep-seated waters that are set at liberty in the case of the artesian well. The latter, as we have already said, takes into account the geological formation of the district, whereas our undertaking is no wider in its reach than a few acres at the outside. It is, as a rule, all guess-work with us. We may be successful in finding water or we may not—all according to circumstances that we are not in a position to cope with. We may at one time strike water at an early stage of operations, but towards the termination of the job, having to penetrate a fair depth when about the business so that a good supply is made sure of, may lose the whole of it by coming in contact with a seam that will absorb the water or give it free passage, without its having to rise to the water-level in the opening. A hole is then knocked in the bottom of our cask with a vengeance. Or we may find after driving the drill a hundred feet or so down that from some similar reason the water will not rise high enough in the hole to be available at the surface, even with the aid of a pump. We cannot help smiling to ourselves at an incident that happened during the sinking of a bore with a view to supplying a dairy-farm homestead with a supply of water. Water had been found and lost as above, but the leak had been made tight by means of zinc casing, and hope was high that the work would, after a little more sinking, be successful. Sunday then intervened. During the long, idle day the farmer betook himself to sounding the well. His apparatus was primitive, consisting of one of his beam-scale weights with a string attached to the ring. But the well was deep (between ninety and a hundred feet), and the improvised line was so weak at places that it parted under the strain of withdrawal, and thereafter the weight most effectually barred the way to further operations in that bore-hole.

Boring was then given up in disgust and attention turned to an excellent spring half a mile or so from the homestead, but eighty or ninety feet lower down. To sink another bore where it was known the chances of obtaining water were doubtful seemed questionable policy. Had the result been less uncertain, it would nevertheless have been faced before the spring was taken in hand. The spring-water was both abundant and of good quality, and was well away from the risk of any serious contamination. There being no other source of water available (all parties being against having recourse to the roof water), there was nothing for it but to pull or push the spring-water along uphill to the homestead. A windmill was set to do the work, and admirably it did it. A small gathering basin, or well, was constructed at the spring. This consisted of two or three large fireclay plain pipes, one on top of the other, sunk so as to enclose the eye of the well, and finished with a flat stone on top. Into this well an end of the pipe was led, the other terminating in a tank situated among the farm buildings. The windmill was erected at a point on the line of the pipe where it was considered there would be a draught so long as there was any motion at all in the air thereabouts. From this coign of vantage it kept agoing the pump that with one hand drew water from the spring while with the other it forced it to the level of the homestead. A 2½-inch iron pipe was laid from the well to the pump, and a 2-inch one from the pump to the storage tank. The storage tank was made large enough to hold a week's supply of water, and was placed at an elevation sufficient to allow the water to run by gravitation to the several points where it was required. The tank in this instance was made of wood, lined inside with sheet lead, and it had a complete cover of galvanized iron. This is a method of securing a supply of water that in the event of a gravitation supply not being practicable can often be fallen back on.

Gravitation Supplies.

The first essential of a gravitation water supply after that of quality of course is, as the name implies, that it issues from a source situated high enough above the homestead to allow it to run thereto of its own accord when afforded a proper channel to course along in. If the source be a tiny rill, the channel thereof must be deepened and widened out so as to form a collecting space or head of water into which, near to the bottom, the conducting pipe can be introduced. When one is sure that the inlet of the pipe will always be covered by the pent-up water, this may answer well enough; but if there be doubt on this point it is advisable to divert water from this rill to a storage tank and make it the head of the water supply. The tank may be placed close to the rill or at some distance just as circumstances admit. This gives us a more satisfactory system. Running the water to the tank before admitting it to the supply pipe enables us better to arrest any sand or fine gravel that happens to accompany the water being drawn from the rill. The mouth of the pipe is placed in the side of the rill so as to avoid the sediment at the bottom; still, there is certain to be more or less at times drawn into the pipe. The tank will retain the heavier of the suspended matter, more especially if we provide it with diaphragms such as are represented in Fig. 151. The water is admitted at one end of the tank and drawn off at the other. Any sand or similar matter that is carried in from the rill will as the run of the water is checked when it encounters the contents of the tank tend to settle. At any rate, only the lightest of the matters in suspension will be carried over the barrier. The outlet pipe is kept, it will be noticed, an inch or two above the bottom of the tank in order to be clear of any sediment; so before the water escapes from the tank it must be carrying less along with it than it was doing when it constituted a part of the rill.

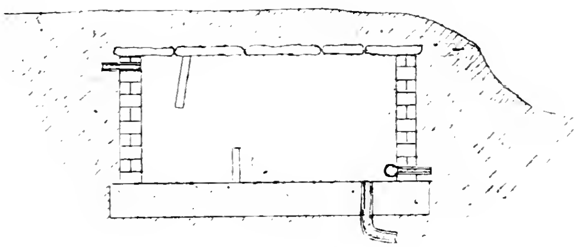

FIG. 151.

Were we to pass the water through a layer of gravel or stone chips, roughish to begin with and finer towards where the water issued, a good deal of the lighter and more minute matters in suspension would no doubt be arrested. But unless these contrivances are regularly attended to they are better omitted from the homestead water supplies. They too often serve but to concentrate noxious matters which, if allowed to pass with the water, are never noticeable to our senses, and are so much diluted or show so small a percentage as to be comparatively harmless otherwise. But arresting these matters at a certain point and allowing them gradually to accumulate, and all the time forcing the whole of the water to find a passage through the mass, is a mild form of "poisoning the water at the fountain." It is giving any dangerous organism that has found its way into the source whence the supply is drawn a capital forcing ground, as well as ample sustenance which in the absence of this concentrated supply it might have difficulty in finding when the various matters are sparsely scattered throughout the bulk of the water. The filter at the farm is therefore, as we remarked before, better to be left out of reckoning. For one who will attend to it there are nineteen who will not—if indeed they know in what form this attention has to be gone about, and why.

Collecting Water from Surface Springs.

Much the same, so far as collecting the water preparatory to allowing it entrance to the supply pipe is concerned, applies when we have recourse to the water of surface springs. These are as a rule not very difficult to locate. A practised eye can soon tell where a spring can be struck. Oftener than otherwise the water is unable to force its way to the surface of the ground directly over the "eye" of the spring, and appears at the top, at a distance which varies according to circumstances. But it is seldom difficult to trace up a surface spring from where the water makes its appearance to its originating point. Indeed, the observant man can, judging from the natural features of the ground, usually take upon himself to say "If you sink here, I am almost certain you will catch a spring." We have never come in contact with a water expert—such an one, we mean, as makes use of the twig, or so-called "divining rod." We know plenty of men, however, who, while ignorant of geology as a whole, are sufficiently well versed in the nature of that part of the earth's crust that comes within their ken as to be able to act as pretty accurate guides in a hunt for effective springs.

It is not, however, so much the difficulty of tracing springs home to their sources that gives us trouble in finding water suitable for the homestead as making it easily available thereto when found. The spring or springs selected must, of course, be well out of reach of the influence of contaminating matters either from the homestead or from dwelling-houses of any kind. It saves trouble and otherwise is more satisfactory when we can build our well or gathering-place right over the eye of the spring. This ensures immunity from surface contamination. We are then able to bring spring and homestead into direct communication, as it were, without the water ever seeing daylight. Generally speaking, however, it unfortunately happens that this is only practicable in those flattish positions that are found at a lower level than the site occupied by the homestead, which means forcing up instead of leading down the water. But when it can be done in this way for a gravitation supply the job is more effective than where the water is to be led to a gathering tank as above, and thence to the homestead. The water is more in contact with the soil, or at any rate more under its influence, in the one way than in the other. When we are fortunate enough to meet with a good spring well above the level of the homestead it is usually found issuing from rock, or from the side or immediate base of a slope, therefore not easy of imprisonment in a large enough well of the kind above implied. In this case we are obliged to form the reservoir away a little from the spring. It is not always impracticable, however, even on the high ground to have spring and reservoir in one.

The Nature of the Collecting Tank.

The nature of the tank or reservoir to be formed for the purpose of collecting the overflowings of a surface spring and affording a good store or head of water for distribution at the homestead depends, of course, very much on the surrounding circumstances. But something on the same lines as we suggest at the beginning of this chapter in connection with the storage of roof water applies here also. It does not require, however, to be anything approaching that in size. What is needed in this case is more in the way of making sure that the pipe which conveys the water to the homestead will be always full than anything else. Were the tank awanting, there would be nothing but what issued regularly from the spring to keep the pipe agoing, which it might not be able to do unless of exceptional volume. But gathered together in a reservoir, the units, so to speak, which, as they issued from the spring, were impotent by themselves, now joined together in force, are capable of acting as a volume of water does.

The stronger the spring the smaller the reservoir requires to be so far as serving the part of reserve to the spring is concerned. But then, on the other hand, we have to keep in view the quantity of water that is likely to be drawn in a short space of time or in one spell at the buildings. The strong spring, however, will be able to deliver almost as much water into the tank as can be withdrawn from it, while the weak one, unable to keep pace with the outgoing supply, requires a long start, or what is the same thing, a large reservoir somewhere between the well and the homestead. But these, as we have so often repeated in this and in other connections, are matters that must be decided on the spot.

Its Construction.

Whatever the size fixed for the tank, we would build it, as before, of brick—the bricks bedded either in lime or cement; if the former, the whole inner surface of the walls being plastered with cement. The bottom we would have constructed of concrete. Where the circumstances are favourable it may be wholly constructed of concrete. For the sake of making it easy to cover over it is advisable to make it long, narrow, and deep, rather than short, shallow, and wide. Two-and-a-half or three feet wide is an ample size for a thing of the kind. It is not like when we are constructing a reservoir that catches water only now and again, as happens with the rain-water one. At present we are dealing with one into which water is being constantly delivered. The delivery may at times be small, but never *nil*, else a mistake has been made in selecting the source of supply. In no instance in a supply of this sort need the reservoir be larger than will contain a full day's supply for the homestead. The tank will make up by night what it loses by day.

Flagstones answer well enough to cover a tank of this description. If allowed to overlap the sides a little, the workmen can easily remove them and lay bare the whole affair at any time this is wanted. And the flags can be laid close enough together to prevent soil or other matter dropping into the tank. These are better left rough at the edges than sawn, because it is advisable to plaster the joints with a little lime, and the rough joint renders this easier than the smooth one. The top may then be earthed over, and all is out of reach of sun, wind, and frost. When the water supply is on a larger scale than our description implies the tank or reservoir may, with advantage, be roofed over—have a house or shed erected over it, in fact. When this is done the tank is at all times open to inspection by the one whose duty it is to attend thereto. But an expense of this kind is not considered necessary in regard to the homestead supply.

How to place it in order to lessen Digging.

If it is practicable to place the tank on sloping ground in such a way that an end or side can have a drain led into it without much deep cutting, unless when close up to the tank, being necessitated, much work is saved. The exit pipe has to be placed near to the bottom level of the tank—not exactly at the bottom, but two or three inches above, for the reason already given, and this means considerable cutting in forming the pipe track. But over and above the exit pipe it is advisable to provide this tank also with a scour-drain, by means of which the tank can be completely emptied when it is thought necessary to give it a thorough cleaning out. This, it is needless to say, requires to be carried in below the level of the base of the tank, which implies a deeper track than serves for the supply pipe leading to the homestead. Moreover, the scour-drain must have a clear fall to its outlet, whereas it is competent, once we are well clear of the tank, and so long as we do not rise too near to the level of the water in the tank, to raise the supply pipe and ride over obstacles that intercept its path. But the scour-drain must go direct to its destination in one or more steady gradients. This is perhaps rather extreme. There are few instances where the scour-drain would have to be carried very far to ensure it a proper outlet. Where this did happen the drain would in all probability be dispensed with. It is, in fact, oftener omitted than made a part of the arrangement, even where circumstances are favourable to its adoption. At any rate, the less deep drain-cutting it is necessary to do in connection with the tank the better for all parties concerned. If one bears in mind that six feet or so will be about the depth of the excavation preparatory to tank-building, it is easy to see how much the cutting of the drains adds to the expense of constructing the tank. A minimum of two feet deep from the surface of the ground does for the position of the supply pipe once it is clear of the tank. This keeps the contents safe from frost in winter, and prevents the sun's influence being felt in summer. But unless the nature of the ground favours a quick approach to the surface on the part of the scour-pipe, the deeper of the two to begin with, a long deep pipe or drain track is the result.

It is well to have some contrivance whereby the water can be diverted past the tank or cut off therefrom at any time this is desired. It is necessary to do so when the tank is being cleaned out or is needful of repair. A side drain into which the water running towards the tank can, as wanted, be diverted and led round the side to the exit end of the tank, and there be joined either to the scour-drain or the drain that leads away the surplus water, gives one the necessary control over the feed pipe.

It is essential to provide the tank with an overflow pipe of some sort. If the spare water issuing therefrom is to be used for supplying live stock in the fields, it had better be led to them in a covered drain. If suffered to run into an open ditch, it will soon be converted into puddle. But in whatever way it is to be made available to the animals, it should not be placed at their disposal until it has been led away some distance from the site of the tank. If the distance is not too great, it serves a good end to lead the overflow water to the neighbourhood of the homestead, there to act the part of tributary to such a pond as we described a few pages back.

The Water-Pipes leading to the Tank.

Ordinary drain-pipes are good enough for laying both the scour and the overflow drains with. But for leading water from the spring to the tank only jointed fireclay pipes, as before described, ought to be used. And the joints should be rendered tight, as before, with cement. If this is overlooked, roots of various kinds will insert themselves through the joints into the pipes, and eventually come to interfere considerably, if not entirely obstruct the bore of the channel. Sometimes these jointed fireclay pipes are pressed into service as supply pipes for the homestead. This is generally done to save expense, but it never answers where any pressure is put upon the pipes. So long as they are laid with a slope from the head of the drain to the foot, and an open end is left at the latter point, they do well enough, but they will not bear a closed end. They act admirably as a channel through which water is obliged to run along and evacuate at once; but they fail entirely when made to do duty as a retaining medium as well as a conduit or aqueduct.

The Supply Pipes: Lead Piping.

Lead and iron are the two materials in use for water supply pipes that have to resist pressure. Lead pipes have few joints, the metal being capable of elongation into continuous lengths of piping limited only by their handiness for manipulation. Each coil can be rolled out in the pipe track as it comes from the manufacturer, joints only being needed between the respective coils. No other work is needed. No preparation is applied to the lead by way of protecting on one side from corrosion in the soil or from the action of water on the other. The few ends are soldered together and the pipe is ready for service. The weight per running foot rules the price of the pipe, consequently either increased thickness of the lead or enlargement of bore makes it dearer.

Iron Piping. Iron is the more generally used of the two. It is much cheaper than lead, which fact allows us to make use of larger bore piping than the price of the latter would justify us in adopting. A two-inch iron pipe can be laid as cheaply as a half-inch lead one, and this is a great advantage, because a biggish supply pipe holds a considerable store of water to begin with, and allows the water to run through it more freely. The iron pipes are manufactured in lengths running from six to twelve feet. They are cast in moulds standing upon end, and have spigot and faucet or socket joints. In some cases the joints are made smooth and tight-fitting and in others are left rough and loose, something like those of the fireclay pipes. The former are simply jointed by inserting the small and slightly tapered end of one pipe into the correspondingly enlarged end of another, and tapping the pipe home with a sharp knock or two of a wooden mallet. The formation of rust on the clean faces thus brought together is thereafter trusted to as the bond of attachment between the two. The pipes with loose joints are fastened together by means of rope yarn and lead forced in by hammer and chisel between the faucet of one pipe and the spigot of another. The lead is first run in molten and afterwards hammered home. The joints are caulked, as it were, with lead, the rope yarn being first inserted to form a sort of cushion for the lead to bear against, and at the same time hinder the lead from being forced into the freeway of the pipe—for a similar purpose to which we saw it was put in the joining together of the fireclay pipes we referred to in a previous chapter.

The Effects of Soil and of Water on Iron Pipes. Iron, being less capable than lead of withstanding the corrosive effects both of soil and water unless protected in some way, is apt soon to wear out. In fact, a two-inch iron pipe runs greater danger of rusting up or becoming choked with encrustation of some kind or other than a half-inch lead pipe runs a chance of becoming obstructed by deposits on its internal surface. It is usual, therefore, to dip iron water-pipes in a solution resembling thick black varnish, and thus coat them within and without with a material that helps them considerably to resist the action of water on one side and the various agencies at work in the soil on the other. The only drawback to this varnishing of the pipes is the sort of tarry taste it gives to the water that at first passes through them. But this soon dies away. In a few weeks if much water be drawn it becomes gradually imperceptible. Water pipes of wrought iron galvanized are to be had, but these are of small bore, and are used for distributing water throughout houses and other buildings in place of lead piping. These are not intended for underground use, but not infrequently we see them doing duty there. That is bad economy, however.

The Effects of the same on Lead Piping. Some soils are more severe on lead than others. This depends entirely on the nature of the emanations therefrom, either gaseous or liquid. Both carbonate of lead and sulphate of lead are among the most insoluble salts of the metal, consequently it stands to reason that neither the presence of much carbon di-oxide or carbonic acid nor sulphuric acid in the soil can have much corrosive effect on lead. If either had free access to the metal, the result would in all probability be the formation round the pipe of an insoluble coating, proof against the constant attacks of the universal solvent already dealt with. But in a soil where nitric acid may come in contact with the lead the piping has less chance of keeping itself intact. Nitrate of lead is one of the soluble salts of lead, and were it formed on the exterior of the pipe, that coating would soon disappear under the influence of water. When it went another would be formed, and ere long the pipe would be too thin to hold its contents within bounds. Acetic acid, if present in the soil, would have a similar effect on the lead. Acetate of lead—sugar of lead as it is popularly designated—is another soluble salt of that metal, and there is every probability of acetic acid, although in small quantities, being present in some classes of soil. In fact, it has every chance of being near at hand wherever there is much nitric acid about. Both are accompaniments of active decomposition of animal and vegetable matter in the soil.

The same holds good in the interior of the pipe. If nitric acid be present in the water that passes through it, the lead will become affected as before. Nitrate of lead will be formed and become dissolved in the water and in this way the pipe will be gradually eaten into. But in practice these eventualities rarely reach perceptibility. We are not supposed to make use of water that shows more than a trace of nitric acid. The water is more likely to contain sufficient free carbonic acid to form an insoluble skin of carbonate of lead throughout the bore of the pipe.

Points to be observed in laying Supply Pipes. The piping, whether it be of iron or of lead, is apter to cause trouble on account of improper laying than by reason of falling under the sway of chemical action either in the water it gives passage to or in the soil in which it is buried. There is no necessity for the pipe being laid in one gradient. In fact, this can rarely be accomplished. It may be led up and down as in Fig. 152, provided none of the crests of the waves or curves of the undulating length of piping rise above the level of the outlet from the tank, else there will be the certainty of the water refusing to run whenever its level within the tank coincides with the top of the curve. In the troughs between waves, however, there it is easy to understand will sediment accumulate, more especially if for one thing the water moves a little sluggishly through the pipe, and for another the depressions be abrupt and not wide across. Care must be taken therefore to flatten out as much as possible all sinuosities of this sort, to keep down the crests and keep up the troughs. They can seldom be avoided, but in this manner they can be rendered comparatively harmless.

In the worst of the hollows it is advisable where it can be managed without much trouble to fit scour-cocks on the pipe by means of which any sediment that collects in these situations can, when water is plentiful, be washed out of the waterway. A main drain or a ditch sometimes comes in handy as a way of escape for the water so discharged from the supply pipe. If such or something equivalent is not immediately within reach, a branch pipe can be carried thereto. The scour must at any rate have a clear outfall, therefore its emptying-place must be some inches beneath the level of the supply pipe.

And at the crests of the undulations it is good policy to have air-cocks fitted to the pipe. Where these are awanting from a supply pipe that goes up and down as we are assuming, it takes a long time to get the air expelled therefrom and its place taken by the water, even with a

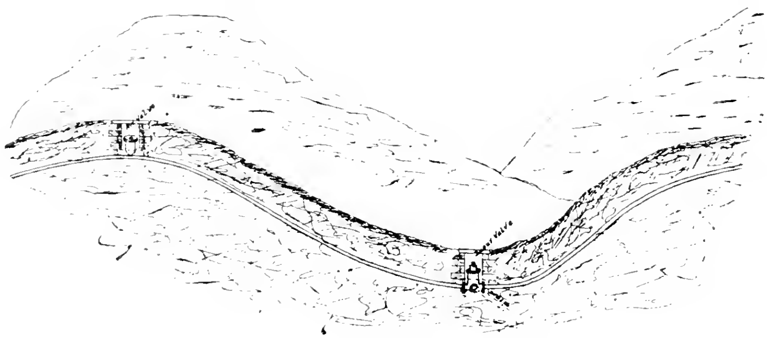

FIG. 152.

good head to fall back upon. The water is unable to force the air over the crests. When the pipe is on one gradient, or closely approaching thereto, the water whenever admitted clears the air before it as it rushes for the open valves at the foot. But where there are heights and hollows in the way it cannot so readily push along the air in its front. The air, a gas, and light in weight, will ascend readily enough. It naturally makes for the highest parts of the pipe. It will then pack into small space under the force of the water endeavouring to push its way over the ascent, but eventually will have to yield to circumstances and seek room for expansion on the other side of the rise. If, however, the rise and fall make but a narrow fold, the air can hardly be forced out of the crown thereof. The sides are so steep that unless exceptional pressure is at our disposal the confined air will not be driven down the opposite side by the advancing water. But with air-cocks attached to the pipe at the critical points we are referring to all we have got to do, while filling the pipe with water, is to open the first cock and let the air escape, and when water begins to flow from it to shut it off, and so on until the pipe is full from end to end. Without their aid it is often a tedious business to get the pipe filled.

Sometimes practicable to apply the Syphon to the Purposes of the Water Supply.

It is sometimes practicable to syphon the water out of a deep-seated well and lead it to a lower level. Usually, however, this is practicable only in regard to small supplies. All the same, there is nothing to hinder its application to the class of supplies we are discussing. The water of a steady spring capable of supplying a homestead could easily be syphoned to the buildings and there be stored in a tank large enough to hold an ample reserve. But a ball-cock

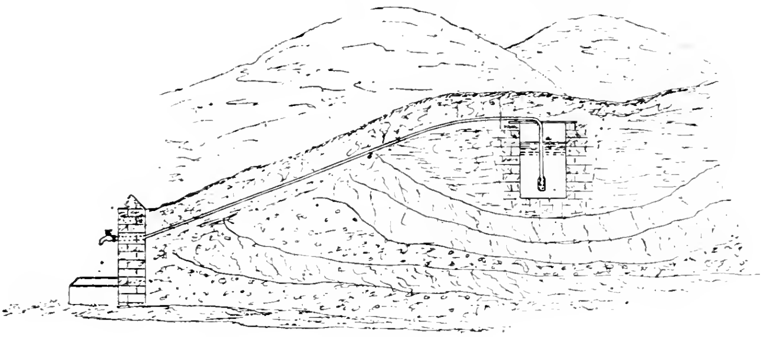

FIG. 153.

would be needed at the end of the pipe, otherwise the well would be emptied right off. The adoption of the syphon saves much initial deep cutting; for instead of having to cut a track for the pipe away from near the bottom of the well, all we have got to do, as we represent in Fig. 153, is to lead the pipe over the side. The principle of the syphon, it is almost needless to say, is, as depicted in Fig. 154, that water contained in any vessel or cavity can be drawn therefrom by means of a pipe, one end of which is inserted in the water, the other, the longer of the two, dipping over its edge and liberating the water at a lower level. In this instance the operator is able to run off a decoction free of lees, or sediment, without moving the vessel. The bend of the syphon must at no time be at a greater height above the surface of the water in the well than is equal to a column of water that can be sustained in a

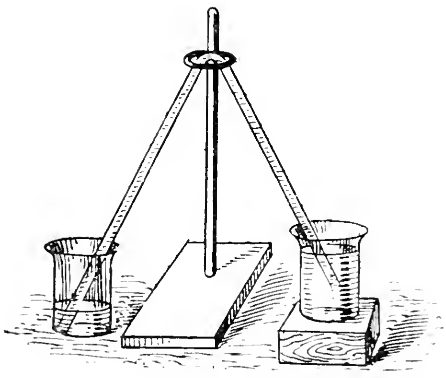

FIG. 154.

tube forming a vacuum by the pressure of the atmosphere. It must be a little lower, in fact, to allow for friction between water and pipe, and for eventualities. The syphon, therefore, cannot be expected to be reliable if the short leg, as in Fig. 153, the one that dips into the well, is longer than thirty feet--that is to say, from where the pipe bends over the side to the bottom of the well. We cannot adapt the syphon to the rise and fall of the contents of the well, and consequently are obliged to take the bottom of the water as the standard whereon to base the proportions of our apparatus.

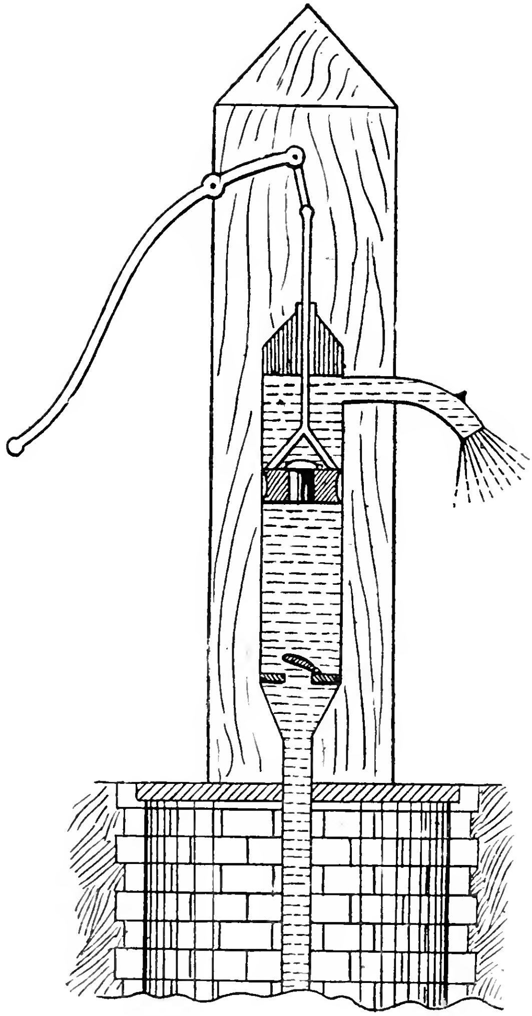

FIG. 155.

The air must of course be withdrawn or ejected from the syphon pipe before the water will flow through it. It would be enough to begin with to get the pipe filled with water between *a* and *b*. The latter point is a little the lower of the two, and therefore the limit it represents is the heavier, and so capable of drawing up the other, after which the automaton begins to work. An air-pump attached to the lower end of the supply pipe will soon exhaust the air in the pipe sufficiently to induce the water to take its place, and once the pipe is full there is no more bother with the affair so long as the water holds out and no harm comes to the pipe. But once air gains admittance, either at the high end of the pipe, on account of water running short, or anywhere in its length between the points *a* and *b*, so tha the continuity of the core of water is broken, the syphon ceases to act. It is a good plan to have an air-pump attached as a fixture to the syphon pipe. This makes one independent of professional aid when the core of water gets broken through other causes than the fracture of the pipe. Lead, it can easily be understood, is the best material for the construction of a pipe of this kind.

The Ordinary Lift-Pump.

The ordinary domestic suction-pump (Fig. 155) resembles the syphon pipe in so far that, like the latter, it is of non-effect in raising water to a greater height than the air is capable of supporting it in an inverted tube or vessel forming a vacuum internally. We work the pump and exhaust the air within the pipe leading down therefrom into the water we are seeking to raise. The pressure of the air upon the water forces it up the pipe ready for delivery at the under valve of the pump whenever we bring the handle into play. But the air will force the water no further up the pump-pipe than it will up the short leg of the syphon—hardly so far indeed. This height varies with the pressure of the atmosphere. When the barometer stands at twenty-eight inches the air is supporting a column of mercury that length. Mercury is thirteen-and-a-half times heavier than water, therefore a water barometer used under the same conditions would register thirty-one-and-a-half feet. But pumps and barometers are hardly on the same footing as regards finish, &c.

Providing Water in the Fields.

Providing a supply of water in the various fields is often a more momentous work than making sure of the same at the homesteads, and one which to a greater extent than the other calls upon the resource and skill in interpreting local signs of the water-finder. It is one, however, that is hardly within our province at present. But we touch on it merely to say that in this connection alone is it pardonable to put to use the old-fashioned surface well excavated in the first place as a wide, circular hole and completed by filling it up again with stones packed loosely therein, but leaving a circular opening in the centre. The clear opening is the well proper, although the interstices of the loose building are there in its company to serve the purposes of storage. Failing brooks, burns, becks, and surface springs, there is often nothing for it but recourse to the "cradled well," as an arrangement of the kind is termed. It is good management to make one serve several fields if such can be accomplished. A well of this sort is pardonable in the field but not in the vicinity of the homestead. It lays itself open for pollution in any situation where such is likely to arise, and once affected it is almost past purification.

CHAPTER X.

"Power" at the Homestead.

The Forces Available for "Power" at the Homestead.

Now that horse-power is nearly obsolete, there are as yet but the three great forces, wind, water, and the expansive power of gases as exemplified in steam and oil engines made much use of for motive power at the homestead. The first mentioned was at one time more popular than nowadays. It is too uncertain, however, to be depended upon to perform work at stated times —to be ready when wanted, in short,—and in consequence has become obsolete as a motive power for thrashing, which is the one operation at the homestead that requires very much expenditure of force. But it is coming into favour again as a force for doing work that does not require to be performed at stated intervals, pumping up water, for instance—work than can be done any time within certain periods so long as a certain amount is carried out during these times.

Water is very different in this respect. Where it is available in sufficient quantity it is the most serviceable of the three for the requirements of the steading. It is ready the minute its services are needed, and it can be turned off without more ado when the work is done. Its installation is seldom expensive; and if this is thoroughly done the upkeep is trifling.

With steam, on the other hand, the installation is costly, and the upkeep considerable. Moreover, a skilled attendant is needed for the engine, and the cost of fuel is an accompanying item. It is available when wanted, however, and is not, like water, somewhat dependent upon weather. In time of drought the water may fail, but never the steam. But the times of drought come usually when the machinery at the homestead is at a standstill for a season.

Oil-engines are now gaining ground as agencies of motive power at the homestead. At first they were introduced for the purpose of working the lighter machines, such as pulpers, corn-bruisers, and cake-crushers, but now they are being manufactured of a sufficient power to cope with the thrashing-mill. Petroleum is the medium turned to account for the development of power in these engines. The oil is vaporised and volumes of the gas periodically ignited and the expansive force thereby generated is the power that they are made capable of turning into work that can be made useful under the guidance of man.

The First Principles involved in the Subject.

But before we take up the practical features of the motive powers we have mentioned it may serve a good end to clear up the first principles that are involved in the subject. When these are understood it is easier to follow up what succeeds. Commencing near the root of the subject therefore, it is beyond dispute that all matter on our earth tends towards the centre thereof, being irresistibly drawn thereto by the natural force known as gravitation. At the poles the amount of matter that with us constitutes a pound in weight will there weigh more, because at either pole the surface of the ground is nearer to the centre than it is at any other part. At the equator it will weigh less, for there it is farther from the surface to the centre of the earth. These facts, the one being corroborative of the other, although invérsely so, go to prove that as we approach the centre the stronger becomes this attractive force.

The Force of Gravity.

The mass of matter we speak of as representing a pound in weight is so called because it takes a certain amount of force to counteract the attraction of gravity that bears it downwards. Hung from a spring balance, what it registers therein is the amount of force that gravity is expending upon it in dragging it towards the centre of the earth, or what is the same thing, the force that is capable of resisting the attraction that the earth has towards the particular mass of matter being dealt with.

Irrespective of the law of gravitation as above defined, masses of matter are mutually attracted to each other, and, if free to move, soon come together, and, further, are under fixed rules as regards their respective rates of motion. Each one attracts the other with a force that bears a fixed proportion to the amount of matter it contains. The larger one advances towards the smaller, but of course at a slower rate than it. Ships becalmed show a tendency to draw together. On a small scale floating objects in a bowl of water, if placed apart from each other, soon yield to this attraction, and are mutually attracted or drawn one to another. In these instances the action is slow, both air and water obstructing it. On a small scale we might exemplify it clearer if the pieces of matter be dealt with *in vacuo*. On the large scale the action has much to do with the behaviour of the heavenly bodies. They move about in the ether unhampered by friction, completely under the influence of the laws that govern the motion of matter in mass. Coursing along in unresisting medium, they are fully susceptible to these laws, and so situated as to be able to respond at once to their dictation.

The Centre of Gravity of a Body.

But coming to earth again, we have to deal with matter in its relation to the parent globe, and gravitation as a terrestrial phenomenon, we may state, is simply a phase of this attraction of separate masses to one another. We referred to the centre of gravity of bodies when discussing the erection of walls and their stability, pointing out that when the centre of gravity of a body was supported the body was at rest. The centre of gravity of a body, we said, is the point within that separate mass of matter through which a single force equivalent to the many forces represented by the weight of the various molecules of matter that together make up the combined mass would act. A set of forces, not necessarily equal in degree, equivalent to the combined weights of the molecules of matter composing the body, and acting in a contrary direction to these, would keep the body at rest against the force of gravity. So too would a single force equal to the several, but it would need to be applied to the point we are referring to—the centre of gravity of the body. It does not matter where the separate forces apply so long as the line of the centre of gravity passes down, as we saw before, within the figure formed by a line joining the outer points of its basis of support. When this holds good the body is at rest; and where it does not the body will move about until matters so adjust themselves as to give it this stability.

When a falling object strikes the earth it is there supported against gravity and can proceed no further. It cannot force its way in towards the centre of attraction because the matter it comes to rest upon blocks its way. All the matter on the surface of the earth is bound on the same errand, being drawn irresistibly to the centre point thereof. Any solid body that is denser than water will press down through it to the bottom. The molecules in fluid matter are less cohesive than in the solid, and therefore more easily pushed aside. But even in sand or soil a body much denser than either cannot penetrate far if under the influence of gravitation alone. Solid matter reduced in texture to the fineness of either sand or soil has certainly lost much of its property of cohesion, but the various particles maintain their property of inertness or disinclination to move under pressure. In the same way even a ball of lead will not be able to sink far down if laid on a heap of feathers. Its weight—that is to say, its downward pressure towards the earth's centre—fails to enable it to make way through the fluffy material that is so much lighter than itself. The feathers give way so far as elasticity is concerned, and the force gets spent in that direction ere it can serve as an aid to penetration. Conversely to the action that takes place in these instances, the balloon rises in the air because its bulk is lighter than the air which it displaces or whose room it takes up. If allowed, it will rise until it reaches a height where the two are equal in weight, when its upward course will cease.

Density of a Body.

The density of a body means the amount of matter it contains in a certain mass as compared with that of other substances. A cubic foot of lead, for instance, is denser than a cubic foot of water. There is more matter in the one than the other. The cubic foot of lead is better packed together than the cubic foot of water. The one weighs heavier than the other.

Specific Gravity of a Body.

The term "specific gravity of a body" is simply another form of speech wherewith to express the density thereof. It implies the density as the latter governs weight. Specific gravity, in fact, is but comparative weight of different substances. Water is taken as the standard substance for comparison. A cubic foot of distilled water at 32° F., under a pressure of 28 inches on the barometer, as at sea level, represents the starting point of measurement. We therefore begin at 1 with water, and rise or fall accordingly as the substance to be compared therewith is heavier or lighter than water. Water being 1, lead is 11·352, and wood, say seasoned fir wood, ·556. Lead accordingly under the influence of gravitation sinks in water till a firm bottom is gained. Somewhat like the balloon, wood of the description mentioned, on the other hand, floats, the power of gravitation not having power to draw it to the bottom. It is not so dense as the water that sustains it, and were both free to rush inwards the water would proceed faster than the wood.

The Action of Bodies under the force of Gravity.

The action of bodies under gravitation can be observed by raising them to a height and then allowing them to fall therefrom. To the eye alone little is revealed, except that all fall with an increasing velocity. This much, however, is patent to any one, that it is exceedingly difficult to throw anything far up in the air. In one's cricket-playing days it is possible to sky a ball with some effect, but further on in life it takes it out of a person when he tries what can be done in this way. The ball or stone that he essays to send aloft soon loses the initial speed at which it left his hand and gradually slows down until a dead stop takes place. Then at once its descent begins, the rate of its drop increasing at a regular ratio until its course is arrested. A falling body, under the influence of gravitation falls through space at the rate of 32 feet each second it is on its way. Were it to take a full minute to reach the ground, it would by that time be travelling at the speed of sixty times 32, or 1920 feet in a second. A body moving along at this rate is, it is needless to remark, capable of exerting a considerable force.

It requires no reasoning to convince a person that the heavier the falling body is the greater force will it be able to bring into play. The degree of force of a falling body is therefore dependent on the amount of matter it represents, and that multiplied by the speed gives us the momentum, or moving force, of a mass of matter in motion. But the weight of the mass must be considered in relation to its density, for it is truer to say that the density rather than the amount, as regards bulk of matter, rules the momentum of a falling body. Density implies, as we have seen, close packing, and the tighter put together or closer packed of two equal weighing masses of matter will of the two be the lesser impeded by the air as it rushes along. A ton of stone will reach earth before a loosely trussed ton of straw let fall at the same instant as it from any height. And much sooner will a marble touch ground than say an equal weight of ostrich-feathers attached to one another let loose at the same time. The one takes up so small room that the air offers but little resistance to its progress, and although the acceleration of speed that is gained by falling bodies as quoted is based on what occurs *in vacuo* or in the absence of air, the marble shows almost as good a record as if it too were performing in a vacuum. The feathers, however, are so differently built up and, on that account, so buoyant and balloon-like that they can hardly be induced to settle on mother earth. They will not, at any rate, come down direct and plump like the marble, but will drift about in the air should currents be forthcoming. At the best their descent will describe a zig-zag course. For the same reason can the aeronaut with parachute on hand drop from a balloon to mother earth with impunity. The formation of the parachute hinders so much its passage through the air that it can retard the velocity of his descent to a rate that is not inconvenient to him. Without this drag he would be precipitated to earth like a bolt from the blue at an accelerated speed that would be but little affected by the resistance of the atmosphere.

Newton's first Law of Motion.

The first axiom laid down by Newton in connection with the motion of matter in the mass is that "Every body perseveres in its state of rest or of moving uniformly in a straight line, except in so far as it is made to change that state by external forces." But no single body can have a sphere for its own uses alone, neither can any constellation have the heavens to itself. If the former case were possible, then bodies at rest would remain so, and those in motion would move gently on without variance, or rush ahead at lightning speed just as they had been set in motion by the last force that had borne upon them. One body is, however, so much dependent upon others that individual action is circumscribed on every side. Were nothing to hinder the passage through space of say a projectile discharged from a piece of artillery, it would move on without ceasing in a straight line at the rate with which it issued from the muzzle of the gun. It no sooner leaves the gun, however, than another force exerts an influence over it. It then comes within the power of gravitation. While it remained in the gun it was borne up against the force of gravitation, but once discharged therefrom, although at a marvellous speed, it came as surely under the grip of that force as if allowed to drop gently out of the mouth of the gun. The resistance of the air comes in too to retard the motion of the projectile, but only slowly it is true. The latter is so constructed as to pass through the air with the maximum of piercing power. That some resistance exists is, if in no other way, fully manifest in the ominous "hum" of the projectile as it proceeds on its message of destruction. But this resistance of the air, if apparently weak to start with, is strong enough to win in the end.

The Forces that bear upon Bodies in motion.

The force of gravitation on he one hand, and the retardative action of the air on the other, between the two serve ere long, as we have said, to stop the career of the projectile. Could the former force be kept in abeyance for the time, the air by itself would be a long time in slowing down and stopping the speed of the body. It would be a case of accelerated retardation or application of the brake. That is, of course, if the air were calm. Were it disturbed, side issues would be brought into play. A head wind would increase the friction, and cross ones would deflect the projectile from the straight path it entered on. We have all heard mention of the "allowance for windage" that marksmen competing with rifles have to take note of when shooting at the target from long distances.

But air or no air, it is much the same to the force of gravitation. The greater the retardation of the air on the object, it no doubt all the sooner falls to the clutches of gravitation. But gravitation will soon have it for its prey whether there be little or no retardation in this respect. It cannot proceed very far before gravitation draws it down to the surface of the ground, after which, though its velocity be far from being spent, it cannot force its way much further. If the ground be hard, it may rebound or ricochet therefrom, its initial velocity enabling it in this way to gain a little respite from gravitation, but its momentum is lessened and its message all but delivered. If the ground be soft or loose, the energy of the projectile is absorbed therein by the inertness and inelasticity of such a medium.

So long therefore as the projectile is kept from striking the earth, its effectiveness in the way of destruction is but little impaired as it is impelled on its way. To keep it above ground and thus secure a long range it is necessary either to give it an upward direction as it leaves the muzzle of the gun, and so increase the distance of the point where it must at last yield to gravitation and come to earth, or to send it forth from the muzzle with such an increased velocity that gravitation is long in overtaking it. Before our weapons had reached such a degree of perfection as now prevails the former course had to be followed up. The "Brown Bess" musket with which Wellington's soldiers were armed, if aimed at the head of a foe a hundred yards or so off, might land the bullet in his chest or stomach. "Aim high" was the order in volley-firing—to make sure that the bullets found a billet elsewhere than in the ground. But the modern rifle, with its small bore and more effective charge, can send off its messenger at a reasonable elevation with sufficient velocity to keep it above ground for a mile or thereabouts before it succumbs to gravitation. It can be ejected with so great speed as to be pulled but a small way downward by the time it has reached that distance. It has to be given a certain amount of elevation as it leaves the rifle, but much less for the mile than was allowed in the case of the smooth-barrelled, big-bored musket for the hundred yards.

The Momentum of a Moving Body. The quicker the projectile travels the greater will be its momentum. A bullet one ounce in weight, speeding along at the velocity of 960 feet a second, has the same momentum as a ball weighing one pound going at the rate of 60 feet per second. The momentum gives the amount of energy or power of performing work on the part of each moving body. It will take that same amount of energy, exerted in an opposite direction, to resist and stop the body. The resistance may be either immediate, intermittent, or gradual. Still holding by our projectile, it will be stopped dead if it strike straight against a thick plate of iron firmly stayed in position—a strong target for instance. But in this action the plate will have to put forth an equivalent amount of energy to what is represented by the velocity of the projectile. If it is incapable of doing this, it will either be overturned in the atttempt, or be pierced through if the projectile be hard enough to rend asunder the texture and continue on its way with what momentum it may still have left.

The resistance may in many ways be intermittent. The projectile may, as in the last instance, pass through some obstructing body at a considerable expense in energy no doubt this time, but yet with enough left to carry it through several other obstructions of a less serious nature, each time, of course, emerging beyond with lessening vigour until forced to yield up its power entirely.

The projectile, again, may, if it meet with no obstacle in its path, be gradually brought to the pass that the energy it had given it at the start is no longer sufficient to keep it skimming above earth in spite of gravitation, when it will touch ground and be brought to a standstill either at once if it penetrate the soil, or at the end of a series of rebounds if the ground be firm and the angle of impact suitable.

Newton's Second Law. But whether brought to a stop by impediments in the way or simply because it has run its career without let or hindrance and can go no further, in some way or other an amount of energy equal to what the body was sent off with has been expended upon it in accomplishing this. Had no antagonistic force or forces interfered, it would, in the words of Newton, have persevered in its state of moving uniformly in a straight line. But the air through which it had to pass disputed its passage, feebly, no doubt, but steadily all the same; and another and stronger force, gravitation, was all the time diverting it from the straight course and with a strong pull dragging it downwards towards itself; for, as Newton's second law says: "Change of motion is proportional to impressed force, and takes place in the direction in which the force acts." The air, then, before the energy of the body had become spent, had met it with an equal amount in the form of resistance to being pushed out of the way. The target barred the passage of the bullet promptly, while the air took a long time to do so; but the amount of resistance offered in each case was the same, and equal to what the body possessed at the beginning of its journey.

Newton's Third Law.

Newton's third law of motion is that: "Reaction is always equal and opposite to action—that is to say, the actions of two bodies upon each other are always equal and in opposite directions." The bullet and the target meet each other straight, and what the bullet delivers upon the target is returned by the latter, not with interest neither with shorter measure, but plain tit for tat, which turns the missile outside in and flattens it like a button. Were the target not equal to the occasion, and the bullet either got through or glanced off it, the reaction of the one not being in the first case equal and in the other not opposite to the action of the other, the bullet would go on its way with what action it had left until brought to a halt by some other body or bodies that would meet its action with an equivalent in reaction or opposition. In the body at rest, too, the action and reaction between it and the body that supports it are equal and act through the centre of gravity of each—through that of the boulder which rests on the outer skin of the globe as well as through that of the globe itself.

No loss of Force in Nature, but easily convertible from one Form to another.

All this would appear to be in direct contradiction to the fact that there is never any loss of force in Nature. The bullet put forth a considerable force as it smote the target, to which the target responded with no less vigour as it knocked the bullet shapeless. What, therefore, has become of these two forces after the contact between the two opposing bodies has taken place? The target remains intact in its old position, the flattened bullet lies flat at its foot, and motion has ceased. Lift the bullet, and it will, perhaps, tell a tale. It is so hot that one can hardly hold it in the palm of his hand without wincing. Where has it obtained the amount of heat sufficient to raise it to so high a temperature? Not in the gun, at any rate, for it sped forth from the barrel in advance of the expanding gas let loose from the ignited charge ere it had time to absorb any of the heat thereby generated. Nor did it derive that amount of heat from the atmosphere as it sped along. No, it received nearly all of it at the moment of impact upon the body which it was unable to clear out of its path, and on account of the force of motion thus suddenly arrested being converted into that of heat. Were it possible to collect the whole of the heat developed in this way, we would obtain an amount capable of doing as much work or of setting free as much energy as apparently become lost when the missile was in an instant stopped dead; and heat, as we shall afterwards point out, is a potent source of energy or force.

The energy of bodies in motion, if it can be turned to account in a practicable manner, is perfectly capable, as we see every day, of doing man's work. Instead of applying his hand to lever or wheel, he can enlist the wind or moving air, running water, and heavy weights of solid matter into such service; and further still, he can impress the force that is connected with the expansion of gases, those that have to do with chemical action, and that are bound up in electricity, to be his bondsmen. Man, we can now realise, gained an irretrievable start over other animals when he realised that he could turn the forces of Nature to account in doing useful work in his own interest. When he first wielded a stick either in attack or defence he increased the length of his arm and the efficiency of that organ of his body as a lever, and his foot was on the first rung of the ladder that led the way to his being the lord of creation. Armed with a stone alone, he added to the weight as well as to the hardness of his fist, which gave him an immense advantage when in conflict with his fellows or with other members of the animal kingdom trusting to their unaided powers alone. A stone-weighted fist or a heavy-headed stick in hand gives one a strong pull over an unarmed antagonist. To these simple, though most effective, advantages in close-quarter strife he by-and-by added the bow as a means of projecting his missiles. These he had all along, from the time he first thought of picking up a stone and shying it in the face of some man or beast that threatened violence, been gradually perfecting in so far as increasing their range went, and, in company with the original stick or club, had developed the longer and lighter thrusting one into the spear or lance. Thus in time man, who was the first of the animals to learn to profit by the use of Nature's more simple forces, stepped so far ahead of his fellow-creatures of the animated kingdom as to make one and all subject to his dominion—to be wielded, alas! indiscriminately by foolish and wise alike.

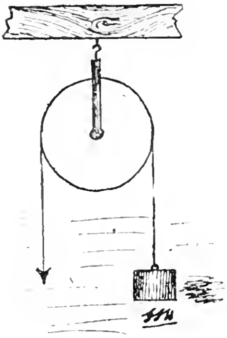
FIG. 156.

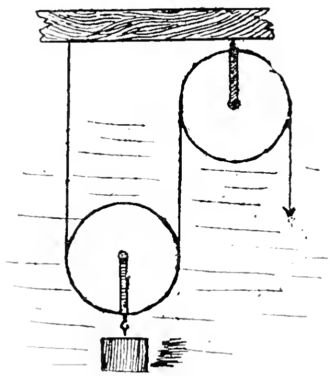
FIG. 157.

Man's first Machines for turning Forces to his Service.

Man's first invented machines for converting force or power at his disposal into useful work were all so many modifications of the pulley, the lever, and the inclined plane, machines which are put to use in overcoming the force of gravitation. In the first the distance through which the power moves in relation to the fixed point or axis which supports the arrangement bears a distinct ratio to that through which the weight does.

The Pulley.

With the single pulley (Fig. 156) there is no difference between the power and the weight, and, therefore, no gain in the use of the machine, unless by way of convenience in handling different commodities. In raising any body by its means as much force has to be exerted by the raiser as the weight bears down on its side. But power and weight move through equal spaces. No more rope is pulled down by the operation than measures the distance that the weight has been raised. With the double pulley (Fig. 157), one fixed and one movable, the same pull as in the last instance will lift twice the weight the same height, but there will be double the rope to drag in. With a three-pulley arrangement, as in Fig. 158, the same pull will raise four times the weight and give four lengths of rope to dispose of. This combined arrangement of a fixed and one or more movable pulleys is termed "the first system" of pulleys. In practice what is known as the second system is the one adopted. An upper and a lower block are used, each containing one or more pulleys, or "sheaves" as they are called, in the combined pulleys or blocks, the upper block alone being attached to a fixed point. In Fig. 159 we represent a four-sheaved arrangement. Usually, however, the sheaves of each block are similar in size and placed together in one case. In this four-sheaved arrangement, although one more pulley is used than in the last mentioned, the same pull will lift no more weight and the same length of rope will be pulled in. It is, perhaps, necessary to say that we are leaving out of account the weight of the movable blocks, and, what is more important, the friction on the axles of the sheaves or pulleys of the blocks.

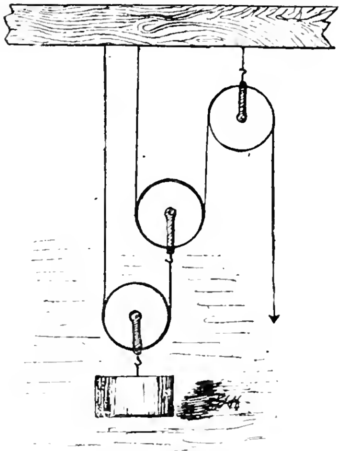

FIG. 158.

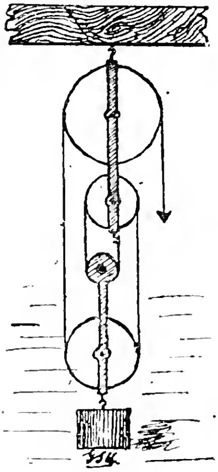

FIG. 159.

The Lever.

The lever acts as a rigid rod supported at some part or other with the power and weight acting in contrary directions to one another. The point on which the rod or lever is supported is called the "fulcrum" thereof, and this, it is easy to see, must be capable of resisting both of the forces that bear upon the lever. A beam weighing-machine is simply a modification of the lever. Its arms are of equal length; therefore, in order that it may

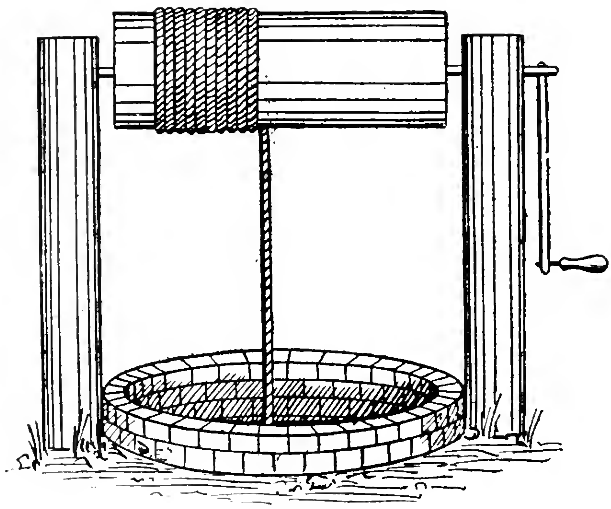

FIG. 160.

maintain a horizontal position, each arm must be equally weighted—the weight in one scale or pan must be counterbalanced by an equal weight of matter in the other—and the points or fulcrum upon which the beam plays supports the latter and the matter in both scales as well. The pulley is, in fact, a form of the lever. If we refer to the single pulley, the axle thereof, we shall find, forms the fulcrum, and so long as the forces applied to the wheel are equal there will be no motion of the pulley. The diameter of the wheel is equally halved by the axle, seeing the latter is the central point of the wheel; therefore, in this case we have, as with the beam weighing-machine, a lever with its arms of equal length, in which machine, in order that motion may take place, there must be difference between the forces that apply to such arms thereof. The windlass (Fig. 160) is an application of the same principle, as we shall see by paying attention to Fig. 161—the wheel and axle modification of

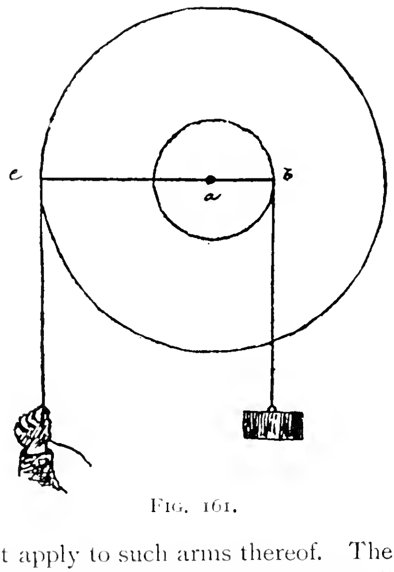

FIG. 161.

the windlass. Here, again, the fulcrum lies in the centre of the wheel, this time represented by the roller round which the rope is wound, *a* on the Fig. Now, as *a b*, the distance between the matter to be moved and the fulcrum is less than *a c*, the distance between the fulcrum, and the force applied to move the windlass, so in proportion is the latter less than the former. The smaller the drum, or roller, therefore (the distance between *a* and *b*), and the longer the arm of the windlass (the distance from *a* to *c*) the more powerful it is.

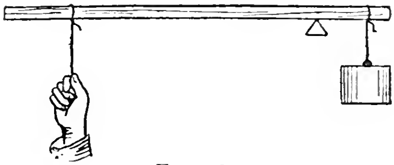

FIG. 162.

There are three modifications of the lever proper. In the lever of the first class the fulcrum, as in Figs. 162 and 163, is between the applied force and the weight — between the force that is set in motion to displace the obstacle to which the lever is applied and the obstacle itself. The force we apply bears the same ratio to what the obstacle has to resist at the hand of the lever that the length of the one arm of the lever, the one we push or draw down, bears to the other. If we force down the free end of the lever with a pressure equal to a hundredweight and the free end of the lever be ten times longer than the other, then we bring to bear upon the body affected a force or pressure equal to half a ton. The longer, therefore, our end of the lever in comparison with that at the other side of the fulcrum, the more effective is the machine at our disposal. And proportional, of course, to the length of the arm of each division of the lever as to the separate forces applied will be the space moved by the respective points of application of the force we put forth and the weight we disturb.

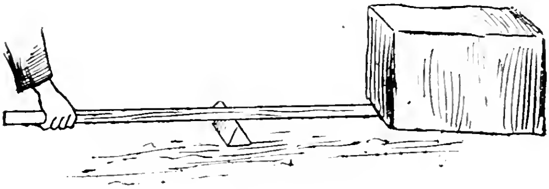

FIG. 163.

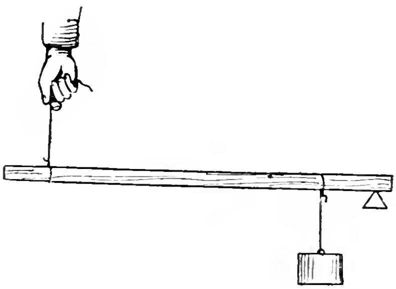

FIG. 164.

The lever of the second class has, as in Fig. 164, the force at one end of the rod, the fulcrum at the other, and the weight between the two. The force in this case is hardly likely to be so advantageously situated as in the lever of the first class. It is capable of being applied as forcibly, however, but not to the same extent as the other. There are fewer cases where it is applicable. It can be used to disrupt or draw a body into separate parts. It is shown in Fig. 165 as put to the purpose of withdrawing a peg from the ground. An ordinary nut-cracker is a double arrangement of this class of lever. The

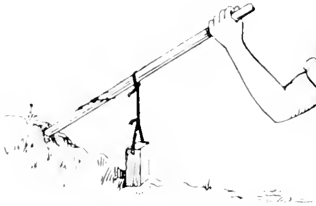

Fig. 165.

humble wheelbarrow, Fig. 166, is a modification of it. The fulcrum is the axis supported on the wheel so as to be capable of being transported or pushed along at a minimum expenditure of force against friction.

The lever of the third class, Fig. 167, has the applied force put in action between the fulcrum and the resistance or weight to be moved. In this instance the applied force must always be the greater of the two. It is, in fact, simply a reversion of the conditions that govern the second lever. The applied force in the latter is the weight in the third variety of the lever. It is of no use of course as a mechanical advantage by way of giving us increased force against any body we are dealing with; but it affords means of obtaining an increased range of movement by the free end of the lever. Nature has in this way turned it to account in giving such a wide range of movement to our forearm. The elbow, as shown in Fig. 168, is the fulcrum, the hand the free end of the lever; and the contraction of the biceps the source of the applied force that sets the contrivance in motion. What an expenditure of force must at times be called forth in the working of that organ we may form some idea of when we consider how close to the fulcrum (the elbow) the biceps muscle (the motive force) is applied. When one displays his thews and with satisfaction

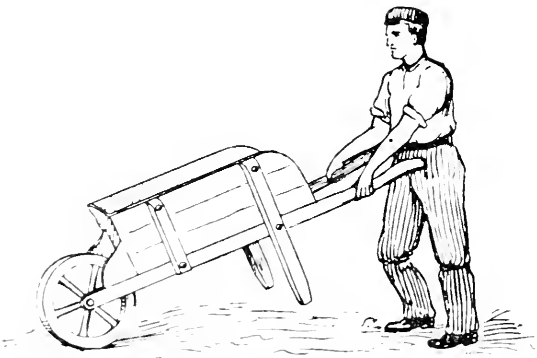

Fig. 166.

shows how his biceps swells as he slowly raises a heavy weight from the horizontal, resting on outstretched palm to the level of his shoulder, he little knows what force is being developed at the expense of the contractibility of the fibres of the muscle of which he is so justly proud. A much greater force, however, is expended in getting the forearm from a hanging to the horizontal position. Man's jawbone is another common illustration of the application by nature of the third lever to the everyday affairs of life. The fulcrum plays on the skull a little beneath the ear, and the muscles embedded in either cheek are the applied forces that move the lever and bring the lower teeth into action as crushers or grinders of food against the upper set.

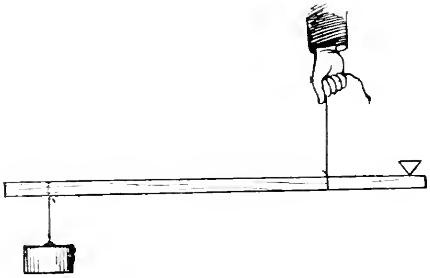

FIG. 167.

The Inclined Plane.

The next of the simple machines, the inclined plane, supplements the applied force by enabling the weight on which it bears to be slid up a gradually rising path in place of its having to be lifted bodily up a height equal to that which the head of the path or plane attains. How much easier, for instance, is it to wheel a cask (one, say, that we can just manage to raise breast high) up a plank from the ground to a lorry than to lift the article direct from the ground and deposit it thereupon. The cask has a longer journey to take by way of the plank than it has straight from the ground to the vehicle, but an easier. Here again, as happens in the case both of the pulleys and the levers, that what we save in the applied force we have to make up for in the increased space that the point of application of that force has to move. The longer the plank the longer is our plane and the more easily can the cask be rolled up the same.

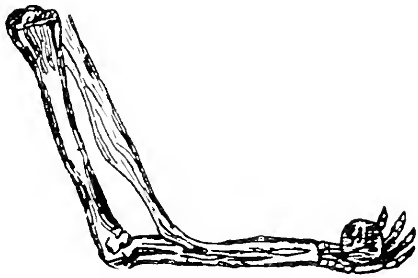

FIG. 168.

The stair is simply an adaptation of the inclined plane. It is an inclined plane with horizontal footholds attached at regular intervals, it being easier of ascension when provided with these on account of their enabling the body to be kept erect without undue strain on the muscles of the legs and back. As we are all aware, the angle at which the stair is set rules its degree of comfortable use. The gently-sloping stair is a pleasure to move up and down upon in comparison to another of a steep slope. We have the longer distance to go in connection with the former, but it can be done with less muscular effort. We do not feel we are climbing when ascending the long, slowly-rising one; neither do we need to hold back when retracing our steps. Were the stair removed for a time we would soon realise its advantage as a machine for circumventing gravitation, as it affects us in our efforts to keep up communication between the separate flats of our houses in a perpendicular direction. We would certainly have less distance to traverse, but then more force has to be expended, a result that no doubt would soon set us about contriving something after the nature of an artificial lift. It is with ourselves as it was with the cask. In carrying our bodies against gravitation, the easier we make the process the longer time we are obliged to take to it, or at least, the further we have to go. The mechanical advantage of the inclined plane is the product obtained by dividing the length of the incline by the height thereof.

The Screw. The screw is a modification of the inclined plane. In fact, it is nothing more or less than a spiral inclined plane. As most of us know, the closer the threads of the screw are the more powerful it is. We have more turns to give it because, as we have so often repeated, the greater is the mechanical advantage of a machine, the more distance has the applied force to describe. The screw is a powerful help in moving heavy weights through short distances. And we increase its power manifold as we add to the length of the handle we make use of in turning the screw. By doing so we introduce the lever between the applied force and the inclined plane, and thus obtain the further aid of the mechanical advantage that it supplies.

The Wedge. The wedge, Fig. 169, is another application of the principle that underlies the inclined plane. Instead, however, as in the case of the inclined plane of the bodies being slowly applied thereto as a means of raising them against gravitation, the wedge is called into service by being applied under a series of blows to bodies, and made to do work either in rending them asunder or raising them slightly from their points of attachment to the ground. It is the sudden impulse of the heavy blow bestowed upon it that gives the wedge its great power. A certain force borne gradually on the wedge might have small effect, but the same coming upon it with the speed of lightning would tell a different tale. Something would then have to go. The reaction of the block or body against the action delivered by the wedge is not, under the peculiar circumstances of the case, sufficient to serve both wedge and hammer as the target served the bullet, for the wedge, when once inserted, cannot as a rule be shaken off by the body, and

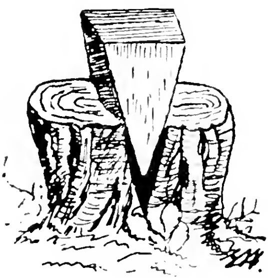

FIG. 169.

until it has got a grip it is not struck hard. Once it bites, however, the pressure of the body on its sides holds it as in a vice, and it is then, so far as reaction goes, now a part of the block. The reaction of the body is then manifest in the rebound of the hammer from the end of the wedge.

What Man was enabled to do with these simple Contrivances.

When man had become master of these simple mechanical contrivances he was fairly on the way to turn the available forces of Nature to his own interests. To begin with, he was able to move and break up heavy blocks, either of wood or stone. He was in no hurry—at least, he could afford time; and it did not matter to him that what he gained in force or power he lost in speed of execution. It was enough if he could move about and break up what before he was all but powerless to deal with. Afterwards he fashioned the windmill, and thus took advantage of the wind to grind his corn or do other work of a similar nature. Earlier, no doubt, he took advantage of the air-currents to waft along the boats and vessels that took hard labour to move by means of paddle or oar. By-and-by he enlisted water on his side, thereby gaining for many purposes a more reliable and steadier servant than the uncertain wind. After a while he discovered the virtue of fossil fuel, and with coal as his friend he had Nature very much at command. The sun is the mother of all the forces that are connected with our universe, and in coal he had unearthed a vast reserve of them. It represents the stored-up rays of the sun that were directed on the earth for ages. It is, in fact, bottled-up sunshine, as Stephenson so pithily put it.

Force derived from Heat.

Coal represents the force to be derived from heat. We have spoken of the force derived from motion as being convertible into heat, and conversely of the force of heat being convertible into that of motion. The force that seemed lost when the bullet we instanced above came to an instant stop against the target developed, as we tried to explain, into heat. The head of the iron wedge becomes hot under repeated blows from the sledge-hammer; and so does the brake as it presses hard against the wheel, and retards its movement. Hitherto we have dealt with force in relation to the amount of bodies or masses of matter under the influence of gravitation, excepting, of course, when air-currents over which gravitation has little influence are taken advantage of. But a different class of phenomena manifests itself when we deal with the forces arising from heat. Heat takes to do with the molecular composition of matter, with the internal component particles that constitute a body. We have already noted how these change their state accordingly as matter takes on its three different physical conditions. In the solid they are quiescent and at peace, as it were. In the liquid they are mobile, but still willing to club together and be at rest once they are adjusted to gravitation. But in the gas each is for itself, regardless almost of gravitation, and had it all space to itself would seek to fill it. In the solid the molecules content themselves within the bounds described by the body and each keeps very much its original position therein. In the liquid this bond of integration is broken, and cohesion is virtually gone. The body is now shapeless and without bounds of its own, and unless held together in the mass, each molecule will, regardless of its neighbour, start to carry out the behests of gravitation. In the solid all work as one so long as the body holds together. But in the liquid there is no such bond of union; each molecule is a body to itself. These two conditions of matter somewhat resemble the well-built wall and the ill-built one already instanced. The separate stones in the former are bound together to make a firm and compact whole capable of resisting gravitation otherwise than it applies to the body corporate. As regards the other, however, the whole is so loosely knit together that each component part is apt to become a law to itself and fall away from the union that alone gives it strength.

In the gas not only are the molecules detached from each other, but, unlike their behaviour in the liquid, in which state they are content in each other's company, they repel one another in their struggles for elbow-room. The liquid can be kept within bounds so long as the bottom and sides of their storage-place are impervious to water. It matters not that its surface is exposed to the heavens. It will remain there until wanted. Water is, indeed, one of the exceptions in the last respect; for in time if thus exposed, it will be absorbed in form of gas by the air, there to perform its most important part in the economy of nature. But with the gas it is different. It must be confined all round, else it will speedily vanish into space. There are heavy gases and light gases: the latter will be the first to disappear. Some are even heavier than air. These, one might naturally think, would be held down in a vessel of gravitation similarly as it affects a fluid. It does for a time, but only apparently, for from the beginning of the exposure of the gas the law of diffusion is at work, and the molecules of gas, heavy in comparison though they be, are being disseminated throughout the atmosphere, and with others left free to knock figuratively against the gates of heaven.

Heat, as already explained, is the controller of the different conditions of matter. By its application to the solid the molecules thereof are forced to assume the liquid state. A further application raises the liquid to the gas and sets the molecules into movement. The tendency of these is, we have seen, to demand room and space. Without these they cannot expand, and expansion is as the breath of their nostrils. It takes force to curb their aspirations. Were the pressure of the atmosphere suspended for a little, were it moved out of the way and its weight lifted off the surface of the earth for a time—for it is simply its weight or its obedience to gravitation that makes it press so heavily upon us—water for one liquid would there and then without assistance from heat pass into the gaseous state. Other bodies would we daresay do the same before it came to water's turn. Thus it is that before water can be brought to boiling-point we must bestow on it as much force in the form of heat as will enable its component molecules to cope with the weight of the air that tends to hold them in thrall. After that stage has been reached the molecules are free to take up their ethereal form and search through the atmosphere at will almost.

It is only at the expense of much counter-pressure that gases can be kept from expanding themselves. The heat and the pressure serve, as we have been saying, to counteract each other. On the one hand heat supplies the force necessary to their expansion, and on the other the sides of their enclosure keep them so cabined and confined that they have not room to stretch. Close confinement even for a long term does not impair their vitality of movement. unless it be that they are again deprived of a certain amount of heat. With heat goes their force. Keeping this in view, chemists. as we have already pointed out, have been able to reduce the most stubborn gases to liquids by placing them under circumstances whereby intense cold and immense pressure are at one and the same time brought to bear thereon.

The Expansive Property of Gases a Source of much Power.

It is clear, therefore, that having at command a body of gas closely confined under great pressure we possess a fund of power that is capable of being put to useful purpose if it is possible to apply the force to a machine by means of which it can be turned to profitable account. Machines of the kind we now possess in plenty. By their means force of the nature we refer to is now turned to account as readily as that of running water or the hand of man can be—much more readily, in fact.

In a store of gas under pressure we have a reserve of force. just as we have one in a good head of water dammed up in a reservoir. In the water thus held back against gravitation we have a store of latent energy ready to be turned into the active energy of motion, as, when released of the sluice, it rushes down to a lower level in search of another resting-place. In like manner we have an accumulation of latent energy contained in the compressed gas ready when liberated to bestow upon the machine it is connected to the energy of motion as it seeks a passage into space, there to obtain relief from its straitened position.

The Use of Coal in this Connection.

Without coal as a promoter of heat man could never have developed manufacture to the extent it has reached since he became alive to the possibilities that lay latent in that commodity, and turned it to the production of power. It enabled him, moreover, to make machines at the same time that it afforded him the means of obtaining the motive power necessary to keep these effective. The property possessed by water of being easily converted into gas, together with the general plentifulness of the fluid, early stamped it as the medium through which to utilise the heat that lies latent in coal. With these two substances, therefore, man was able to evolve steam, and steam as a force capable of being turned to man's interests was the fundamental cause of the great progress made for one thing in quick transit, and what is implied, both in the attaining and carrying on of the same, that will for ever characterise the nineteenth century.

It was fortunate for man that Nature stored up so vast a supply of concentrated force-supplying matter. True, she afterwards suffered enormous quantities to be either shorn away or crumbled down from their places of deposit in the course of changes in the geological features of the earth's crust, and only patches remain of the original widespread coalfields. But enough was left for man wherewith to enable him to obtain and keep in easy touch with all parts of the globe, and to develop arts and manufactures in a mighty way. This is being carried on, however, at a tremendous expense as regards eating into the supply of coal. Future generations may have reason to regret the manner in which we dip into this precious store of heat and force. We cut and come again regardless of those who are to succeed us. Woe betide man when the inevitable stage of universal scarcity, not to say want, of coal has been reached! He will neither have sufficient fuel to give out heat for his own comfort, nor enough to provide the higher kinds of motive power. Thenceforward, judging from analogy, he will perforce be obliged to confine himself to warm latitudes, and to fall back on wind and water as force suppliers.

The sun itself must in time cease to give forth enough of heat to maintain our globe in its present condition. Since the vegetation the remains of which compose the deposits of coal grew the sun's power has evidently lessened, because nowadays, among other proofs, plant growth is far less vigorous, partly due no doubt to loss of heat in the earth itself. What with increasing multitudes of people, the sun declining in power, and coal practically used up, habitation of the earth in the remote future does not call up a pleasant picture.

The Tendency of Heat and Force alike to come to a State of Uniformity or dead level.

Every display of force that manifests itself on earth is but a see-saw movement in the universal tendency of all things to come down to one dead level. It is the same with heat as with gravitation. All matter on our globe seeks to wind its way towards the centre. Whether solid, liquid, or gas, all forces are alike. The densest stuff gets the furthest in, and the nearer the centre the more tightly is the matter packed together. That, at any rate, is the lesson unfolded in the earth's crust so far as it has been penetrated. The fluid matter apparently can only force its way a little distance into the crust, and has to content itself with pressing against the outer skin thereof, collecting in volume where it can in the depressions on the surface that are available. The gases, being the lightest, have to rest content with the outermost circle, where, like Mahomet's coffin, they exist, as it were, between heaven and earth. On one hand their molecular expansive force would lead them heavenwards into the starry space, were even they, etherealised matter though they be, not in manner similar to more materialised matter, completely under the grasp of gravitation. The earth allows them full scope to swell out to their utmost limit, but withal they are unable to break loose from the tie that binds them to the globe in its giddy whirling course in the ether. So tight a grip does the earth keep of her airy mantle, or rather, so closely does it cling to her, that it presses around her, as we all know, with a force equivalent to a weight on her surface of 15 lbs. to the square inch.

A mass of solid matter will, if left free to obey gravitation, fall through air for a similar reason that a stone sinks in water, because, as we have already indicated, gases as well as liquids fail to support compact masses of matter of a greater density than themselves. Denser solid matter, as exemplified in boats and balloons, can be fashioned into such form or be so balanced and assisted as to float in water and drift in the air; but we are speaking just now of matter in the lump. If free to slide or roll down a hillside, it will similarly set out in obedience to the same influence and keep on its way until checked. In the same way, as we have so often repeated, will water take the first advantage to run or slide down to a lower level. All matter, even when in the gaseous condition, is, indeed, ever on the watch to evade obstructions that come between it and its inherent desire to be off on that errand of Nature's bidding to find its level. Once all matter has under this law—that of gravitation—found its level, what is there that can disturb the balance again, and so afford us some opportunity of turning to useful account the force expended in restoring the equilibrium? It is evident that falling masses of solid matter and water seeking a lower level would be capable of performing useful work for us could we succeed in applying their energy of descent to a machine that can convert force of this nature to a useful purpose. But it would take as much force to raise either to a position of vantage whence they could yield energy as what it would be capable of exerting on its way down again. That process would therefore simply be robbing Peter in order to pay Paul, and could serve no profitable end. It would, at any rate, be impracticable in cases where much expenditure of force was in question. In several minor affairs of life it is an accepted mode of deriving force. Clocks, for instance, that depend on weights for giving motion to the machinery, afford a well-known example of this method of turning gravitation to account.

We have nothing advantageous, then, to look for from the falling of solid matter in the way of obtaining useful force; and well, perhaps, it is so; for the placing by Nature of solid matter in places of the kind would imply such convulsions and upheavals of the earth's crust as would make it a very unsuitable field for our operations. Thanks, however, to the sun's influence, water, in spite of gravitation, is constantly being raised in vapour, afterwards to be let loose as rain, which, when it accumulates on sites at all elevations, gives man a never-failing source from whence to derive force that can be put to service in manifold ways. Only a small fraction of the immense power that Nature in this way develops is taken advantage of by man. But now he is recognising its adaptability to many of his purposes, and is beginning to avail himself of it on a much larger scale than of old.

As all matter tends to find its level, so, as hinted above, does heat incline to come to an equal temperature in all substances. When a hot and a cold body are placed together, in time they will be of one temperature. The hot body will have yielded heat to the cold one until the latter was of a like temperature to itself; and further, these two will do likewise with surrounding objects, if not with the air itself, and then there is stagnation in so far as force is concerned. But even with coal all spent, so long as the sun is there to rule by day we have a head of energy that can effectually kick the beam and disturb any balancing of this sort. While the prime source of terrestrial heat maintains its prominence, there is little fear of a general levelling up of force in that respect. The vulgar interpretation of socialism which implies equal shares all round of the world's gear has no counterpart in Nature's economy. Her fundamental laws are based on inequality and opposition; and when a general peace on the part of her forces that rule the earth is at hand the end of the globe as an animated stage, if not then reached, is very near.

Summing up.

Gathering together the threads of our discourse, the sum and the substance of what we have been seeking to make plain in this chapter is that man is able to put to his own uses many of the forces of Nature as represented in the movement of matter. In our present connection—that of the homestead—there is hardly need to touch on the more subtle forces, such as those of chemical reaction and electricity. It is only the simpler ones that as yet are of moment at the farm. The movements of air and water in the mass and of the expansion of gases as exemplified in the generation of steam in the steam-engine, and in the sudden expansion of petroleum vapour in the oil-engine are—never of course forgetting the assistance of our invaluable serf the horse—the only sources of energy that farmers find practicable for the hitherto rather cumbrous sorts of machinery that are in evidence at the homestead. These the agriculturist finds it easiest to enlist into service in the working of his fixed machinery.

In the simple machines that we referred to and described, viz., the pulley, the lever, and the inclined plane, we saw that when we sought to concentrate the power at our command, whether strength of arm or weight of body, or, as it were, make it more effective and do more work at the other end, we had either to cause it to move through a greater space than the point of application did, or make it move at a greater speed, usually indeed both. What we gained in efficiency we sacrificed under these two heads. Coming now to the application of force to the machinery representative of the homestead, we find the position of matters somewhat reversed. The stronger force is now the one that is applied to the machine. We are now, so to speak, working from the wrong end of the lever, the one that moves the slower and for the shorter distance of the two. But ere we get our motive force fairly to bear upon the part of our machines that do the useful work, much of it is unavoidably rendered non-effective. There are almost necessarily so many parts through which it has to be transmitted that a great deal is swallowed up in passing from one point to the other.

The inertia or unwillingness of the matter involved in the construction of the machine to move has, in the first place, to be overcome. This, however, disappears as a factor of resistance when proper way has been gained on the machine—these two incidents illustrating rather patly Newton's first law quoted on page 208. It takes, for instance, a considerable effort to set the thrashing-mill going; and once it is in full swing, it takes as much to bring it quickly to a standstill again, assuming, of course, that no corn is being fed into it. It would gradually come to a stop of its own accord, proving that there was much resistance against its "moving uniformly" on its course.

None of the force expended in giving motion to the mill is lost, although it does not give a full account of itself at the further end. What disappears on the way thither is lost in the many changes in direction that are given to the force in leading it to the point of application. Every change of this kind means resistance in the form of friction. When a body is made to move against or to glide over another the attraction one to the other causes some degree of resistance to this movement. When the faces of the bodies in contact are rough there is greater resistance than if smooth, and if soft and yielding, more than if hard and firm. Force exerted against friction is converted into heat; but heat that we do not wish for is no compliment. Perfection of workmanship in the construction of the mill, together with due lubrication of the bearing parts, reduces friction to the minimum point. The parts that rub together during motion are made hard and smooth, and are in addition kept from complete contact by means of the lubricating medium employed.

The Retardative Effect of Friction in Machines.

The great art in machine-making is, of course, to make the machine so smooth-working that as much as possible of the force bestowed on it will be transmitted to the working point. The amount of power that is taken up in overcoming friction in a home-made or crude sort of machine as compared to a well-finished one would astonish any one who has never considered these matters. It comes home to him when we draw his attention to the extra force a horse has to put forth in drawing a load over a newly metalled road not yet rolled beyond what is needed at another part that is firm and smooth of surface. It is on account of friction being reduced to the lowest point that the railway is such a perfect road for the transportation of goods. The polished unyielding surface of the steel rails affords such an easy path for the equally smooth-tired wheels to roll upon that between the two similar surfaces there is only the minimum of friction involved. The traction power put forth to draw a heavy train would not have much effect in dragging the same along an ordinary road. It would be a very small part indeed of the train that it could even manage to give a start to.

The part of the motive force applied to any machine which is swallowed up in overcoming what we may call the inertia of its various parts is called the co-efficient of that force, the other factor being its mechanical efficiency. The less the co-efficient, the less, other things being equal, is the motive force needed to make the machine perform its work. As we shall see in the course of the succeeding chapter, there is considerable room for improvement in this respect as regards the usual class of machinery put to work at our homesteads.

What a Horse-power represents.

It is usual to speak of force-producing machines as being of so many horse-power or even a fraction of that measure. We may have, for instance, an eight-horse-power steam-engine or a half-horse oil one and so on. This, no doubt, has arisen from the fact that horses have to so large an extent been devoted to the purpose of providing motive force. One-horse-power is equivalent to a force that will raise 33,000 pounds of matter one foot high in the course of a minute in opposition to the force of gravity.

CHAPTER XI.

"Power" at the Homestead—*continued.*

"Power" now in Demand for many more Purposes than formerly at the Homestead.

Once upon a time the thrashing of the corn crops was the sole operation at the homestead that had other than manual power provided for its execution. Now, however, there is pulping of turnips and mangolds, corn-bruising, cake-crushing, and very often coarse grinding of grain all to be provided for. In the earlier days at the small farms even the thrashing was done by hand. In fact, the noise of the flail is occasionally to be heard at this date. It is not, indeed, so long since the thrashing-mill came to be an essential at the big homesteads. Before its introduction there was nothing for it but to beat the crops on the thrashing-floor.

When the thrashing-mill was introduced, in the absence of a head of water for its motive power, there was only the wind or the never-failing horse to press into service in this way. And because of the rather wayward nature of the wind it was seldom turned to account. To the steady horse, therefore, fell this addition to its already full round of labour. This extra branch of labour formed a heavy burden on the horse-power of the farm. Heavy, unremitting, and most monotonous work in the mill-course took the spirit sadly out of the poor animals. The farmer, obliged to make use of his horses for driving the mill, had good reason to envy his neighbour who had water at command for the same purpose. Notwithstanding its cost, he gladly turned to the steam-engine when it appeared in the market as a practicable aid at the homestead.

Horse-power all but Obsolete.

In those districts, where, as a rule, the farms are small, even there the horse-driven thrashing-mill is now being often left to fall into decay. The itinerant thrashing-mill is at the farmer's disposal, and he prefers paying for its help to "taking it out" of his horses. But this is a plan that, in many cases, is conducive both to untidiness and waste. It usually implies heaps of loose straw about the place. The straw thus yielded in large quantities at a time is never put together so neatly as the sheaves are to begin with. It could be, no doubt, but as it has to be used soon the labour spent in doing so would generally be looked upon as lost. With so much at hand there is certain to be less economy in the using of it: and being so much exposed to air and weather, it loses not a little of its freshness as fodder. These, however, are points of less moment at the big arable farm, where often the cry is how to get enough of the straw trodden underfoot, than they are at the dairy farm, for instance, where the straw is held as an article of fodder. Asking recently the tenant of a North-country farm of the latter class, whose horse-mill was fast becoming useless, if he now depended entirely upon the travelling mill, the reply was, "'Deed no; I get it as seldom as I can; it makes sic a waste." "What do you do, then?" we inquired. "Do you handle the flail?" "Oh, I daud a few sheaves against the rungs of a ladder every morning," he answered. And not a bad idea either. If the sheaves are not clean thrashed, the cows and the horses enjoy them, and consequently profit by them, all the more. They are served to them for being eaten, not for being slept upon.

The Advantages of Water Power.

So great is the advantage of having water power at the homestead, one has reason to be surprised that this has been so often overlooked. That we find so few homesteads provided in this way is, perhaps, due to the fact of their respective sites having been chosen at a time so far back that there was then no machinery calling for motive power other than manual labour could cope with. It is not, however, to long-established homesteads alone that this neglect on the part of those who planned them in seeking the aid of water power is applicable. The same can be advanced against many of recent date. It is only, of course, in certain districts that water is available in this way. In some of the wide level tracts of good cropping country, where thrashing is such an important operation, water is too scarce for the purpose; and were it more plentiful, the configuration of the ground is usually of such a nature that it cannot be fully turned to account. There is generally a difficulty in giving enough of fall to the water to allow much work being got out of it. We are, unfortunately, likelier to meet with water available as power at the homestead in those districts where corn growing is more a subsidiary branch than the almost all-absorbing one it is in the strictly arable parts of the country.

But wherever power is needed at the homestead, whether on the half arable or the wholly arable farm, water when available in this respect should be taken advantage of. And whenever it falls to one's lot either to select the site for a new homestead or to give advice thereon he should bear in mind the great importance of securing so valuable an aid in the performance of work at the place. A homestead well supplied in this way ought certainly to add to the letting value of the farm. We question if it ever did so in the past, but the cost of labour, whether manual or mechanical, is not now what it used to be in country districts any more than in towns; and the time is approaching when a cheap source of power, such as water in many cases can be made, will be taken at its proper value.

The three Modifications of the Ordinary Water-Wheel.

There are three modifications of the vertical water-wheel, viz., the undershot, the overshot, and the breast wheel. In the first-mentioned, as Fig. 170 shows, the force of the moving water is applied to blades which are attached to the circumference of the wheel, and in turn as it revolves dip into the water. The running water strikes against these blades, its momentum as applied to them serving to give motion to the wheel. A wheel of this kind is applicable in cases where water is so plentiful that there is not much need to economise it. Almost all water power derived from pent-up streams is utilised in this manner. In fact, it can hardly be applied otherwise, unless the bed of the stream happens to have a steep declivity. With a lowland stream there is usually so slight a fall from where the water is diverted into the mill lade or lead and the point at which it rejoins the stream that no other class of wheel is practicable. But the abundance of water in these instances makes up for the deficiency in the fall of the stream.

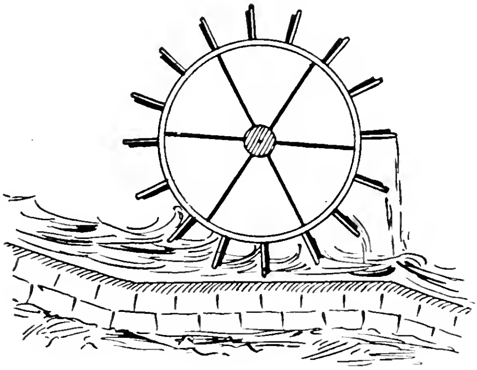

FIG. 170.

The Undershot Wheel.

The undershot wheel acts in a directly opposite fashion to the paddle-wheel of a steamboat. In the latter the blades of the wheel strike the water, and in this way impel the boat onwards, but with the undershot wheel the water is this time the moving agent which, as it strikes against the blades, causes the wheel to revolve.

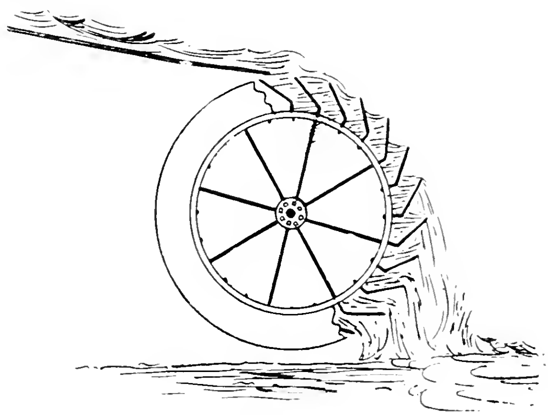

FIG. 171.

The Overshot Wheel.

The overshot wheel, on the other hand, is utilised where water is not so plentiful, and where, in addition, it can be afforded a considerable drop in order to give it increased impetuosity. The water, as indicated in Fig. 171, is led on to the top of the wheel, and is caught in the series of buckets that in this class takes the place of the blades or paddles that characterise the undershot wheel. Not only does the water tend to force round the wheel as it is arrested in its course by the constantly succeeding buckets, but its weight as these become filled adds to the weight of the rim of the wheel, and thus, under the law of centrifugal force, increases the momentum of that part. The buckets empty themselves before the water can become an encumbrance by being raised on the other side against gravitation.

The Breast Wheel.

The breast wheel is a sort of compromise between the other two. It is used where a shorter drop is given than in the case of the overshot wheel, which, of course has to be compensated by a fuller body of water. The stream of water is led on to the side of the wheel, or, perhaps, the shoulder rather than the side. But a reference to Fig. 172 will explain the arrangement. This wheel, it will be seen, turns in the same direction as the undershot wheel, but contrary to the overshot. The water is dropped between the end of the shoot and the wheel, and falling upon the latter, fills the buckets, which, as with the overshot wheel, are fixed upon its circumference, and so carries it round by sheer weight. Where water is plentiful paddles are substituted for buckets.

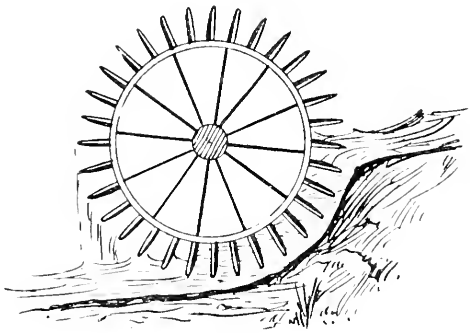

FIG. 172.

The mechanical Advantage of the ordinary Water-Wheel.

The water-wheel not only enables us to transmute the motion of the water to other points more convenient to our purposes, but it also serves the part of a simple mechanical advantage. It is a modification of the lever, as exemplified in the wheel and axle, Fig. 161. The length of radius of the wheel multiplied by the momentum of the water (the sum of its weight and velocity) gives us the amount of power we have at command at the axis of its axle.

Sticking to round figures—for mathematical accuracy is hardly practicable in the every-day affairs of the farm, and in consequence is seldom run after—a cubic foot of water weighs about 62½ pounds. In a cubic foot of fluid, as we have seen, there are about 6¼ gallons, and a gallon of average surface-water weighs rather better than 10 pounds, but for our purpose may be taken at that figure. These figures are sufficient to prove the comparative accuracy of our statement, and they are easy to remember. With this knowledge for a start, what is needed in addition to enable us to calculate approximately the power of any water-wheel is the quantity of water that can be steadily applied to the same, together with the distance which the water falls while it is in contact with the wheel.

In addition to this, however—at least, as regards both the undershot and the overshot wheels—there comes in the momentum (the quantity and rate of motion or velocity) of the body of water as it impinges upon the floats in the former case and against the buckets in the latter. In fact, as regards the undershot wheel, the somewhat primitive data given above is not sufficient for guiding us to a solution of its power. Something besides what we have stated is required to lead us to any degree of accuracy on that point. The running water is in contact with each of the floats as its turn comes but for an instant, and only a proportion of the passing water gets a chance to bear upon the wheel. The floats are never so large as to take up the whole area of the channel.

But with the other two respectively, when matters are properly adjusted, nearly every drop of the water led forward is applied to the wheel, and accompanies it in a part of its revolution in the overshot for half a turn, and in the breast wheel between a half and a quarter turn. Applying now our data, suppose we have available a supply of water capable of playing upon a wheel, 20 feet in diameter, at the rate of 300 cubic feet in a minute, and that it keeps in contact with the wheel while it descends, say, 10 feet. Here we have 300 cubic feet of water, weighing 18,750 lb., which, multiplied by 10, the number of feet it falls while doing work in connection with the wheel, gives us a force of 187,500 lb. applied at the rim of the wheel. This represents a motive force of 187,500 foot-pounds. A horse-power we noted at the end of last chapter as being equivalent to 33,000 foot-pounds. We have, therefore, with our assumed wheel and available water supply at our command, a working force equal to a little over five and three-quarters horse-power.

This is only theoretically, however. In practice the farm water-wheel is too clumsy a contrivance to transmit a very large proportion of the motive power to the working point. Only about ·60 of it comes to be effective. Ten times the initial force playing in this case upon the circumference of the wheel comes, we must bear in mind, to act at the central point of its axle.

A reference to Fig. 173, taken from Stephen's "Book of the Farm," and which explains itself, makes clear how simple in all its parts, as well as in the application thereto of the force, is the ordinary water-wheel. Simple in construction, easy of control, and not readily put out of order, it is a mechanical appliance admirably adapted to the uses of the farmer. The figure represents a breast wheel, the water being led on about forty-five degrees from the top. It is shown made all of iron, excepting the buckets and the rim to which these are attached. Sometimes these parts of the wheel are also of iron, but wood is, perhaps, the preferable material with which to fit them up. A bucket made of wood can be more easily repaired or replaced than one of iron. The wheel is cast in separate pieces, which can at any time be taken asunder for repair. The simplicity of the arrangements for letting the water when not required past the wheel and for regulating the quantity to be applied is self-apparent.

A Drawback of the Water-Wheel.

The one drawback to the water-wheel is the introduction in connection therewith of so much water about the place. As a rule places of the kind are damp enough without adding to that condition by introducing an underground stream alongside some of the buildings and beneath others. The wheel pit, in order that the power may be nearer its work, is usually placed alongside the barn wall in line with the thrashing-mill inside, and, on account of so

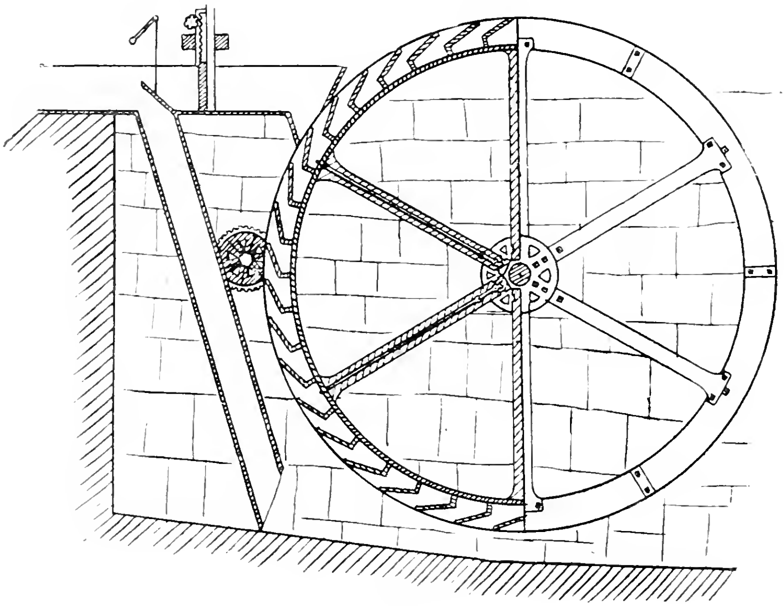

FIG. 173.

much water being splashed about it, that part of the wall is constantly dripping. If the side wall of the barn be badly built—loose and hollow inside, as so often happens—there is little wonder that the barn itself is damp, and not infrequently infested with rats. But there is no reason why the water-wheel cannot be prevented from becoming a nuisance in this way. If care be taken in providing for the introduction of water to the homestead as a source of power, and its installation be carried out properly, there need be nothing to fear in that respect. With large-sized fireclay pipes now so readily available, the water can easily be provided with a watertight channel, if not all the way from the dam to the wheel, at least as far back from the latter as will safeguard the homestead from the effects of leakage as the water approaches the buildings. And what with fireclay bricks and cement easily procurable, it need be no difficult matter to render the sides of the pit watertight; and with concrete to put the bottom thereof in like condition. And if pipes are not practicable in the construction of the tail-race or exit from the pit, bricks and cement will serve to keep it from being a source of dampness until it is clear of the buildings.

Through neglect of the former of these precautions, that of making the lade or conducting channel from dam to mill-wheel watertight, we have often seen parts of homesteads rendered worse than useless. The places so affected got the name of sheltering or housing cattle; but while affording this they lay the stock open to diseases which they would never contract if left out in the open without other shelter than fences, and perhaps an open shed to which they could retreat in times of stress. And not only does the stock of the occupier suffer under conditions of this sort. The woodwork of buildings so situated very soon becomes a prey to the lowly organisms that breed and flourish in the mouldy corners characteristic of buildings which are subjected to a constant state of almost stagnant dampness. But the mill-pit is generally the greater sinner of the two in respect of introducing dampness to the homestead. In neither case, however, need there be room, as we have already said, for any harm to arise from water as the motive power to the homestead. It is as easy to make a satisfactory job here as in any other department of the buildings. Careful, though by no means necessarily expensive, work is no doubt required here, but the same applies to all the other parts. Something like what holds good with the drains, however, is apt to be the case with the water-power installation. Because it is to be out of sight it is thought less care may be taken with it than with work that will be above ground and always in view. The laying on of water for this purpose is undoubtedly a considerable addition to the cost of building the homestead, but, as we have said, it is seldom taken account of in estimating the value of the farm it is intended to benefit. This extra cost has, we suspect, much to do with the number of places unprovided with water power that might easily have been served with so great a convenience. But estate managers stand in the light of the interests of the estates they control when they curtail expenses that would confer so great a benefit on the occupiers of a homestead.

It is not necessary, of course, that the water-wheel should be absolutely alongside of the barn wall. There is nothing to hinder it from being placed some distance away from the buildings so long as it is practicable to transmit the power to the point where it requires to be applied. But this implies shafting and allied means of passing the force from the wheel to the thrashing-mill, all of which add to the cost of installation. Moreover, a good deal of force is sure to be dropped by the way in overcoming the friction between the various parts that serve to transmit the force.

The Turbine Water-Wheel. There is a class of water-wheel which, in our opinion, is not so much taken advantage of at the homestead as it ought to be; we mean the turbine wheel. One can turn a head of water, whether it be a plentiful one with a short drop, or one small in quantity but with a long fall, to far better account with the turbine than with any of the other kinds of water-wheels. This form of wheel takes up far less room than any of the others we have mentioned. It sits horizontal and immersed in the water of the tail race. The water is led on to it in an iron pipe, fixed vertically above it, and parallel with the shaft or axle of the wheel. With the older sorts the water pours down the pipe into the wheel, entering it at the centre and escaping at the circumference, but those of later construction reverse the process by admitting the water at the circumference of the wheel and allowing it to escape at the centre. Internally the wheel is vertically divided into watertight compartments radiating from the central point to the rim—not straight, however, like the spokes of a wheel, but at a tangent, with a certain twist or sweep that impels the wheel round as the water in its eagerness to escape impinges upon the walls of these compartments. The whole arrangement is of necessity so compact and so well constructed that this method of utilising water as a motive power cannot lead to much dampness in connection with the farm buildings. Its installation may be more expensive than is the case with the others, but so much depends upon the site of the homestead and the general configuration of the surrounding ground that comparisons of this kind in the absence of reliable data are aimless as well as unsatisfactory. At any rate, a much smaller supply can be made to do useful service in conjunction with the turbine water-wheel than with any of the others.

It is so well adapted for developing small powers that we often feel surprised that it is not oftener made to do duty in this direction. A three- or a four-inch pipe is sufficient to keep going a well-appointed turbine wheel capable of developing a force in accordance with the available fall of the water. Even at a large homestead supplied with ample steam power a subsidiary power such as we refer to would prove a great boon. The lighter machinery, that used for preparing food for the different classes of animals, could be kept going thereby. Some of the machinery in that department is at work on most days of the week—at least, it would be if power were available. But when there is none other at the homestead except the strong power that has been provided to deal with the thrashing-mill, putting it to do these petty jobs is like setting three men to do a boy's work. Instead of doing so, however, it is usual to put off the minor jobs until the thrashing day comes round. This is equally the case where water instead of steam is the prime power. And then too, when the water-wheel is one of so powerful a nature that its use in connection with the minor machinery savours of mockery it would not be bad economy, if matters warranted such a step, to provide a small turbine as a subsidiary source of power. But there is less likelihood of that being required at those places that depend upon water power than there is where steam is the force-giver. We can limit the amount of water being led to the wheel until it is just sufficient to keep the wheel moving and little more, and in this way bring the giant's force down to child's work. We cannot very well do the same with an eight-horse-power steam-engine. This is a matter, however, on which no one can dogmatise. No rule is in this respect of general application. Few homesteads are placed under similar circumstances, and there are many thousands of them scattered over the face of our country. The fact remains at any rate that in numerous cases it might easily have been practicable to lay on water power to homesteads that are deprived of so cheap and easily managed a help towards executing the heavy work that goes on there. In no instance ought water power to be overlooked, whether it be plentiful enough to serve the ordinary wheel, or so limited in quantity as to be only sufficient for the more ingenious and less exacting turbine.

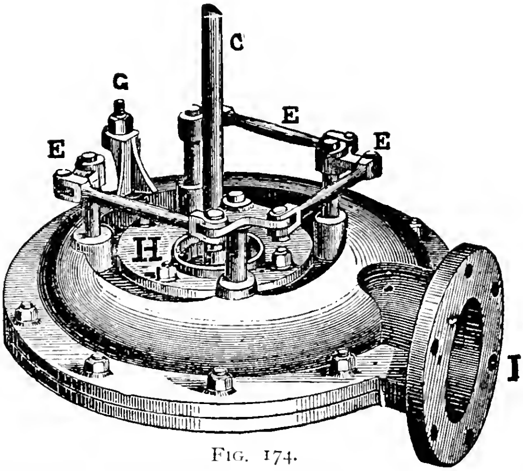

Fig. 174.

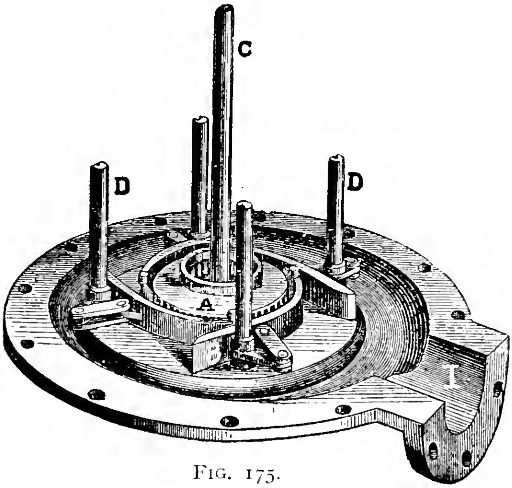

Fig. 175.

A Representative Form of the Turbine. In order to make clearer the matter of the turbine wheel we represent in Figs. from 174 to 179 the one known as the "vortex" turbine. It was invented by Professor James Thomson, and is manufactured by Messrs. Gilkes, Kendal. Since it was put on the market it has been applied to falls ranging from three feet to five hundred feet. It consists of a movable wheel (Fig. 176) with radiating vanes, which revolves upon a pivot, and is surrounded by an annular case, closed externally, but having towards its external circumference four curved guide passages. The water is admitted by one or more pipes to this case, and entering through the guide passages, acts against the vanes of the wheel, which is thus driven round at a velocity depending upon the height of the fall. The water, having expended its force, passes out at the centre both above and below the case. In Fig. 174 the case is complete as usually placed at the bottom of the fall; in Fig. 175 it is shown with the cover removed. The wheels range in diameter from six inches upwards. In this instance A is the revolving wheel keyed on the shaft C. B represents one of the guide blades for regulating the amount of water admissible to the wheel; and D the bell cranks and shafts connecting the guide blades with the outside bell cranks and coupling rods E. F is the guide blade gear (kept out in this instance, but easily discernible in Fig. 177); G the bracket and screw for raising the pivot; H the wheel cover; and I the supply pipe by which the water enters the case.

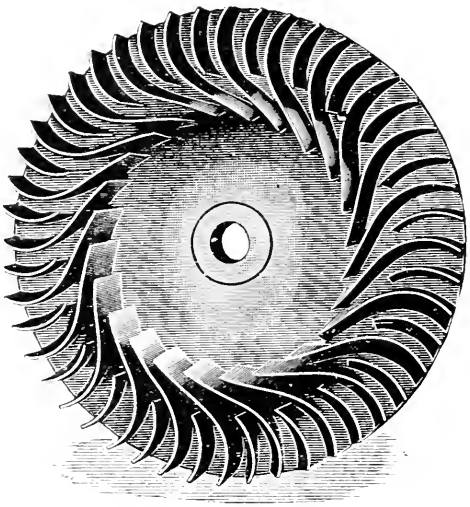

FIG. 176.

Fig. 177 shows a wheel of the kind fixed in position, the top of the case being level with the floor of the tail-race, so that any loss of fall is avoided. The water in this case has a fall of eighteen feet, and it develops a force of fifty horse-power. The wheel rests upon three large stones with an opening towards the tail-race for the escape of the water from the under side of the wheel. The lever end of the shaft works upon a lignum vitæ pivot, supported by the bridge or bracket seen below. A lever, with a rod rising to the surface of the tail water, is provided for raising the pivot when worn. Above the case are shown the cranks and rods for working the guide blades, which are moved by a worm and segment, seen towards the right-hand side of the fig. A part of the strainer box (intended to keep sticks, &c., from gaining access to the wheel) is broken away to show the arrangement of the strainer and bell-mouth entrance of the pipes. The power is transmitted from the upright shaft of the turbine by a pair of bevel-wheels to the horizontal shaft which passes through the wall into the mill.

It is practicable, as we see in Fig. 178, to construct the "vortex" so that it can be fixed in a vertical position. And this form of the wheel admits of being placed without much loss of power at any height above the level of the tail-race not exceeding thirty feet, or the length of a column of water which the atmosphere pressure is capable of supporting in a tube with one end closed and the air abstracted therefrom. We see the principle put to practice in Fig. 179. The principle is that the water in the pipe between the wheel and the tail-race is drawing round the

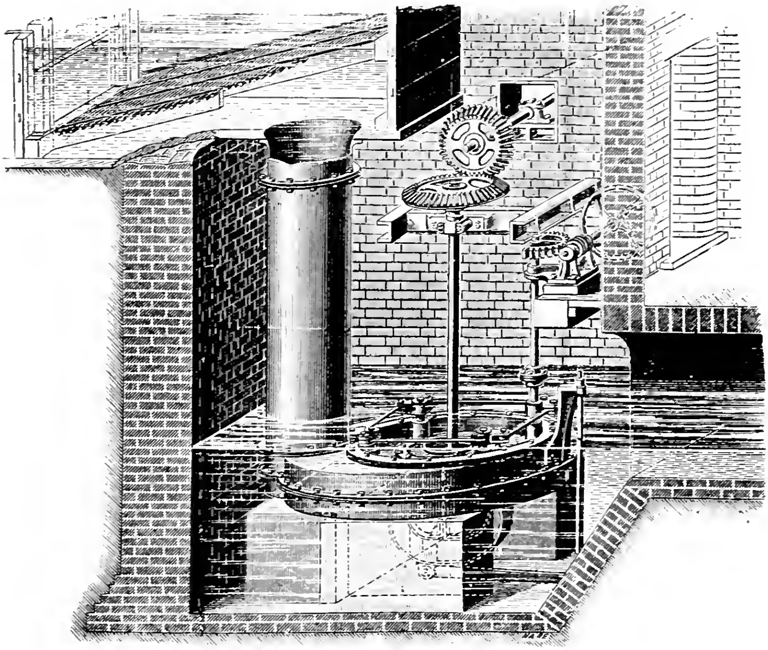

FIG. 177.

wheel with about as much force as it would push it round were the wheel placed at the bottom of the column. The water in the pipe below the wheel is still in this case a continuation of the head of water between the reservoir and the tail-race. At more than thirty feet beneath the wheel the column of water disconnects: therefore beyond that distance the water has no draw, or suck, on the wheel it has passed through.

The Wind Wheel.

It is in respect of acting as a water supplier to the turbine, if in any, that we think the windmill can be called into service as an auxiliary power at the homestead. It is too uncertain, as we have said, to serve as a prime power. In accordance with the perversity that is so often displayed in human affairs it is apt to fail us at the times it is most needed, and be rampant when not required. But if taken in connection with water and bound in partnership to that less wayward medium, it is quite practicable to blend its extremes into a steady average force of almost automatic habit. While in many cases it is utterly impracticable to avail oneself of a head of water to give motion to the fixed machinery of the farm, in not a few of these is the project quite feasible of pumping up by means of wind power to a level where it can be utilised to drive a turbine

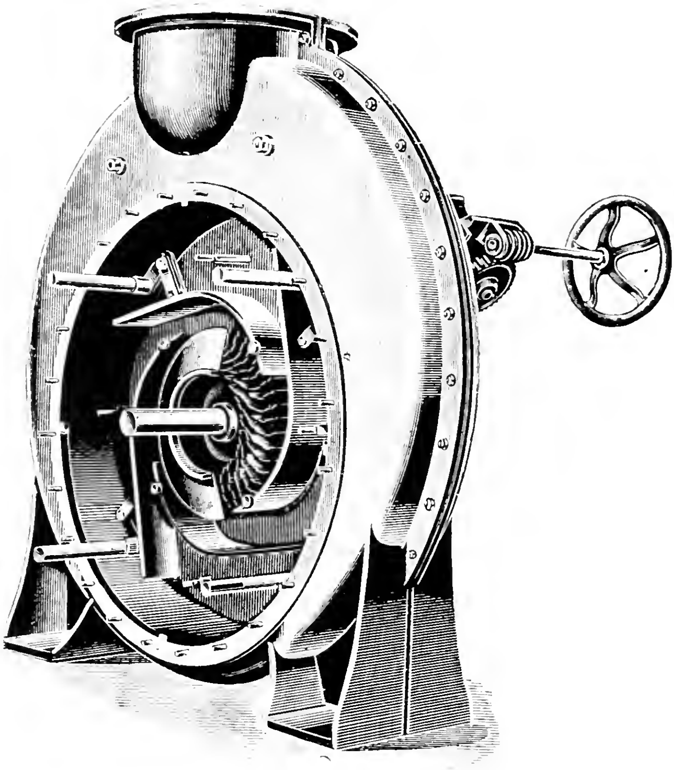

FIG. 178.

wheel. That form of wheel, we repeat, is not exacting in its contribution from water, and there are places without count where water of some sort or other—either running or stagnant—is available for the purpose indicated. By means of a suitable wind-motor it is easy to raise water from a level lower than the site of the homestead to one equal to or above it. And it is no difficult matter, and need be no costly one, to form a reservoir capable of supplying the requirements of the wheel. This is, we consider, the only feasible way we can contrive to turn wind to account as a help at the homestead. The windmill will often be idle, but it will be oftener on the move, and, like Cuddie Headrig's tree, it will during most of its existence be making progress in its way while we are sleeping. If the installation is well planned, the reservoir, provided that the pump never sucks, will always be prepared to meet its calls.

Thanks to makers in the United States, followed now by those of our own country, we have ample choice of easily erected and easily main-

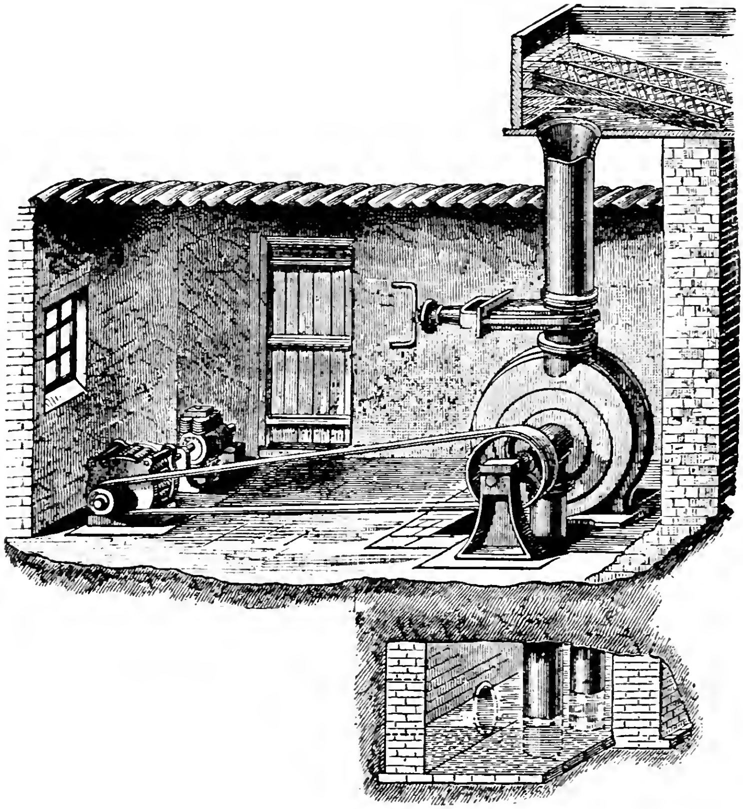

FIG. 179.

tained wind-motors suitable to the purpose we suggest. Fig. 180 is an example of one of these useful machines which are familiar to the readers of agricultural journals as being prominent in the advertisement columns of these, and to frequenters of agricultural shows as figuring among the groups of machinery exhibits. Some are of wood, excepting, of course, the axles and allied parts; and others are wholly of metal, the most being galvanised. They are so constructed as to a certain extent to be self-regulating. When the wind increases to a pressure that is too severe for them, they come almost to a standstill, patiently waiting their chance to resume operations in a normal way when the gale has blown itself out. When the wind reaches a certain pressure, or, what is much the same thing, when the wheel attains a certain velocity, it brings a lever into play that so affects the rudder or tail-piece, whose prime duty is to keep the wheel dead on to the passing air-current, as to cause it to throw the wheel out of the eye of the wind—to "luff" as a sailor would say, and thus reduce its rate of revolution. The harder it blows the more does the rudder force the wheel to keep its full face from the wind, and to turn sideways thereto, until at last the rim of the wheel is presented to the gale and the machine is brought to

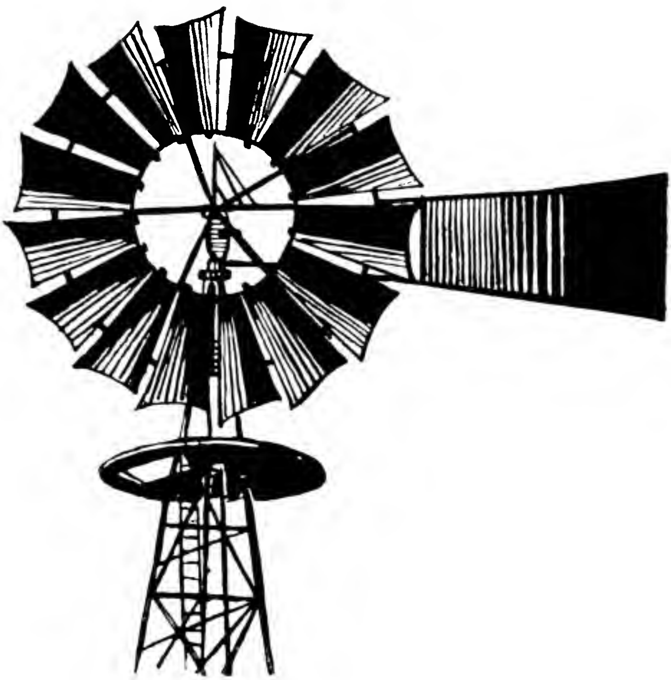

FIG. 180.

a full stop. When the force of the wind moderates the rudder is eased from this abnormal duty, and the wheel begins to face up to its work again. By reason of this simple contrivance therefore are these machines prevented from racing and coming to untimely ends. Its application thereto enables them to maintain a steady pace which is a favourable condition as regards wear and tear. It is practicable further to fit up a simple automatic arrangement whereby when the reservoir becomes full the wheel can be thrown out of gear, and thus be saved from doing unnecessary work.

We have spoken, under the head of Water Supply, of the utility of such a wind motor as we are discussing in raising drinking-water to a height that will admit of its being distributed at various points of the homestead. What applies to it in the instance of raising water to afford power at the homestead applies to it also in raising water to supply the demand for it there on the part both of man and beast. It is a most useful aid in either case when water at a lower level than the building is to be had for the lifting any distance that is not beyond practicable means.

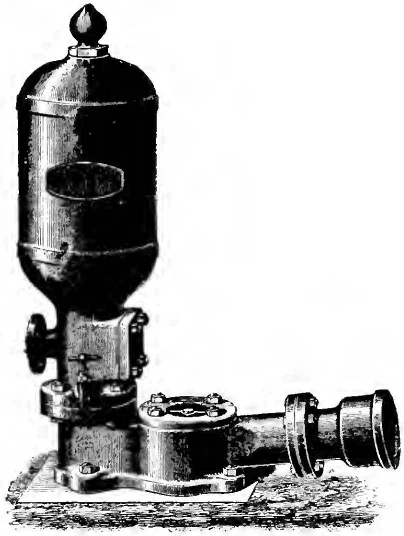

Fig. 181.

The Water Ram. While on the subject of forcing drinking water to a higher level it may be opportune to look into the action of the hydraulic ram, under the influence of which a moving body of water is made to force part of its own volume to considerable heights if wished. Fig. 181 shows the apparatus as supplied by the Glenfield Company, Kilmarnock, viewed externally. It looks simple, and it does not belie its appearance. The section of the ram given in Fig. 182 enables one to understand the principle of this useful appliance. It is fed through the pipe D P which leads the water into the body of the ram. The latter has no other outlets than the opening at D V, leading direct to the exterior, and that at C V, which leads into an air chamber. Both openings are, it will be seen, provided with valves that can effectually bar the passage of water through either, except in the direction desired. Further there

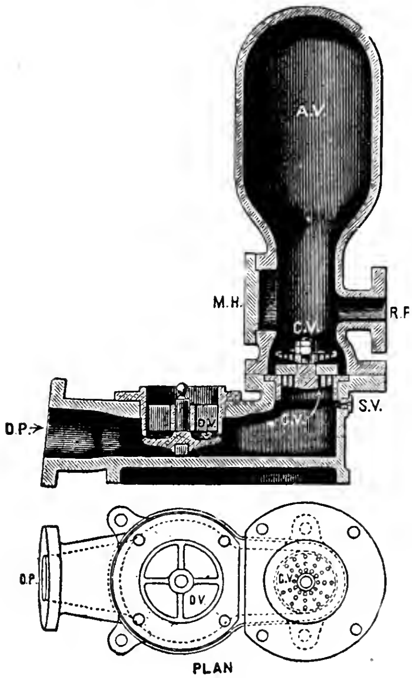

Fig. 182.

is led away from the air chamber the rise or supply pipe R P, which, it will be observed, is much smaller in bore than the drive pipe. S V is the snifter valve for the admission of sufficient air into the chamber to replace what is carried therefrom by the water that passes through or past it; and M H is the manhole cover which allows access for examination of the clap-valve at times.

When the body of the ram is empty the drop-valve D V, which sits bottom downwards, leaves the opening free. The clap-valve C V sits the reverse way, closing up the passage that communicates with the air-chamber A V. If we turn on the water into the drive-pipe D P, it forces its way down the pipe and seeks to escape past the valve D V. But the rush of water to the opening there carries up the valve, which now suddenly blocks the opening, and in consequence the momentum of the water stops with a sudden jerk which reacts on the water, and seeks to force it back. It cannot, however, force the water back up the drive-pipe, but it is strong enough to press up the valve at C V, and force some of it therein. The air within the chamber acts as a cushion in giving way before the water that is suddenly ejected into the chamber, and in its turn forcing it into the rise pipe R P that is led away to the point of delivery. Meantime the balance within the body of the ram has been redressed, and the various forces have come to a momentary pause. There now being nothing to withhold the valve D V against the force of gravitation, it falls to its original position, and once more the water begins to flow down the drive-pipe and out at the opening thus afforded. But headway has no sooner been gained than the valve is again carried in the upward rush, with the same result as before—an instantaneous check to the movement which spends itself in forcing open the valve C V, and forcing some water into the chamber whence through the elastic force of the compressed air it is pushed along the rise-pipe which leads therefrom. And so when the various parts of the ram are properly adjusted does this combined and automatic action proceed with regular beat day and night without attention from anyone. Floods and frosts may, of course, come to interfere with the steady performance of its work, but how these will affect it is simply a matter of situation. The ram may be so placed that it is out of the way of frost; and the rivulet may be of such a description as not to be much liable to flooding. A flood would not harm the ram so long as it was not submerged—so long, at any rate, as the opening at D V was above water, and the valve had free play.

With rams of a high power it may be feasible under certain conditions and in suitable circumstances to raise water to the homestead, there to be turned to account in developing power capable of giving motion to machinery. But these would be exceptional cases. The place of the ram, so far as we are presently concerned, is as a carrier of water for drink either to man or animal, and even in this department of farm economy only to a very limited extent. In Fig. 183 we show a contrivance capable of doing work similar to what the ram is put—a small water-wheel driving a pump. It is forcing up water from that which supplies it with motive power.

The Expansive Force of Gases as Power.

Failing the means of obtaining water power at the homestead, there is nothing for it at the big arable farm but to turn to the expansive property of gases as the motive force for thrashing the corn crops. The oil-engine, we have hinted, is now being put forward as both a handy and cheap agent, well adapted to the end in view; but it has hardly become popular yet. The steam-engine was the only one available when horse power was being discarded as wasteful and behind the times, which, no doubt, accounts for its general adoption. Had any other more handy source of power been at command, this cumbersome and expensive one would not have been in such demand.

Steam.

Steam, as we remarked in the last chapter, brings us to a different kind of energy or source of work than we have to deal with in respect of the power either of wind or of water. The source of power in these is the momentum of moving bodies. We erect our wind motor in face of currents of air, and the latter, as they seek to force it out of their way, impart motion to it. In like manner, we set our wheel in the path of water running to a lower level while it may, and the wheel, receiving the impress of the stream, has some of the momentum of the moving water imparted to it. As regards steam, however, we have, we repeat, to do with the molecular forces of the water we take in hand, not with the body itself in motion. We get our force now out of the tendency of the body to expand, not to be set in motion itself and carry other bodies with it. We enclose water in a strong boiler and heat it until it is converted into steam. Steam being the gaseous form of water, its component molecules are, in that condition, free, if not too stoutly opposed, to expand towards infinity. But opposed to them are the thick iron plates of the boiler, which bids

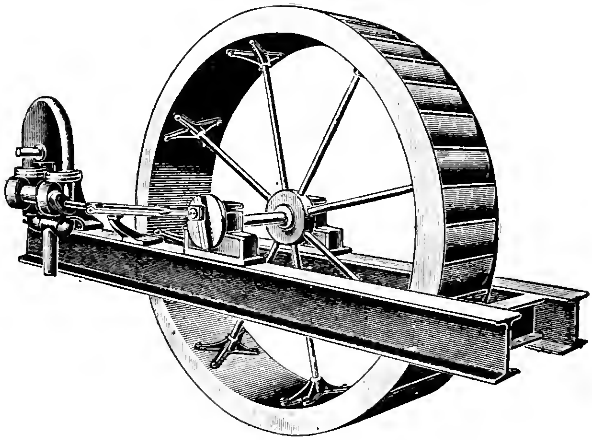

FIG. 183.

defiance to their strivings after liberty. Thick though these be, however, it is possible, if we apply great heat to the boiler, to rend them asunder.

It is this expansive force of water turned to gas that the steam turns to account as useful work. The steam is utilised by allowing it to escape into a chamber—the cylinder—in which works a piston, the head of which fits close to the sides, but can easily be moved from one end to the other. The handle, or rod, of the piston projects beyond the cylinder through a close-fitting hole at one end, and the motion of this as the piston moves to and fro, taken up by crank and fly-wheel, constitutes the motive power of the steam-engine.

Fig. 184 demonstrates at a glance the principle on which the steam is brought to play upon the piston within the cylinder. *A* is the cylinder as a whole, and *b* the head of the piston; *c* is a supplementary part of the cylinder into which the steam is admitted through *d*, preparatory to being brought into action upon the piston head. As the piston moves to and fro this reciprocatory motion, with its sudden stops and starts, is converted into a circular one by means of the crank *e* keyed to the shaft, which is attached at its other end to the fly-wheel—which is not shown,

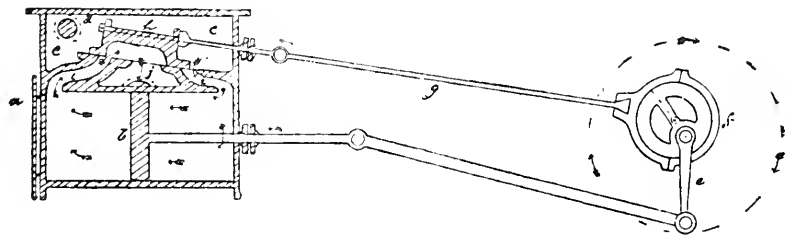

FIG. 184.

however. Attached to this same shaft is what is termed the "eccentric," *f*, the rod of which, *g*, moves backward and forward the port-cover *h*, which regulates the admission of steam into the cylinder through the two ports *i*. By this arrangement, while steam is being admitted to one side of the piston head a way out by the escape pipe is being left for the steam at the other side of the piston head.

The Steam-Engine.

The forms in which steam-engines are now manufactured are legion, and successive makers, profiting by accumulated experience, are able to produce machines that can almost be termed perfect of their kind. One of a simple description, however, is the best suited for the requirements of the homestead. Skilled men are not readily available at country places, and during the part of the year that it is needed for one day the engine is idle four or five; while from the end of spring to late in autumn it is wholly at rest. A strong, simple machine answers treatment of this kind more satisfactorily than a complicated one, well balanced, no doubt, in all its parts, but ill adapted to withstand inattention of any kind. Those of the latter description are made with a view to economise fuel as far as possible, and to turn the steam thereby generated to the best account. Still, conducted as the affairs of the homestead have usually of necessity to be, it is better to lose a little in extra fuel at the hands of an easily maintained engine than run the greater risk of rendering the more perfect one ineffective.

At the more important homesteads it is usual to find the engine apart from the boiler, the latter built up in a house by itself. This arrangement saves the engine from exposure to the dust and moisture that arise in the boiler-house from the work connected with attending to the furnaces and the escape of steam from the boiler. The fixed boilers necessitate a tall chimney-stack such as we see in connection with manufactories, but on a smaller scale than these, of course. The tall chimney is necessary in order to promote a strong draught in the furnace. Without it the fire would not burn briskly enough, nor could the heated gases and air arising therefrom be led along the boiler in the manner best adapted to heat the water to advantage. The higher we make the chimney the more effective we make the furnace, but there is a medium point beyond which it is unnecessary to go. This depends, it is needless to say, on the circumstances peculiar to each case, and we seldom find two alike. In no case, however, need the homestead boiler-house chimney be made to compete in height with the factory chimney. The factory furnace is generally fed on dross, which requires a powerful draught to digest it; but the farmer is usually obliged to deal out good coal to his, and it burns with less coaxing. Further, the manufacturer is compelled by law to deliver the smoke that emanates from his boiler furnaces well above the heads of the lieges or else his place of business will be declared a nuisance.

Engine Boilers. There is about as much ingenuity displayed in making the most of the boiler as we have already hinted is the case regarding the engine. At many homesteads there is to be seen the primitive long tubular, egg-ended boiler, with the furnace underneath. It takes a long time to get up steam in a boiler of this description. There is so small a quantity of water in proportion to its total bulk in contact with the heated surface, that before all has been raised to boiling-point much time and patience, as well as fuel, have been expended. More heat goes, we suspect, up the chimney than can be imparted to the water under an arrangement of this kind. The man whose duty it is to attend to the furnace must be at work overnight if the engine has to be agoing next morning. This simple old sort of boiler forms a striking contrast to the one, for instance, that is typical of the locomotive. In it are inserted in the body of the boiler numerous tubes running its whole length at equal distances apart and open at the ends. Briefly, it is a series of parallel open tubes encased in a water-tight box of boiler plating. The water fills the interstices between the exterior of the tubes. One end of the latter communicates with the fire-box and the other with the smoke-stack; the tubes, in fact, are but a continuation of the furnace. They are the big flue of the old boiler cut up into small branches and led through the heart of the water instead of the original cavernous opening that led from the furnace along the bottom of the boiler more or less direct to the chimney. The heat, instead of playing upon a small surface of water as it hurries past to the chimney under the old arrangement, is here distributed uniformly throughout the bulk of the water, with the result that the same amount of fuel will, in the one case, give a very different account of itself to what it can in the other. So much progress has been made in these matters during recent years as to justify the statement we recently noted that at the beginning of the late Queen's reign a ton of coal was equal to twenty horse-power,

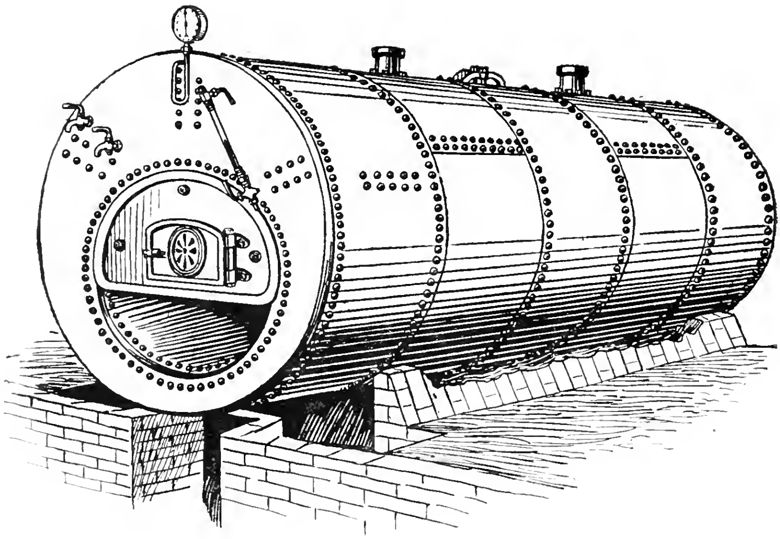

FIG. 185.

in 1853 to forty horse-power, while to-day the power represented by a ton of coal is sixty-three.

The Cornish Boiler.

A great improvement on the old round boiler is effected by placing the fire-box or furnace in the centre thereof instead of having it underneath. It then forms a central tube or box, as it were, right through from end to end of the boiler. The flames and heated air from the fire pass along the tube, which represents a water surface all round throughout its entire length. Under this arrangement the water, it is easy to see, will be more easily heated than it can where the big boiler sits over the fire like a kettle in the kitchen grate. Fuel will be saved, and steam will be raised in a much shorter time. And the boiler made on this principle, known as the "Cornish" boiler (see Fig. 185), is as safe as that of the original type. Other improvements have been wrought on the same lines, but for homestead use the boiler we have described is quite advanced enough.

Combined Engine and Boiler.

It is becoming common to construct boiler and engine in one as indicated in Fig. 186. This is a very handy arrangement. It economises room at the homestead, and it saves the erection of such a large chimney as the fixed boiler necessitates. Here again it is practicable to have the furnace or

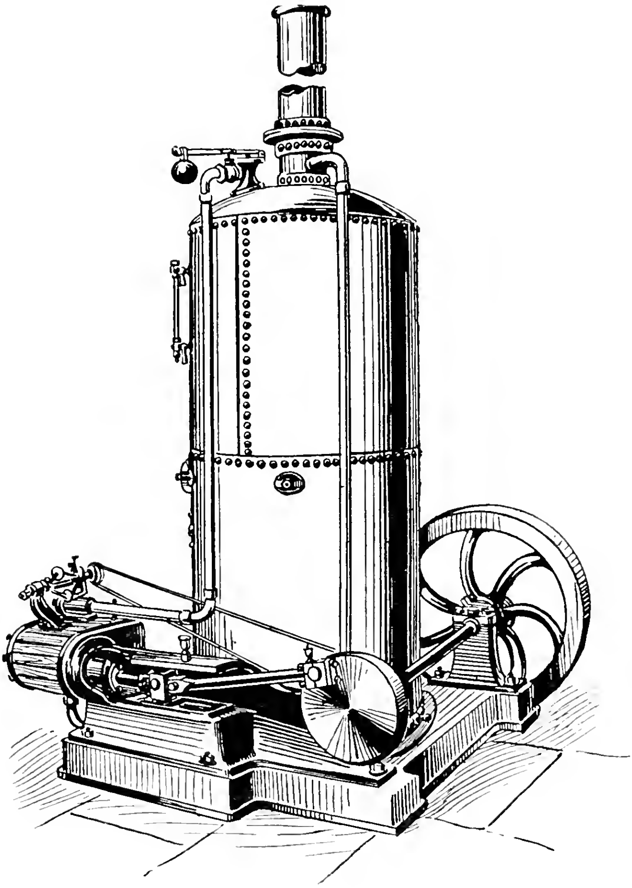

FIG. 186.

fire-box placed in the heart of the boiler, and so make as much as possible out of the fuel consumed, as we see in Fig. 187, which gives the section of a detached boiler such as we are describing. The furnace box is jacketed round with a thin sheet of water encased between concentric plates reaching to the base block on the ground. A little above the bars, high enough, of course, not to hamper the fire, tubes (known as "Galloway" tubes) cross from one side to the other of the water skin, while, finally, the heated gases pass up through the dome in which the circular jacket-shaped boiler culminates. The bulk of the water is in the upper part of the boiler over the dome in the part in which the heat vibrations strike hardest, and the entrance to the chimney being up through the centre of this, the very most almost can be taken out of the coal that is burned on the furnace bars. The fire, together with part of the chimney, is almost completely surrounded by water, and, further, several cores of the same cross the heated chamber between firebox and flue, so that the water is spread over a wide surface exposed to the influence of the fire—very different, indeed, from the state of matters we spoke of as prevailing with the huge circular boiler, in connection with which the flames crawl along the bottom in a half-hearted sort of way, seemingly aware that the work in hand is too much for them in any reasonable time.

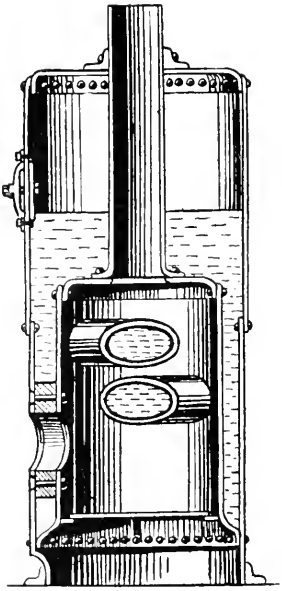

Fig. 187.

Locomotive Engines.

On a few exceptional farms traction-engines are put to service for thrashing. They are employed in haulage work of various kinds, and on thrashing days are drawn up near the barn in a position handy for transmitting power to the mill. There used to be more engines of this kind seen about farms. Twenty years ago much ploughing and cultivating generally was done with their aid. But since then agriculture has fallen on bad times and undergone severe straits—so much so as to put out of count all such costly investments as are implied under the head of steam tillage. Machines of the kind are too cumbersome as well as costly ever to gain an important place of their own at the farm. Could a handy traction-engine, suitable for farm use, be introduced, it would soon gain hold. We mean such a one that would not cut up both roads and land as the one that we have hitherto had to rest content with. The heavy and unwieldy traction-engine we are accustomed to requires better bottomed roads than prevail at the farm, and when taken on the fields they poach them in a most distressing manner. But we are on the eve, we suspect, of a great change in this connection. Motor machines are making progress towards practicability, and ere long attention will no doubt be paid to motors suitable to farm roads and fields. What with india-rubber tyres; and with mineral oil as a force-giver, and, more important still, liquid air with its immense head of expansive force, there is no end to the possibilities that may be attained by means of motors. Lightness and mobility will have been secured to start with, after which handiness is but a matter of detail. We see nothing to hinder their coming eventually to supersede our patient friend the horse in the work of cultivating the soil, hauling manure to the fields, taking home the matured crops, and otherwise transporting farm produce. A handy little motor, with plough attached, might be made to perambulate a field as easily and with as little detriment to the soil as occurs with a team of horses. America has already produced one combined with a self-binder reaper.

The traction-engines we see at the farms have boilers of the same class as are typical of the railway locomotive—a bundle of tubes, as it were, encased in the boiler and surrounded by water whereby the heat of the fire as it courses along these is carried right into the heart of the water. Some of the engines of this class meant for colonial use are made with a fire-box that will consume straw and chaff as auxiliary fuel. These are intended for the vast corn-growing farms. Coal is scarce thereaway, and straw and chaff both plentiful and valueless. An engine, therefore, that can utilise this waste crop must be a welcome machine. But the stoking of such will surely be a terrible as well as a continuous strain on the attendants.

Steam for Heating, Scalding, and Cooking Purposes.

At some homesteads, more especially those of dairy farms, a supply of steam is in constant demand, not so much, however, for motive purposes as for heating water, cooking food, and scalding utensils. In these instances copper fires are dispensed with, the food being steamed instead of boiled. Much labour, one can understand, is saved by this arrangement. Instead of several copper fires having to be lighted and attended to, there is here but one, that which generates the steam. Along with the saving of labour that this involves, the risk from fire is lessened The copper fires are kindled with live coals either from house or farm under some other boiler, and on a windy day to carry matter of this sort about the homestead is anything but fair to insurance companies. We remember a case where a shovelful was emptied by a violent gust and blown against the end of the season's hay packed in a new shed over a hundred feet long, with the consequence that in a few minutes hay, shed and all were enveloped in flames and soon thereafter reduced to ashes.

Steam for the purposes mentioned can of course be derived from the boiler of the power-giving engine, if there be such about the place when steam is raised therein. The former is wanted every day, however, while the latter may not be ; and to heat up the latter daily for the sake of obtaining, so to speak, casual steam, would be bad economy. The engine in question may happen to be of so small power that it would be wise enough policy to turn it to account in the manner referred to. But when the circumstances are otherwise, a supplementary boiler is necessary. It need not be a very large affair, neither need it be so strong as one connected to an engine. Such a one as shown in Fig. 188 (of which Fig. 187 is a vertical section) is very suitable for the purpose. It being wanted merely for discharging jets of steam here and there, no great amount of pressure is ever brought to bear upon the plates that form the shell thereof. Very few pounds of pressure serve the end in view, and the escape valve being set accordingly there is in consequence a very small strain upon the casing of the boiler. Indeed, experienced persons maintain that steam issuing forth from an orifice under easy pressure, and therefore close to the boiling-point of water—212° F.—is a far more effective scalding medium than steam under high pressure which means steam at a higher temperature than the boiling point of the water which it arises from. They say that dairy utensils can be more effectively plotted with one than the other. This statement, coming from men whose opinions can hardly be gainsaid, has sorely puzzled the quidnuncs of agricultural science. It is more than likely that this paradox arises from the fact of steam at 212° being at a temperature that allows it at once to revert to the liquid form, and in so doing liberate the great amount, comparatively speaking, of latent heat that we reverted to when discussing the physical properties of water. The hotter steam, one would think, would soon cool down to the critical point, and then part with its latent heat, but by that time a good deal of it might have escaped. Much of it would be bound to do so under the circumstances to which the paradox applies—the steaming of dishes, milk-butts, etc. At any rate, in making use of steam for the above purpose, it is a waste of fuel to raise pressure in the boiler to anything beyond what will deliver it freely at the points where it is wanted. High-pressure steam is not called for in these operations; and raising steam above its initial temperature is all so much waste of heat in the fire-box.

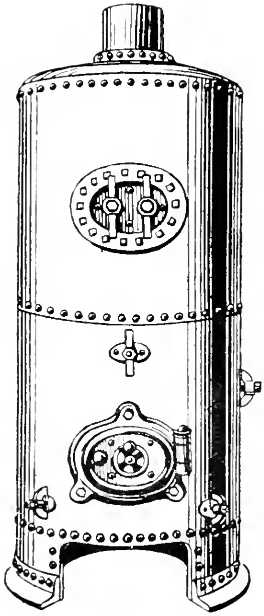

FIG. 188.

The pipes required for leading steam to the different coppers have no need to be of larger diameter than from a half to one inch; neither need they be of any extra thickness. The respective pipes are led from the main one to within an inch or so of the bottom of the copper each has to serve. The free end is left open, but within easy reach of the hand there is fitted to each, close to its junction with the main pipe, a shut-off valve with which to control the steam. A curious coincidence sometimes happens in this connection if care be not taken to close the valve before the boiler cools down on the one hand, and before the contents of the copper have been removed on the other. As the water in the boiler cools the steam therein condenses and the space it occupied forms a vacuum, with the result that the contents of the copper—at least, those that are plastic or fluid enough—are forced along the steam-pipe into the boiler; the boiler sucks the lot into its maw.

When we think of the heat that is held in reserve by steam we can easily understand what a potent agent we possess in having its services at command in this connection. Among other advantages that can be claimed for its adoption in this respect is the saving in the erection of the coppers. No furnace has to be built under them and no chimney-stack above. Further, in the absence of the furnace, they do not require to be placed so high above ground. They can be fitted either in or as near the latter as will best suit the convenience of the operator.

The Petroleum-vapour or Oil-Engine.

The oil-engine, as already remarked, is rapidly taking the place of the steam-engine as a provider of motive power at the homestead. It is now being manufactured to develop high powers as well as small powers. One can be had fit to drive the thrashing-mill with ease, and another that is only capable of coping with, say for instance, the cow-milking machine. This engine is certainly an advance on the steam-engine for farm purposes. It is not nearly so cumbersome. Fig. 189 represents one of nine horse-power. How much less room it takes up in comparison with a steam-engine of equivalent power, especially if it be one of which the horizontal boiler forms a part. The oil-engine is ready for work in as many minutes as the old-fashioned egg-end boiler takes hours almost; and it takes up but little room, and necessitates no factory-like chimney being erected. Neither, of course, as we saw, does the vertical steam boiler already referred to, which also saves room compared to the horizontal one. But the oil-engine takes up less space than it even, and is ready for work in a few minutes after a light has been applied to it. There is no coal to be carted in order to keep the oil-engine going, nor ashes to be removed when it has done a spell. Neither is there smoke about; nor do sparks issue forth. When its work is finished for the time the oil has simply to be turned off and the light extinguished. The stoking consists in keeping the oil-tank supplied and attending to the taps that regulate the quantity to be consumed. The consumption of 1lb. of oil is capable of maintaining one horse-power for an hour, so that the cartage of fuel with which to maintain the oil engine is but a small item in the labour bill in comparison to what is needed either in the case of the old-fashioned horizontal boiler or in its recent modifications, and even as regards the more scientific vertical boiler.

The Gas-Engine.

The principle on which the oil-engine works, similarly to that which underlies the steam-engine, and the gas-engine as well, is, we repeat, the force that is put forth by the expansive power of heated gases. The oil-engine is, however, more closely related to the gas-engine than the steam-engine. In the last-named we have first to produce gas (the steam) from the boiler, and it is this that causes the extra plant we have in this connection. As regards the gas-engine we draw the gas already made from the nearest main connected with the gas-works, thereby escaping the necessity of providing ourselves with gas-making apparatus. But it is only in populous places that coal gas is available. We cannot look for it at the ordinary homestead. There, if we want it, we must make it ourselves, therefore we are obliged to dispense with it. The oil-engine was happily introduced to meet the cases where coal gas is not procurable. It is an advance on the gas-engine in so far that it provides itself with the gas that is needed to supply it with the requisite motive power.

The Differences in Principle between these Engines.

There is this difference between these three engines, that while steam is led into the cylinder ready for action against the head of the piston, both the coal gas and the oil vapour have to be exploded either in their respective cylinders or in chambers closely connected therewith. Steam acts with a steady pressure, but the other two in a series of impulses or jerks. The heating is done in the boiler of the steam-engine and the gas passed therefrom to the cylinder, but both in the gas and the oil-engine the heating is done in the cylinder, with the result that boiler and furnace are dispensed with. The steam in its struggle for elbow-room is ready to seize on any weak place in its prison walls that offers a chance for expansion. Admitted to the cylinder, it tries conclusions with the piston, which, if found movable, is kept going to and fro by the endeavour of the steam to gain an outlet. It presses equally on the different surfaces that hold it in control—those of the boiler plates, the pipes it is led into, and of the cylinder itself. But with the other two engines the expansive force of the gas is felt in the cylinder alone.

In the gas-engine coal gas mixed with air is exploded in the cylinder, and the great heat developed thereby gives a great expansive or explosive force to the new gases formed under the chemical reaction that takes place in the process. This drives the piston before it. And likewise with the oil-engine: the vapour of the oil and the charge of air are exploded by means of the ignition tube, and so drive the piston forward. The piston returns under the impulse of the fly-wheel, forcing out through the exhaust pipe the gases that result from the explosion. Once more it is carried forward, oil vapour and air filling up the space behind. On its way in again it compresses and forces them in intact with the ignition tube, causing another explosion and a renewal of vigour to the piston. Unlike the action of steam, therefore, which plays alternately on each side of the piston in these engines, the action is on one side alone of the piston and not at every stroke of the same either. The governor is so arranged, indeed, as to regulate the action of the exhaust valve, and thereby adjust the explosions in accordance with the varying resistances the engine has to overcome. But there is a vital difference between the gas-engine and the oil-engine, in so far that with the former we have, as we said, gas ready made to deal with, whereas in this we have first to vaporise the oil into gas before it is on the same footing as the other. This, however, is accomplished without having to make the oil-engine much more complicated than the one that depends on coal gas as the explosive substance. Mineral oils are, as we all know, very easily vaporised—too easily under certain circumstances, as the many accidents through the careless handling of lamps fed therewith testify.

A state of most intense heat prevails in the interior of the cylinder both of the gas-engine and the oil-engine, far beyond what is developed in that of the steam-engine, and on that account the cylinders of these two are surrounded by water-jackets. No chemical action takes place within the cylinder of the steam-engine, and the temperature of the interior coincides, therefore, with that of the steam which is admitted therein. Within the other two the action of combustion takes place

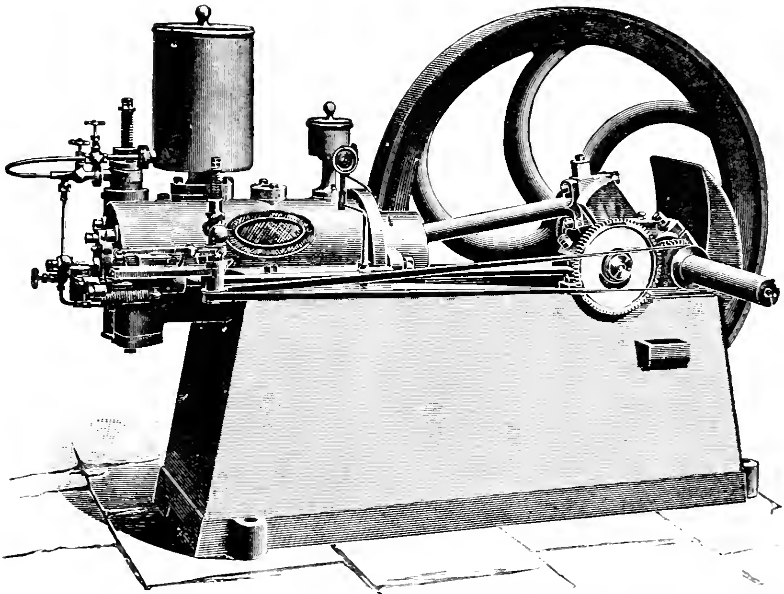

FIG. 189.

through the hydro-carbon substances of the gas and the oil respectively becoming oxydized by the oxygen of the air that is allowed to mix with them as they enter the explosion chamber. We obtain heat and light by the slow combustion in the air of either coal gas or mineral oil. The bodies referred to, while undergoing oxidation as they emerge from the gas burner or from the lamp burner, give forth much heat at the same time that they shed abroad light. At these points they are being consumed slowly, but in the explosion chamber of either the gas or the oil-engine they are being consumed instantaneously in quickly recurring instalments. It is, however, this strong force of heat that lends motive power to the engine of either class. The igniting of the gas in either case is like sending a spark into a charge of gun-powder. In that instance, the spark sets free the gases that are loosely held together in the cunningly-devised mixture, and the ever ready oxygen laying hold at once of the carbon compounds thereof, develop so much heat that the gases expand to such an extent, and that so suddenly, as to send forth the missile with a tremendous force. The unremitting explosions in the cylinder of such an engine as we are dealing with are just so many shots being fired, the piston in this case representing the projectile. A gun of any kind becomes after much shooting untouchable on the barrel by the naked hand, which will give some idea of the heat of the interior of a gas or an oil-engine when in action. The explosions in the latter are not, of course, so violent as in the gun-barrel, but they proceed more steadily and continue for long spells.

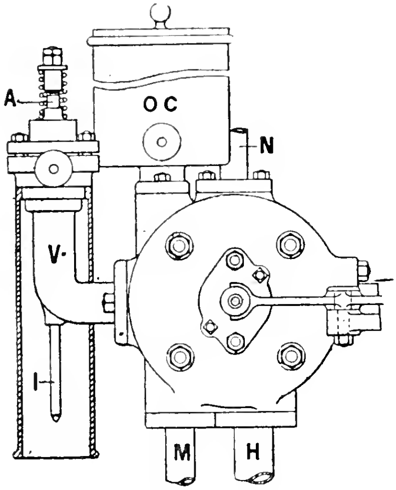

FIG. 190.

Figs. 190, 191, and 192, taken together with Fig. 189, enable one to grasp the working principle of the oil-engine. These are illustrations of the Campbell Oil Engine, and are taken from the report on the trial of oil-engines given in the "Transactions of the Highland and Agricultural Society, 1900." We have selected those bearing on the engine in question for no other reason than their apparent simplicity. The first is the front end view of the working parts with the interior of the vaporiser laid open; the second gives a vertical section of a portion of the same end; and the third a corresponding horizontal section. The requisite oil is placed in O C. the oil cistern, whence it is allowed to trickle through the pipe O into the vaporiser V, which communicates with the inlet valve. "This valve is automatic in its action and opens when the piston makes a suction stroke—provided the exhaust valve E is then closed; the oil can then flow through past the valve into the vaporiser; at the same time, air also is drawn in, and

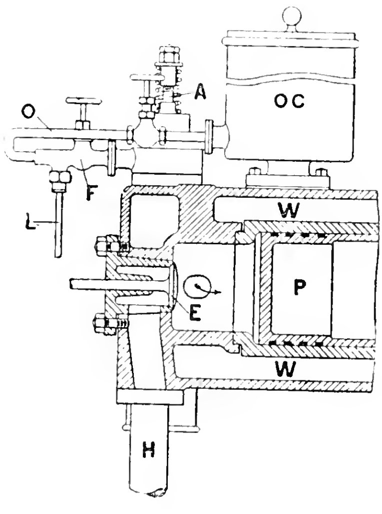

FIG. 191.

spreads or sprays the oil against the heated sides of the vaporiser. The oil thus completely vaporised and mixed with sufficient air to form an explosive mixture is drawn into the cylinder, and finally ignited at the end of the compression stroke through contact with the heated ignition tube I." The following is the key to the lettering of the several parts illustrated by the diagrams: V is the vaporiser; O C the oil cistern; O the oil supply-pipe; F the oil-cock; L the oil supply-pipe to vaporiser lamp; A the stem of air and oil inlet valve; E the exhaust valve; I the ignition tube; H the exhaust pipe; M the water inlet pipe (to jacket); N the water outlet pipe (from jacket); W the water jacket; and P the piston.

The Piston and Crank of the Engine.

The reciprocatory or back and forward motion of the piston-rod of the engine is turned, as we have seen, into a rotary one by means of the mechanical arrangement termed the "crank" *e* in Fig. 184. There is a feature in connection with this arrangement which is worth noting here. It may be observed from the fig. that when the piston has made its full thrust it, for the moment, has no power whatever over the crank. It has reached its limit, and for the time is neither pushing nor pulling against the pin. The same thing occurs when the piston is home at the inner end of the cylinder after dragging the pin back with it. These two stages in its movement are called the dead points of the crank, for the very obvious reason that at each the motion of the piston is for less than a second arrested—the forward movement has to be checked and changed to a backward one and *vice versâ*. But both checks take place at the points where the piston is powerless over the crank.

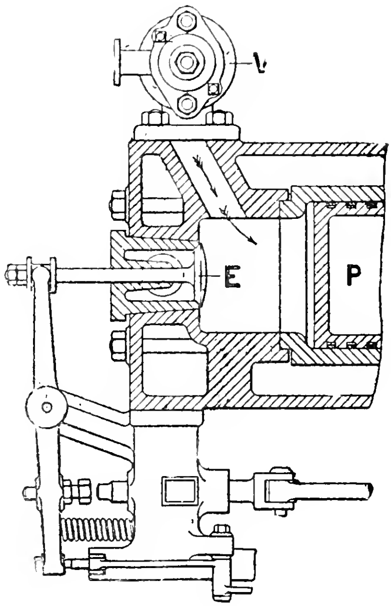

FIG. 192.

The Fly-Wheel.

In the fly-wheel of the engine we have the means, however, of effacing the dead points. In the mass of metal it is composed of, bulking largest at the rim, once this wheel is set going the momentum attained thereby serves to tone down the irregularity of motion in the piston due to the back and forward motion above described. This formidable body, part of the crank shaft be it remembered, is quite competent to persevere in its state of moving uniformly without being put out in the slightest by such breaks to continuity of motion as occur at the dead points referred to.

CHAPTER XII.

The Barn Range.

We have now, we hope, cleared the way sufficiently for us to take up the different parts of the homestead in detail. It has cost time and space, but our race loves to be logical, and is fond of the fundamentals. If our readers have followed us, the remainder of our work ought to be to them both easy and interesting.

The Barn Range the Centre of the Group.

We have chosen to start with the barn range as being the central building of the group, the one near to which it is desirable to place all those that accommodate live stock in order that the straw may have to be carried to the animals as short a distance as possible. We have already pressed the importance of this matter, and need hardly say much more on that head. To begin with, we would have the door of the thrashing-floor in the gable. It may either be in the centre of the gable or a little to one side. Having it at one side allows storage-room for sheaves at the other, while if it be placed right in the centre neither corner is then of much avail in this respect. The door we would elect to be a sliding one, and when the doorway is in the centre of the gable it is competent to have it made in halves, one to slide one way and the other in a contrary direction. With the doorway up to one corner we are obliged to have the door in one piece. It is an advantage, no doubt, to have the door halved. In this way it is both easier to work as well as easier on itself and its supports.

The Position of the Barn Door.

Where the storage of sheaves on the thrashing-floor is an important matter, more may be gained in this way by having the door in the side-wall of the building than in the gable. If thus placed nearer to the mill than to the gable, it allows considerable storage room between it and the end wall. At some farms it is usual to fill the available space referred to with sheaves which are thrashed at convenience, not necessarily on the day they are carted in. What space of this kind there is to be provided for, however, ought to be arranged to accommodate the contents of some fixed number of ricks, be it one, two, or three, so as to have no broken stacks left liable to damage through exposure to the elements. The carts loaded with sheaves are backed into the barn and tipped up on the floor and roughly heaped up by any odd hands who are to spare for the job, and the thrashing done as circumstances arise. In this way fewer hands are able to overtake the work. Those who filled the barn beforehand are so many extra hands to attend to the mill on thrashing day ; and with the thrashing-floor full the beating out of the grain can be taken in hand when a storm arises and outside work is interfered with.

The usual Arrangements for Thrashing.

There is nothing of this kind, however, at the big arable farm. There the work of thrashing is a more momentous affair. But girls and lads are more plentiful at these busier places, and the bulk of the business is seen through by them. An experienced and trustworthy man is required to preside at the feeding-board of the mill and to see generally that all goes right with the latter. And perhaps another is needed at the other end of the mill to see that the straw is cleared away briskly and stowed properly. The hired girls and a lad or two usually attend to the rest. The odd horses—the old and the halt—which are kept for doing the miscellaneous cartages incidental to the daily wants of the homestead are retained on thrashing days for conveying the sheaves from the stackyard. Managing in this way, neither the ploughmen nor their teams are taken away from the tillage operations of the farm. A whole day is then usually devoted to thrashing, if steam is the motive power, that is to say. Where water is the power the spell is ruled by the length of time that the water will hold out. It would hardly be worth while getting up steam, more especially in the case of the old round-ended boiler, if a day's work were not to be the result. It is different, of course, with respect to the vertical boiler, and more so still when the oil engine is in question. The latter, as we have said, can be set going while one waits, and be stopped when wanted, without our grudging the loss of heat that takes place when a steam-engine is brought to a standstill while there is yet a considerable reserve of both heat and steam at disposal.

The Itinerant Thrasher.

Thrashing by means of the home appliances is thus arranged to fit in with the routine work of the farm without disorganising it in any way. It is different, however, when the aid of the itinerant thrasher is called in. A considerable addition to the ordinary staff of attendants thereat is then required. Both the grain and the straw, in the absence of the elevators and similar contrivances that do service in the barn, have to be handled and conveyed to shelter. The mill in this instance is taken to the ricks, instead of, as with the home one, the sheaves being carried to it. On the other hand, the grain and the straw are correspondingly withdrawn from the arrangements set apart for delivering them in their proper quarters. And, further, mills of this description are capable of dealing with such large quantities of stuff in a day that the handling of the same, taken together with these other causes, necessitates, as we have just remarked, a large number of workers being in attendance. These movable mills show a great advancement alike in labour saving and in construction over the fixed mill usually seen at the homestead. They deliver the grain much better dressed, and turn out the straw bound up in trusses or lead it away loose on elevators and deliver it to the rick builders to be tramped under foot. It is not uncommon, indeed, to see the fixed mills provided with arrangements after the nature of an endless web or band on which to convey the straw, so that it can be stowed at all parts of the barn; but it is, to find one fitted up with a self-trussing arrangement. We can instance a case where a movable mill, such as above referred to, is dismantled of its wheels and fixed in position in the barn as the every-day mill of the farm, partly on account of securing the advantage of having the straw trussed up as it quits the thrasher.

The position of the fixed Thrashing Mill.

Both engine and mill, however, are matters that lie more in the province of the tenant than the proprietor, seeing they are usually fixtures that pass from the tenant to his successor. But the homestead must be so planned that a due amount of room is afforded both one and the other. The mill is handiest on the ground floor, unless, of course, the configuration of the site of the homestead is such that it is practicable, or it may be necessary, to have the second storey of the barn somewhat on a level with the stack-yard, in which case the sheaves can be carted direct to it as the thrashing-floor. It is always the most convenient to have the mill so placed that it can be fed with the minimum of labour, and whether that is better accomplished on the one floor or the other is very much a matter of circumstance. In the foregoing instance of the movable mill dismounted from its wheels and fixed to the barn floor, it would, of course, be a great saving of labour could the sheaves be carted to the upper floor and be tipped thereon within easy reach of the person or persons who feed sheaves to the mill. A mill of this description is fed on a level with the attendants' feet, and when the sheaves can be tipped directly out of the cart upon the floor on which they stand all the labour of having to pitch them up to their level by fork is avoided. In a case of this kind, should the levels forbid a natural cart access to the upper floor, it is worth while indeed to construct an artificial one. It is not uncommon to find the mill on the top floor, and all the sheaves being forked thereon from the carts drawn up alongside on the basement level. Two separate forkings of the sheaves are thereby entailed —one from the rick to the cart and another from the cart to the thrashing-floor. One of these is saved wherever the cart can be tipped up at a level to suit the purposes of the person who feeds the mill. One man with a couple of girls to untie the sheaves for him can keep the ordinary fixed mill going. It requires to be steadily fed, the sheaves having to be well shaken out and the whole length of the rollers to have an equal bite. The movable mill has a more capacious maw, and is less particular about the form and size of its mouthful, which it almost instantaneously licks into a shape that can easily be dealt with in its passage through the mill. More than one feeder is needed to keep pace with its capabilities. But the sheaves can be dropped in whole almost; therefore the girls, whom we spoke of above as untying the sheaves and passing them to the feeder of the common farm mill, can drop them in on their own account when the improved mill is the one in action.

The hand-trolley system of conveying sheaves from the stackyard to the mill, which we hinted at towards the beginning of our work, is calculated to prevent much unnecessary handling of the sheaves, and consequently to go far to economise labour generally. It would save both hand and horse labour. Horses could, as we have said, be altogether dispensed with where it was installed. Three, or at most four, girls could keep the ordinary mill supplied with sheaves. They could, we mean, keep the hands at the feeding-board in full supply. The system could only, however, be worked to advantage where sheds were erected for holding the sheaves. Trolley rails could be run alongside a shed, but they could hardly be laid so that a wide-spread group of ricks could be severally assailed therefrom. But this is a detail that affects the occupier rather than the proprietor. If the former saw it was to be to his advantage to adopt such a system, he would find the rails and make use of them in his own way. Movable contrivances of the kind are in the market, and such plant might be turned to useful account at the homestead in many various ways.

The Barn Windows.

Considering the barn range is two-storeyed, side windows would be a necessity. On thrashing days the big door would be open most of the time, so that the place would, to a certain extent, be independent of window light; but there might be work to do on other occasions when it might be inconvenient to have the door open. Stormy weather, too, might compel the shutting of the door between the times when sheaves were being admitted; and then we have to keep in mind the thrashing as conducted at those places where the sheaves are housed previous to starting the mill—one or more days beforehand. We have not marked positions for them on the ground plan of any of our typical homesteads. Their place in the wall would have to be arranged in accordance with the character of the farm which the homestead was being built to serve. If they were placed in such a way as likely to be interfered with by the stored-up sheaves, care would have to be taken that the glass was protected from damage. Stout wire-netting or some iron bars would meet the end in view.

We are somewhat prejudiced against large windows being built in places like the barn. Our preference is for a window after the pattern of Fig. 193 put well up in the wall. They, no doubt, help to light the floor better the lower down they are, but if the inner sill is given a quick slope, as in Fig. 194, the light will strike down to the floor without leaving much shade along the foot of the side wall. And when well up from the floor they are better out of danger. It is with us a matter of Hobson's choice, however. We are obliged, according to our various plans, to keep the windows high. The side sheds preclude their being in any other position. It may be necessary, perhaps, to have a window put in at a lower level than the others, somewhere adjacent to the feeding-board of the mill, even though the light be borrowed. It need not be a large one, however, neither need it be an opening one. Our recommendation of the kind of window referred to is largely based on the getting rid of one after the pattern of those used in houses. Such, as we have already said, are not at all well adapted for the ordinary farm building. They are so apt to be neglected that they soon fall into disrepair, and nothing looks so untidy about a building as broken and decayed windows. As we pointed out when discussing windows at length, the opening window, at least the case and sash one, is far too delicate a work of art to be put to the rough-and-ready usage

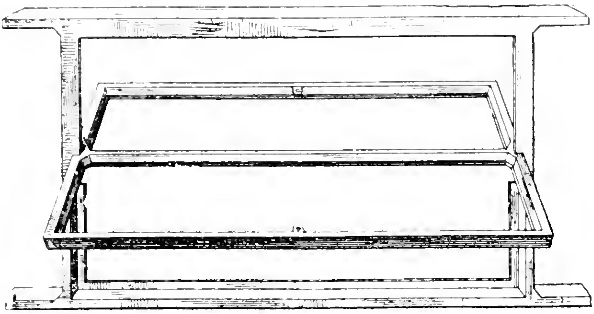

FIG. 193.

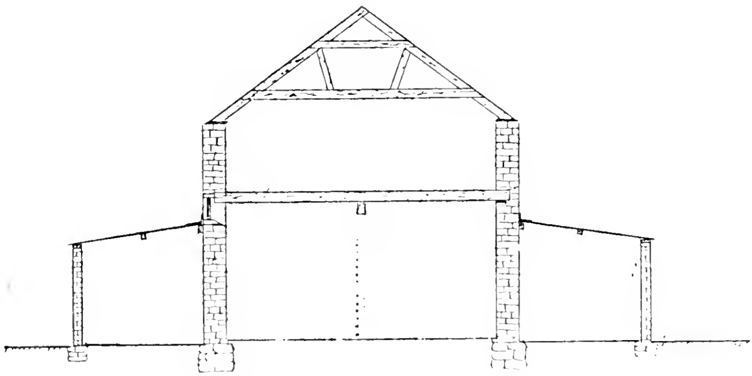

FIG. 194.

that prevails at the farm. The fixed wood window is not so liable to suffer harm through neglect, there being fewer parts and less workmanship concerned therein. But in the barn we want an opening window—if not to let air in, at any rate to let dust out. The kind of window we suggest can be so built in as to give sufficient light; and with the glazed part made to open as shown, dust can find an easy exit. The case is of iron. The sides of the opening can be finished with brick, the outer part of the sill with freestone, and the inner bevelled part of the same with cement plaster. This class of window is well clear of the floor, and consequently in no wise interferes with full advantage being taken of the area within the barn. And protected with netting or bars, they are not in the way as regards the storage or piling up of sheaves against the walls.

Were no granary erected over the thrashing barn we would, of course, have the place lighted from the roof, using the kind of window described in an earlier chapter. But whether or no there happened to be a second floor in the barn, some skylights would require to be in the roof. They would be there to light the barn in the absence of a granary overhead, and were there a granary they would be needed to give light to it.

The Ground Floor.

The ground floor, we need hardly say, we would have of concrete. It is not necessary to have such a finish, but a cement skirting about nine inches deep all round the base of the wall is an improvement. Made an inch in thickness and bevelled off at the top, it is not at all in the way. Its presence serves to make the place look neat, and it forms an additional check to rats and mice seeking a base of operations in the wall. At the doors the floor would require protection against chipping, either by means of a granite or a whinstone step. Or a border or edging of cast iron would do. Something of this nature is needed, because concrete corners are easily fractured. The body of the concrete will stand wear and tear, but the edges of any sheet of this material soon crumble down under traffic, more especially if wheeled vehicles come to play upon it. At the big doorway alone will there be carts passing in and out; but at the others sack barrows and such like will frequently be made use of. An edging, therefore, of some more durable material in this respect than the concrete is a necessity to protect the same from being worn away where it finishes in doorways. A kerb or step of granite is the best of all where carting is practised. At the smaller doorways freestone, if hard and close grained, will do.

The Upper or Granary Floor.

The upper floor must of necessity be of wood—of joisting and flooring, as already described. The joists would require to be of considerable strength, not less in section than nine inches by three inches, set on edge of course, and running the short way of the building, across it that is to say. One ply of flooring would be ample were the place to be for the storing of grain alone. If, however, the upper floor were to be the thrashing-floor, a two-ply floor would be called for. It might not be requisite all over the floor space, but it would wherever the horses were likely to tread or the cart wheels to bear thereupon. Felt between the two layers, as recommended in connection with the dairy buildings, would be unnecessary in this instance. The extra ply is recommended here principally for the purpose of acting as buffer between the under boards and both the horses' feet and the cart wheels. The extra strength afforded thereby is indeed almost essential, especially if the bottom boards are to suffer the wear and tear as well as do the supporting of such trying burdens as horses and carts. But the top boards alone come in for the wear and tear proper, and would be certain of renewal or repair long before the boards beneath came under the direct action of the heavily-shod feet and the iron-rimmed wheels.

It is not always convenient to give a centre support to joisting. To make this effective pillars or posts of some description are a necessity in the space beneath, and these are apt to be in the way—to somewhat interfere with the floor area of the part of the building where they are. But in some way or other the joisting of a floor that has to carry loaded carts requires support of this kind. No risk of disaster in this connection must be run. A six or an eight-inch square beam borne on cast-iron pillars would enable a floor such as we are describing to carry with safety any weight that under the usual circumstances would be brought to bear upon it. The beam to be made effective as a support would require to run down the centre of the building so as to apply to the joists in the centre of each. The space bridged across by the joists would then be half the distance they would stretch over in the absence of the beam, and their strength would be proportionately increased at a far higher ratio, be it understood, than the double thereof.

Even where the loft or upper floor is to be devoted to granary purposes alone it is advisable, as we suggested, when dealing with floors under their proper head, to stretch a point towards providing the centre support now being discussed. This means, of course, the erection of pillars in the straw barn as well as in the thrashing barn. But perhaps these are less in the way in the former than in the latter. Carts are less likely, one would think, to have business in the straw barn, although it might at times be a convenient arrangement were they at liberty to be loaded directly from the mill instead of the straw having to be carried outside to them. There is nothing, however, to hinder this being effected, although pillars are in the straw barn. In the off season, when straw takes little or no part in the daily operations at the farm, the straw barn comes in handy for odd purposes other than those of storage. It is, for instance, a convenient place for rolling and packing fleeces at sheep-shearing time. No matter, however, what end it may be put to serve, there is none, we think, that the presence of the pillars we refer to will seriously interfere with. And the same may be confidently said with regard to the thrashing barn as well. A little forethought should enable them to be placed where they will not be much in the way.

A partition or division wall shuts off the one barn from the other. The mill communicates with each. In the one, indeed, it is wholly situated, but its end opens into the other so that the straw may be delivered therein. A doorway at the other end of the partition affords communication between the two places, the door from choice being a sliding one. The partition is carried to the upper floor if there is a loft overhead, and to the roofing boards if there is not.

The Straw House attached to the Barn.

The straw barn is even more devoid of fittings than its sister building. Doors and windows are all that we have to provide for over and above the walls, roof and floor. The floor we would arrange to be of concrete. The doors we would have hung on rails. And the windows we would stipulate to be the same as in the thrashing barn.

In Fig. 194 we give a section common to the combined barns. Eleven feet we consider the minimum height from floor to ceiling (the under side of the flooring boards) of a good barn for the homestead of an arable farm of the ordinary type. Where neither place happened to have a loft overhead a lower side wall might be sufficient; but either one or other is usually covered over in this way, and the roof being continuous so must the walls be.

The Style of Roof best adapted to the Range.

The granary we are obliged to roof on the couple pattern in order to gain head-room without unduly heightening the walls. At least six feet six inches of head-room is required in the granary. Five feet of side wall will enable us to get this, because the bottom couple tie or baulk is, as we have seen, in a good position for strength when eighteen inches above wall-head level. Were it to be roofed on the king-post principle, the tie sitting, as it then would, on the wall-head, would cause us to add other eighteen inches to the height of the walls. In fact, the clear head-room in the granary is all the better to be six feet nine inches. This only means an additional three inches of building to that we have indicated. Allowing for that in the section, the walls thereof show a height of sixteen feet three inches from inside floor level to the top of the wall. Eleven feet in height of the wall are apportioned to the barn, and five feet three inches to the granary. The barn being eleven feet clear to the flooring boards, the thickness of these falls to be deducted from the granary head-room, but then the wall-plate raises the couples to almost an equivalent degree. Eleven feet may be considered an undue height to make the barn, but in many ways much head-room is an advantage there; besides, we need it in order to gain light.

The Granary.

The granary is usually characterised by the naked simplicity of floor, walls and rough roofing timber. For our part we incline to the mild extravagance of having the side walls lined right up to and hard against the roofing boards. This saves the expense of beam filling the wall-heads, while, at the same time, it renders the granary far more efficient. Grain can at any time be heaped against the side walls with impunity when they are lined: it cannot always be so when they are bare. The advantages of lining the walls in the manner suggested, irrespective of tidiness and cleanliness, are the counteraction of the dampness that more or less is inseparable from a bare wall surface, and its playing the part both of a skirting to the floor and as an efficient beam filler. A skirting to the floor is a necessity to keep grain from trickling through the crevice that is sure to be left or to form between the wall and the boards. Filling the wall-head angle, though not perhaps essential to usefulness, is a precaution that no man who cares for efficient work will leave out of count.

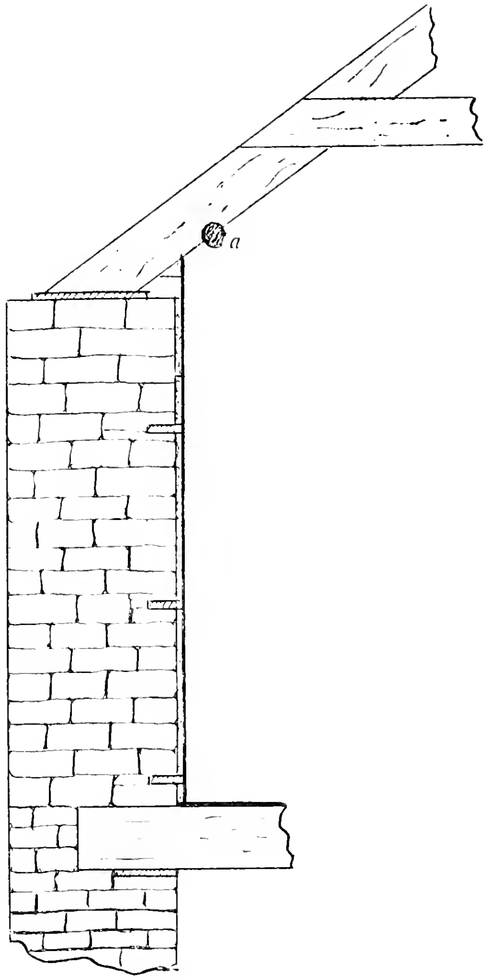

FIG. 195.

The lining need not be thick. It will do capitally if five-eighths of an inch in thickness; in fact, half an inch if the boards are carefully put on is ample. The best way to do this is to have strips of wood, say three inches broad by one inch thick, built in the wall as it is being erected. One would require to be placed a little above floor level. Other two between that and the wall-head are all we need to make sure of the boards having the chance of a firm attachment to the wall. A fillet may be required to be fixed to the roofing boards so as to ensure a good backing to the tops of the lining boards. This can be dispensed with, but its presence makes a more satisfactory job. Fig. 195 gives a section of the wall finished in the manner we advocate, and will make matters plainer. The rail or rod *a*, attached to the couples in the position shown, is a useful acquisition in the granary for hanging empty sacks thereon.

It is well, of course, to secure as dry wood as possible for lining the walls. The joints will then shrink less than if unseasoned wood is taken. To make certain of a good job the wood built in the wall (bond timber as this is called) should project say a quarter of an inch beyond the face thereof, and, previous to the boards being nailed on, this space be brought up flush with the edge of the bond timber by means of Portland cement plaster. The boards will thereby have an even and solid backing, and one that is thoroughly dry, and behind which it is impossible either for rats or mice to gain entrance from any direction.

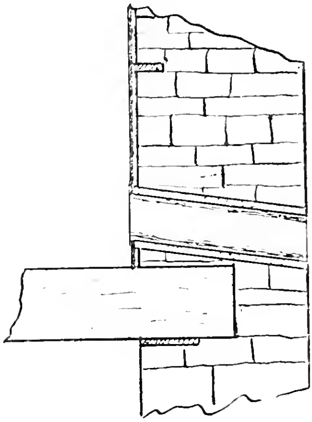

FIG. 196.

Side Ventilators for the Granary. Side ventilators are sometimes inserted in the wall, a few inches say, above the level of the floor. We show one in the section represented in Fig. 196. It is questionable, however, if these are worth the trouble and expense they cost. Not, as we shall see, that there is much of either involved, but in most cases there cannot be much need for them. In districts where the corn crops are at times difficult to "win" thoroughly, it must undoubtedly be an advantage to command at will cross currents of air to bear upon the grain that lies on the floor or heaped against the wall: the grain must be all the better for the air that will circulate through its bulk by way of these openings. If called for, however, they can be easily constructed. They are not in the way when not wanted.

The passage through the wall is handiest formed with the aid of plain jointed fireclay glazed pipes, say six inches in diameter, laid with a good slope outwards. To save the bevelling of the ends that this slope implies, the maker of the pipes will, if requested, supply pipes specially manufactured for the purpose, which ensures a much neater job than having recourse to chipping the pipes as their fitting in takes place. At the outer end the opening requires the protection of a galvanised iron grating of such a shape as to interfere as little as possible with the area of the pipe. If not guarded in this manner our cheerful little friend the sparrow will speedily set up house therein. He is a rough hand at building construction, but spares not material, so that by the time he has established himself comfortably the usefulness of the passage as a ventilator is altogether in abeyance.

The grating may either be left flush with the face of the wall or it may be kept in a little, whichever way it is considered the better job can be made. The only danger connected with the opening is the chance of water thereby gaining access to the heart of the wall. It cannot gain admittance to the granary without being forced upwards, which is nowise probable, but it will readily take any advantage of chink or cranny that may happen to be about the sides of the outer end of the opening to penetrate within the wall. The grating can be made securest when a proper opening, bordered either with brick or with freestone, is made for it to fit into. If of freestone a solid block thereof can be turned to account, after which there need be little to fear from the cause referred to. The grating can be checked into the stone and thus be kept back from the face of the wall a little. The bottom part, whether the opening be round or square, can then be bevelled or "washed" off, and thus make surer of rain being quickly cleared away.

On the inside all the finish required is a piece of copper wire-netting of small mesh placed over the mouth of the pipe behind the boarding. The end of the pipe is supposed to be flush with the thin coat of cement and coterminous with the back of the lining, therefore the wire-netting will be kept securely in position. It might, for that part, be tacked on over the opening on the inner face of the boards, but we prefer it to be placed where we have indicated. It is more out of harm's way there; moreover, we consider it advisable to provide a covering to the opening in order that it may be used or shut off as desired. This we accomplish in the simple manner indicated on Fig. 197, which speaks for itself. A flap or some sliding arrangement can be contrived; but what we illustrate is as simple as effective, and as little in the way as any of these is likely to be.

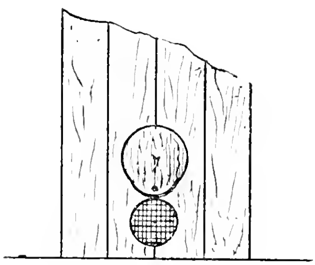

Fig. 197.

It may be desirable to divide the range of granary room into two or more places. There is no need, however, for other kind of partitions than boarded ones, and we need hardly spend much time over these. Upright pieces, say four inches by two inches, set up three feet apart, fastened to the floor or the joists at foot and to the roofing timbers above; and with runners, say four inches by one-and-a-half inch, checked into them horizontally, also at three feet apart, would make a strong framework upon which to fix the boards. Lining boards seven-eighths of an inch thick are strong enough for a division of the kind. A doorway, it can readily be understood, is easy of construction in a partition put together in this manner.

The finishing of the Roof.

With regard to the roof of this range the remarks we have made on roofing generally may be applied to this as well as to any other one in particular. We strongly advocate having the roofing timbers planed smooth. There is not much extra cost concerned in this. We wish grain in store to be kept free from dust. Quite enough develops in the grain when in bulk without having it exposed to dust that arises from other sources. We have already drawn attention to the secure lodgment which rough surfaces of wood afford to dust. It is not easy to sweep it off places of this nature even when one tries. The trial is seldom made, however, and consequently dust and cobwebs are allowed a free and undisturbed domain into which the fear of cleaning day never enters. When the wood surfaces are made smooth a less firm foothold to dust is the result. It may accumulate on the upper surface of a beam, but it cannot do so to any appreciable extent on the sides as it will, and even on the under faces, where the wood is used rough as derived from the sawmill. The same of course holds good with the roofing-boards. In the case of the granary we incline to use flooring-boards in covering it in. These laid with the smooth face downwards make an excellent finish to the inner side of the roof.

Light to the Granary.

As to light, we need hardly repeat that we would use opening skylights of the kind previously referred to. Thirty inches by sixteen inches is a suitable size of roof-light to adopt. Sixteen inches is the distance across from one rafter to the other, which, coinciding with the breadth of glass, makes the most of the space there is to spare. A lesser breadth of glass would be a waste of space in so far as the position of the rafters goes, and a wider one would mean waste in the form of the glass projecting on the boards at one or both sides. Besides, the frame of a skylight of the breadth quoted has its bearing directly on the two rafters that border the opening made to suit it. This is not a point to make much capital out of, perhaps, and one hardly worth advancing.

The window placed in the roof of the granary is clearly in a more advantageous position than when built in the side wall thereof. As a rule, no sufficient height of window can be secured in the side wall. It could not, at any rate, with our five feet three inches of building. But room or no room, we maintain that side windows completely destroy the continuity of the walls of the granary, and very much mar the usefulness of the place. Little or nothing can be thrown up against the sides of the store. Grain in bulk cannot, nor can bags filled with it be ranged for any length in continuous rows against the wall. If they are, the light is shut out and the windows had as well been omitted while the building was being constructed for all the good they then perform. Up on the roof, however, they cannot be interfered with either by grain in bulk or in sacks; and whenever it is considered advisable they can be thrown open to their full extent, whether for the admission of more air or for the outlet of dust that is being driven from the grain as it is being passed through the cleaning-machines. The undesirable dust will escape more readily by way of an opening in the roof than it will through a window opening not much above the level of the floor, and rather below than above the winnowing-machine. The side window is in the way when sound and effective so far as it goes, but when out of repair it is a source of harm. It opens a road for water to get into the wall, and also allows it to reach the barn floor, to the general hurt of the building, and to the damage of what may be stored therein.

Ridge Ventilators for the Granary. We have still the ridge ventilation to provide for, after which our granary is about complete. These we would have to be of the description already advocated—the double horned zinc arrangement with the diaphragm up the centre. A due number of these fitted into the roof would keep up the circulation of air that is necessary to maintain the woodwork of the roof in good condition, and at the same time to keep the air within the granary in a wholesome state. Fewer would meet the end in view here than in those buildings in which animals are housed. What the number of these ought to be in connection with the granary depends on local circumstances and must be based thereupon. One to every twelve or fifteen feet of length of ridge ought to meet the requirements of average cases.

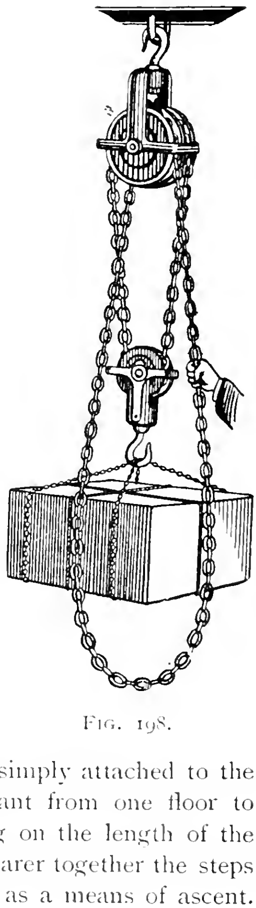

FIG. 198.

The Granary Stair. Where the stair leading from the thrashing-barn to the granary should be placed depends upon the exigencies of respective homesteads. We show it on the several ground plans in the corner beside the doorway that is mutual to the two barns, at the corner opposite to that occupied by the mill. The stair need not be other than a simple affair, something after the nature of a trap ladder or gangway. Three feet three inches would afford an ample breadth of stairway. The steps would do very well if nine inches broad and an inch and a half or so thick. Risers would not be required, the steps being simply attached to the side pieces or stringers that stretch on the slant from one floor to the other, the steepness of the whole depending on the length of the inclined plane. The longer the slope and the nearer together the steps are placed, the easier of course will be the stair as a means of ascent.

And it goes without saying that an easy stair is a boon to those who at times have heavy loads to carry up and down thereon.

Conveniences for filling and emptying the Granary.

But it does not follow that all the grain, seeds, and other commodities that are taken to the granary have to be carried up on men's shoulders, or, on the other hand, that they have to be taken out by the same exit. The mill of course delivers the grain on the upper floor by means of mechanical elevators. And there is nothing to hinder what other substances are independent of the mill (feeding-stuffs, for instance) also being hoisted up by mechanical means. Some pulley arrangement is quite easy of contrivance by which full bags can be raised to the upper floor without their having to be carried upstairs pick-a-back. One of the description depicted in Fig. 198 is somewhat suitable to the purpose. It is known as the "differential pulley." One person can work it by him or herself. The motion can be stopped at any point and the load will remain there as long as one wishes. They are made of different powers, so that half a ton, for instance, can easily be raised by one person with a pulley of this nature at his disposal. The progress of the load is correspondingly slow, and the distance travelled by the working point considerable; the reason why our readers ought to know. A simpler arrangement still, and one more adapted to the farm generally, is a hoisting apparatus such as we show in Fig. 199, which is an application to practical purposes of the principle of the wheel and axle discussed on page 214. Unlike the last mentioned, however, if one lets go the chain, the load drops. But while we raise the load the free end is descending in readiness to be attached to another when the former has reached its destination, thus saving all waste of time in reversing the tackle.

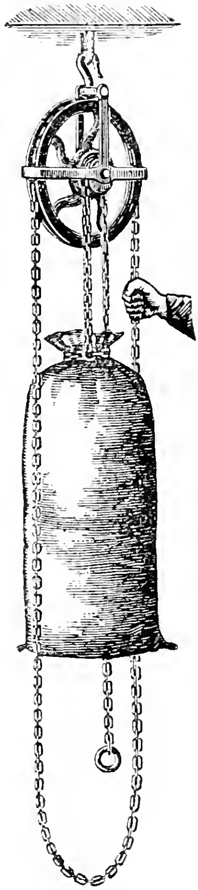

Fig. 199.

Contrivances of this kind, however, are movable fittings such as the occupier sees after for himself. But we are not going very far out of our way if we provide a place convenient for the working of such an apparatus. It is easier, as well as more satisfactory, to make a suitable hatch when the floor is being laid than to cut up the place afterwards. At any rate, if it is decided at the beginning that the floor is to be formed as a continuous whole, we can make provision in setting the joists for there being a hatchway therein at some future time. In this connection it simply means cutting a piece out of the length of one of the joists and supporting the free ends or cross-pieces stretching from the complete joist on one side to that on the other side, as in Fig. 200, the various pieces being firmly fastened together. The respective ends are usually half-checked into the side of the joist they abutt against, and they are in addition spiked through from the opposite side of the joist, and thus firmly held in position. Even if floored over to start with, it is easy, should it be wished thereafter, to form at any time a suitable hatchway to serve for the purpose we indicate. The width at which the joists are set binds us to a breadth of hatchway of thirty-nine inches, unless of course we cut into two instead of a single joist. But the width mentioned is quite sufficient, and we are not bound down in the matter of length. We can take whatever we consider practicable. From three to four feet would be ample to afford a hatchway that would admit the passage of anything that had to be hoisted to the granary in bags. But how handy one, say twice the extreme length quoted, would come in for the operation of packing fleeces!

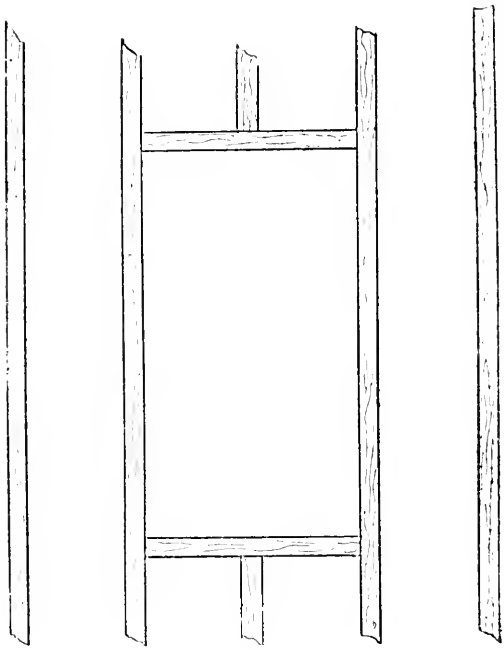

Fig. 200.

"Trimming" the Joists for Hatchways in the Granary Floor.

Carpenters speak of this manipulation of the flooring timbers as "trimming the joists." It has to be done more or less with all upper floors. In the dwelling-house the places for the hearths have to be trimmed in this way because of the danger that results from carrying beams near to fire-places. And the staircase has similarly to be dealt with. So indeed has the hatchway for our granary stair. This necessitates the interference with more joists than are affected by the hatch set apart for the hoisting up or lowering from one floor to the other of sacks of grain. Four or five of them at least are cut into by the stair hatchway. Fig. 201 represents a plan of the framework of this opening in the floor. It is evident therefrom that the joists *a* and *b*, besides having their own parts to perform, are saddled with the upkeep of the joists which intervene and are attached to the cross piece *c*, seeing that they have to act as supports to the latter. The joists *a* and *b* can of course

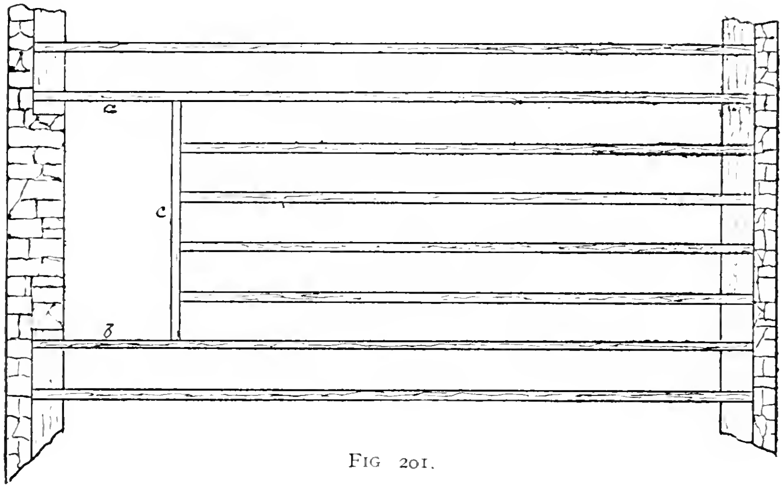

FIG 201.

be made heavier than the others; but the better plan is to place supports bearing upon the floor underneath below each end of the cross piece where it joins these joists. Or should two be inconvenient, one placed under the middle of the cross piece will have about the same effect. It will have more pressure to bear than either of the pair, and ought therefore to be stronger than they.

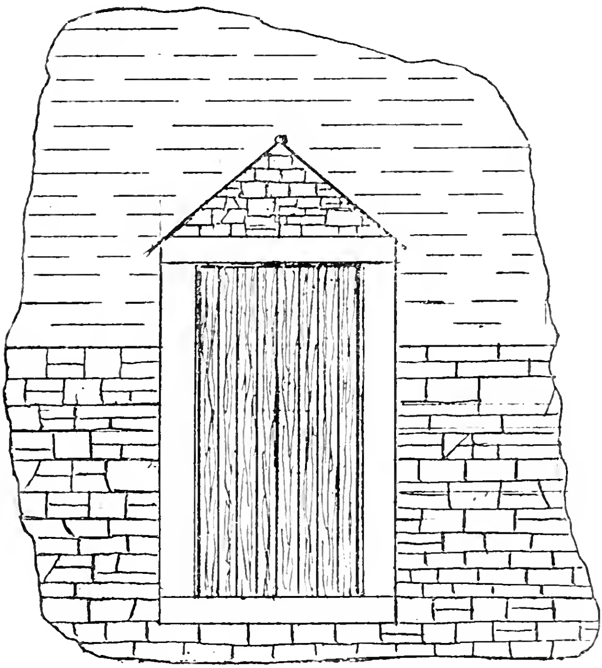

FIG. 202.

Provision for Loading and Disloading Carts in connection with the Granary.

It is even more essential to provide a place whence carts can be loaded direct from the granary floor than one by way of which the various farm commodities can be passed straight from cart or waggon to the granary, because it is easier for men to carry loads on their backs up a stair than to come downstairs with similar burdens so disposed. In fact, it is out of the question nowadays to set the farm hands to do porters' work. Labour has become too valuable for this. If the hatchway first referred to happens to be in an impracticable position for filling carts as well as emptying them, then a special one must be arranged for furthering the first - mentioned operation. Sometimes, indeed, this can be managed if there is a doorway below the level of which a cart can be drawn up alongside the wall. It is easy then to slip or drop bags into the cart and thus make up the load. Failing a convenient door, however, the hatch has to be resorted to. It should be placed so that horses and carts have to trespass as little within the barn as possible. There is no use in allowing more traffic of this kind on the barn floor than is absolutely necessary. In either of our barns there is ample head room for loading carts from the floor overhead. But increased granary accommodation may be called for, and it might not be practicable to obtain it over so lofty places as those we are dealing with, and it is well to bear in mind the danger that lies in working with horses in a building scant of head room.

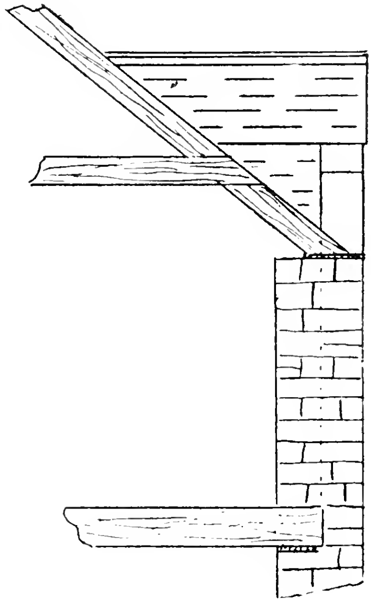

FIG. 203.

Hatchways of the kind referred to should, where possible, be avoided in situations of the latter description. If a door can be constructed suitable for carts being brought close enough to it to be loaded and unloaded thereat, this is a safer arrangement. A door in the gable is often made serviceable in this way by erecting a pulley above the lintel by means of which bags can either be raised or lowered to or from the granary floor. To effect the same at a doorway in the side wall generally means the formation of a pediment roofing over the door, as in Figs. 202 and 203, for in nine cases out of ten the side wall will not be high enough to enable the doorway to be got in under the level of the wallhead. But breaks in the roof, such as the figure represents, are better avoided. They are troublesome to make, and they always remain so many places that are readily thrown out of repair, and which, if not speedily attended to, thereafter bring harm upon the rest of the building.

Outer Doors of Granaries generally troublesome.

For our part, although we show one on Plan I.A, we seek to steer clear altogether of outer doors in granaries. They are generally so many inlets for rain and snow. When one happens to be in a part of the building that is exposed to a stormy point of the compass, it is almost impossible to make it capable of keeping out rain or fine snow when either is beaten upon it by a gale. In consequence the water is driven along the floor to the detriment of what may be stored therein, and to the eventual decay of the woodwork. If, therefore, there is to be an outer door in the granary, let it, if possible, be in a position of least exposure to the prevailing winds of the district—those that are aptest to lash rain against the door. We have no liking, as we have said, for outer doors, nor have we for outside stairs in connection with granaries. But where the conveniences we have just described are provided, there is need for neither.

Arrangements for the Delivery of Food Stuffs by Gravitation from the Granary.

The mill automatically delivers the grain on the granary floor, and the hatchways and doorways provide for the transmission here and there of grain in sacks. But to further economise labour provision has to be made for the delivery at points on the ground floor of grain intended for consumption at the homestead. It would be poor management to sack up this and send it down the hatchway from under which to be wheeled to the desired place, whether to the stable direct or in the first instance to the food-preparing room to be passed through the corn-bruiser before being served to the animals (or if for the cattle to be previously ground into meal), when it is possible to deliver the grain at a point handy for the stable and to feed it direct either to bruiser or grinder.

The latter arrangement is not very difficult in contrivance. A hopper fixed against the side wall and communicating with a shoot, which may either be of metal or wood, leading to the desired point, whether on the floor beneath or in an adjoining shed, is all that is required. The shoot must of course be given the due amount of slope necessary to allow the grain to slide along under the force of gravitation. A wood shoot will answer well enough where the point of delivery is in the barn underneath. When it is in an adjoining building, however, one of metal lends itself more readily to taking a curve through the wall of one house into the other, or of turning a corner for convenience sake. Were we to make a shoot of this devious nature out of wood, the resulting corners would retard the passage of the grain, and often choke the affair altogether. But piping is easily to be had that will follow all the twistings that are likely to be comprised in such an arrangement as we are referring to, and consequently allow the grain to slide along without difficulty.

It would indeed be almost entirely in the food-preparing sheds that the loose grain sent down from the granary would be sought delivery of. A shoot would be handy also to deliver corn for odd purposes in the barn at some convenient point. In connection with the bruiser, and the grinder as well, not only is it a handy appliance, it is a necessity. Each of these apparatus must indeed have a hopper and shoot to itself. A four-inch, or, at the outside, a five-inch thin cast-iron pipe, will make an efficient shoot. It is easy, we repeat, to fit up piping of this description. It is manufactured, as we have hinted, as well in straight lengths as in pieces of varying curves or bends which make it quite easy to be led in almost any direction wanted — any one reasonably practicable in this respect, that is to say. We need hardly indicate that the shoot is imperfect unless fitted with some arrangement whereby the delivery therefrom can be regulated. The nature of this we must leave to individual ingenuity.

The Buildings subsidiary to the Barn.

With regard to the buildings we have shown on the respective plans as subsidiary to the barn, we shall only deal in this chapter with those that are directly related to the commissariat department. As catering for the cattle is the leading operation at the homestead, it is only natural that the food-preparing sheds should be at the side of the barn nearest to the byres and loose-boxes. We show two sheds in position there. One we set aside for the preparation of grain and cake, and the other for the preparation of roots and the chopping of hay and straw. Which is to be which is a matter of choice. Either will do for one or the other purpose. The power-shed being at the opposite side of the barn easily admits of motion being given to the various machines in these two sheds by means of shafting passing through the main building. Our choice would be to have the grinder and cake-crusher in the end shed, and the pulper and chaffer in the corner one.

On the plan of the homestead for the cattle-feeding farm we show these sheds of an equal size, while in that for the farm where dairying is an additional branch we show the corner shed the larger of the two. Where dairying is prosecuted there is usually less cake-crushing and grain-grinding going on than at the former class of farm. Chaffing is not much in vogue, either, where dairying is concerned. It is well, however, to afford the place the use of the two sheds in question. The smaller can at least serve either as a cake or meal store; or for that part do to house both substances. And the larger one is there, should the occupier wish house room for any of the appliances mentioned.

We have taken further advantage of the barn to place two smaller sheds against it on the other side for the purpose of affording accommodation for horse provender and the preparation of the same. One may be turned to account for hay-chopping, and the other for corn-bruising. They, too, are conveniently situated as regards the power-shed, and not far from the stable door. If hay-chopping should not happen to be practised by any occupier the shed is there as a useful store for some kind of dead stock. And should corn-bruising be considered unnecessary by him, the other shed is there as a cornstore, in which delivery can be taken of the grain direct from the granary which it adjoins. Where chopping was carried out extensively the more economical plan would be to do the work in the granary itself; and so with corn-bruising, and grinding, and cake-crushing. It would be a simple method to raise the hay and straw and the cake from the barn beneath in elevators to the upper floor, there to be dealt with and thereafter dispatched down a shoot for use either by cattle or horses. Indeed, were a portion of the second floor set apart for these operations the roots might also be elevated to these quarters in order to be pulped, and the resulting stuff be sent down as before, ready for use.

Different Plans of arranging these Buildings.

Where dairying proper is conducted, as at the homestead delineated on Plan III., we not only keep the sheds as first arranged, but add another between the dwelling-house and the barn. This makes a capital place for a meal and cake store. In the shed next to it pulping, chopping, grinding, and cake-breaking, or such of them as may be thought desirable, could be carried on, while the end one could be devoted to scalding or boiling or otherwise preparing the sappy messes that are considered necessary to the welfare of the cows at certain stages of their physical condition. It strikes us, however, that one or other of these houses would at times be turned to account as a store for oat chaff. This is carefully collected during winter with an eye to its being the principal ingredient or rather the basis or thickening medium of the aforesaid concoctions that are given to the cows between mid-winter and spring as a substitute for roots on the one hand and grass on the other. Roots do not play the important part at the dairy farm that they take up so prominently at the combined cattle and sheep-raising holding, and are never much in evidence thereat. Were they looked upon as essential in this branch of farming more of them would, no doubt, be forthcoming. But they are not considered indispensable thereat, and this, together with the trouble and expense involved in their cultivation, almost entirely throws them out of court.

The end shed would be the proper one in which to have the coppers fitted up. There they would be convenient both to byre and piggery. To that end a short chimney stack would be required in the side wall where indicated. But if steam were to be used

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in this connection such an erection would not be needed. The steam would be derived from the power-shed on the opposite side of the barn, whether from a subsidiary boiler or from the vertical engine, which we presume would be the prime motion developer of the homestead. It is no difficult matter to convey a small steam pipe the distance suggested. Wrapped in felt or some similar non-conducting material very little heat would be lost on the way, and its proximity to any of the wood-work of the barn would cause no harm.

The buildings we are discussing are set forth on the various plans as leaning against the side walls of the barn. We have already expressed disapproval of ranging one building against another in this manner. But we were referring then to making the houses occupied by live stock act as main props to smaller ones. The case of the barn is on a different footing. So long as we are able to get the interior lighted and ventilated it matters little how or in what way the building is surrounded. The building occupied by animals, however, needs all the air around it that can be obtained.

Their Construction: the Walls. Fig. 194 gives the outline of these sheds in section. In order that we may be able to admit sufficient light into the barn we must not keep the roof of the sheds too far up the side wall of the main building. If we leave two feet clear between the under-side of the granary floor and the outer finish of the shed roof, there is room therein for the insertion of the kind of window we recommend for the barn. We have allowed nine feet as the limit of height to which the shed roof may be carried up the side wall. The front wall of the sheds we have put down as of brick-work. This takes up less room and reduces the length of the roof, which is an important point where there is likely to be a deficiency in the slope of the same. In this we are confronted with that contingency. At the back wall the shed is nine feet high over all. Now, if there is to be enough of head-room to allow of effective doorways in the front wall it must be at least seven feet to the line of the outer covering. The shed is nine feet inside, and the outer wall is nine inches in thickness, consequently we are left with only two feet of fall to clear away the rain over a space measuring nine feet nine inches across. This is too little for the purpose if slates are to be used. We might increase the slope either by raising the back wall or lowering the front one, or by both methods. But raising the back wall means interference with the lighting of the barn, and lowering the front one renders access to the sheds inconvenient. A building is not thoroughly efficient so long as we are impeded in taking the full advantage thereof; and low doorways are always obstacles in this respect.

The Roof. We can get out of the difficulty by adopting corrugated galvanised iron sheets as the roofing medium here. A roof of this description will do with far less slope than serves for a slated one. We have no liking for a covering of the kind for the permanent buildings of the homestead, it being perhaps rather too much of a makeshift at the best. But under the circumstances we consider its use quite justifiable here. The front wall may even be obtained a little higher than the seven feet spoken of. If, however, we manage to get a doorway, say six feet three inches high, and still leave room for the wheels of the sliding doors to clear with ease the eave gutters, then we have all that is required to make a satisfactory job of that part of the building. The width and the position of the respective doorways are matters that it is needless for us to enlarge upon here. They fall to be decided in accordance with the type of homestead taken in hand, and the class of live stock likely to be maintained thereat.

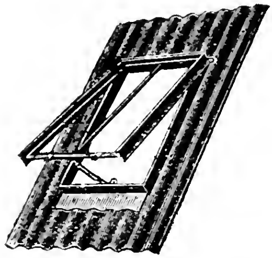


Fig. 204.

The Floors. The flooring of the sheds in question would, of course, be directed to be of concrete. The brickwork of outer wall and partitions, if brush-pointed with Portland cement mortar, would form a hard, smooth surface that needed no further finish. And were the surface of that part of the barn wall included in the sheds plastered over with a thin coat of Portland cement, the interior of those places would afterwards leave little to be desired from the points of withstanding wear and tear and being easily kept clean. The floors would not admit of being much above the level of the surface of the courtyard. It would be all the better to be a little higher, however, if only an inch. There would be no likelihood then of surface-water finding its way into the shed. The floor could be kept so much higher than the yard by simply bevelling back the outer edge of the

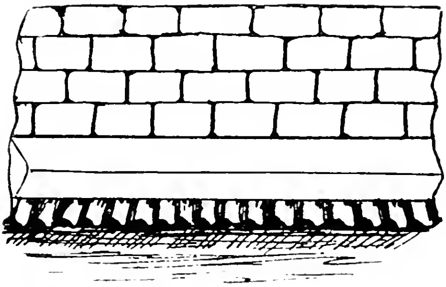


Fig. 205.

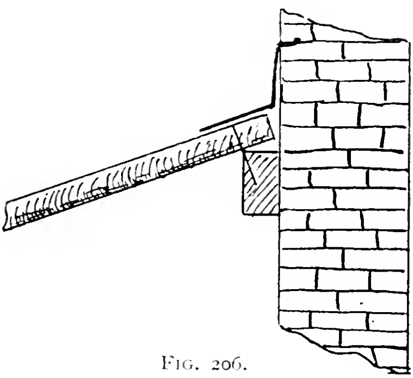


Fig. 206.

step or stone finish to the concrete of the floor to the extent that the difference of level would not interfere with the passage of a wheel-barrow or similar contrivance for the conveyance in and out of the stuff peculiar to these sheds.

Light and Ventilation.

Sheets of corrugated iron roofing are now to be had with lights fitted therein, so there is no difficulty in lighting the sheds by way of the roof. The lights referred to, as Fig. 204 reveals, are similar to the ordinary skylight already referred to. These, seeing they can be opened at will, may be considered sufficient for ventilation as well as for light. But the method we point out in the section of the shed, and more in detail in Figs. 205 and 206, of protecting the junction of the roofing sheets with the barn wall enables the place to be kept well aired at all times, irrespective of opening skylights or other arrangements. The sheets of iron, it will be seen, butt against the wall, while close above them, resting upon them, in fact, is an apron of zinc with one edge let well into the wall and the other lapping over the iron for a few inches—as far, indeed, as will guard against the inlet of drifting rain. When the barn is being built there is nothing to hinder the raggle for this apron being formed in the wall. A strip of wood might be built in the desired place in such a manner that it could be removed when the zinc was about to be inserted in the wall. The raggle would require to be formed with an inclination to suit the final position of the zinc, for the latter, unlike lead, is a metal that will not stand bending or twisting without soon showing signs of fracture. The zinc flap rests upon the crests of the corrugations, while beneath it, in the troughs thereof, there is room for air to pass to and fro and round the heads of the sheets into the shed itself. Should this not meet the requirements of the shed wherein the coppers are contained, it is an easy matter to keep a sheet or part thereof clear up for an inch or so from the others it is in touch with. A few extra washers between the sheets in question will effect what is required in the matter of affording a ready outlet to the vapour that arises from the cooking-pots.

CHAPTER XIII.

Buildings West of the Barn.

The Nature of these Buildings.

West of the barn block we place on Plans I. and II. the byre or cowhouse—in the former instance a single byre, and in the latter, since it is connected with dairying, a double one. It is a chance, in fact, if many cows are kept at the class of homestead of which No. 1 is typical. The byre is there, however, and, if not required for cows, it can be put to use for housing fattening heifers. One or two cows, at any rate, will be kept, and there is nothing to hinder their being kept under the same roof as their shorter-lived virgin fellows. If they must be kept separate, a wood partition will enable this to be done. The byre in each of the two instances occupies all the end of the homestead west of the barn. And at right angles thereto runs the range of building which occupies the whole of the west side of the establishment. This side in the first instance is, with the exception of a root house at the extreme end, wholly taken up with cattle feeding-boxes. In the second instance it is set apart as additional accommodation for cows and other dairy stock; part, if necessary, to be used in connection with beef-raising cattle. And the adjunct to these byres, in the form of dairy offices, are, it will be observed, placed in isolation near to the outer angle of the two ranges we are now about to discuss.

On Plan III., that of the homestead for a pure and simple dairy farm instead of the byre we started with in both the above cases, we set down the dwelling-house separated from the barn by the small storehouse referred to in last chapter, along with the sheds built against the barn. And at right angles thereto, as before, comes accommodation for the cows and for the younger animals destined to fill the stalls of their elders when the latter are driven off to furnish, if not beef itself, then beef extract, or, at least, sausage meat and gelatine. The dairy offices, as in the last-quoted instance, are also isolated from the main group of the buildings, but, notwithstanding, placed convenient to house and byre alike.

How the Cow fares for Room in her Winter Quarters.

Figs. 207 and 208 show sections of a single and double byre respectively. These, however, are representative of the requirements of the Ayrshire breed of dairy cows, and the sizes they indicate would in consequence render the accommodation too restricted for other classes of cattle. For the Ayrshire cow, from seven feet to seven feet three inches, measuring from side wall of byre to edge of grip or gutter, is the length of lair allowed; but throughout the south-west of Scotland one will meet with more of the lesser than of the greater length. The proper length is the one that allows the cow to stand and move about without having to place her hind feet in the grip. She is wanted to be close to the latter without being obliged at times, for the sake of gaining more room, to place her hind feet therein. The grip is there, to use plain terms, to catch her droppings, and the nearer the two can be brought together, so long as the cow is not restricted in the length of her stance, the more cleanly can the latter be kept. In a byre well fitted to the size of the cows it contains, or the other

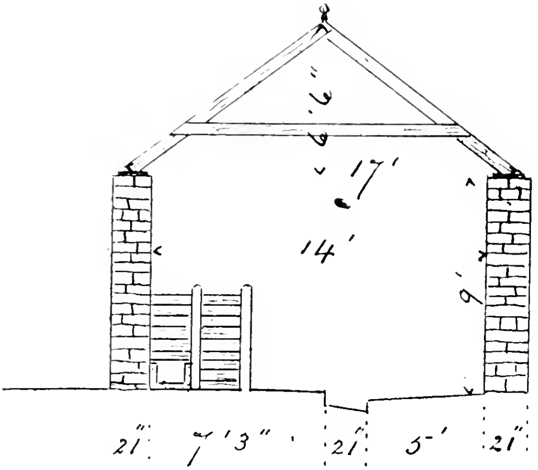


FIG. 207.

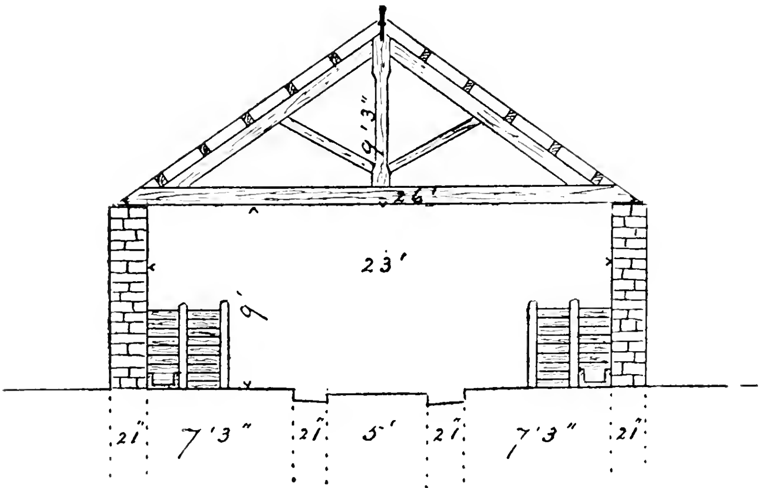


FIG. 208.

way about, say, the droppings, both solid and liquid, of the various animals will invariably be deposited in the grip without messing the lairage in the slightest. This only holds good, of course, so long as the animals are kept at right angles to the side wall, and this posture on their part can, as we stated at an early stage of our work, only be maintained by dint of close packing. Three feet is almost the invariable width of elbow-room allowed to the Ayrshire dairy cow. Perhaps it is truer to say that six feet is allowed to each pair of cows, seeing that the travises or stall divisions are fixed up six feet apart and each space divided thereby holds two cows. Seven feet by three feet, or at the outside seven feet three inches by three feet, is truly a small space for such a large animal as a cow. About as much as that is allowed to man's remains when "dust to dust" is enacted. The remains rest undisturbed, however: but the cow has to stand and lie in her allotted space through many months in each year of her life. From October till April has she, who has roamed at liberty in the fields during the rest of the year, to content herself with the close quarters noted. In fact, she has less room than the figures indicate, because the breadth of the travis, in whatever manner constructed, falls to be deducted therefrom. The breadth of the double stall is measured from the centre line of one travis to that of the next. Necessity decided the point, however, and the lessons derived from such a teacher usually leave little room for question. Had the cow more lateral space at her command she could hardly, we repeat, be kept so passably clean as we see her under existing circumstances. She cannot when ranged up in the manner indicated make so free with her tongue as a toilet appliance as she can when at liberty out of doors, but this does not seem to have any influence for evil upon her, and then there are no flies in the byre to annoy her and keep her on the fidget.

The Byre Floor. If we cannot help her in the matter of room, we can, however, make her lot in confinement a little easier by seeing that her stance is made smooth. She will then be able to stand as well as lie in comparative comfort, which cannot be the case when the surface of the lair is rough and irregular. It becomes painful to stand as well as to lie on a surface of the latter description. Concrete, as we have already pointed out, comes in here again as a suitable material for a floor on which to station cattle. In addition to its other good properties, both in keeping ground-damp from rising through it and preventing surface moisture from being absorbed instead of run off, and checking the inroads of rats, the concrete floor affords the animals an easy place to stand upon as well as a smooth bed to lie on.

The Position of the Troughs. As the sections show, the feeding-troughs are placed on the floor—on the top of the concrete. Some are inclined to omit the concrete under the troughs, laying the latter upon the soil, as it were, but this we consider mistaken policy. One might think that it would give greater comfort to the animals if the troughs were placed higher. It seems to be otherwise, however. The universal custom is to place the troughs on the floor of the house. The cow and the ox have to tear their food from the surface of the ground in the act of cropping grass and herbage of a lowly habit; and in feeding them at troughs not raised from the ground we are but conforming to nature. It is good practice to keep the troughs back a little from the wall. If set close to the wall some of the animals have difficulty in rising without touching it with their horns. There is not much in this, perhaps, but a well-bred animal looks blemished a bit if her horns are worn down ever so little. In time the wall, too, suffers. It is a good plan, therefore, to keep the troughs back from the wall as far as is equivalent to the breadth of a brick. If bricks are not difficult to get, these may be bedded between the trough and the wall. If they are, then concrete or any other material will answer equally well. But whatever material is used the angle formed by the upper edge of the trough and the wall should be filled with cement, given such a slope that nothing can lodge upon it. It is advisable, also, we think, to add a thin coat of cement plaster to the walls in front of the cows, carried up to be in line with the top of the travises, perhaps. This ensures a good hard and smooth surface to the wall directly in front of the animals, which must obviously conduce somewhat to the improved sanitation of the building. We see no need for carrying the plaster any higher than we have noted. The noses of the animals are seldom elevated so high, and it is with the view of there being few chinks and crevices and little roughness of surface on that part of the wall upon which the breath of the animals is likely to play that we are inclined to suggest this skin of cement being applied thereto. There is less chance of pathogenic matters expired from the lungs of some unsuspected unhealthy animal that may be in the rank gaining a foothold on a smooth, hard surface such as we recommend, than upon one characteristic of the ordinary rubble-built wall. A brick wall, that is to say, one built of smooth, hard bricks with sharply defined edges, not one of what the trade knows as partition bricks, has no need of any additional finish of the kind. Such a one, if neatly pointed with a good mortar, forms an almost ideal wall surface for the interior of farm buildings. One of the best finished and most substantial homesteads we have had the pleasure of inspecting has the walls externally of strong red sandstone rubble work, and inwardly finished with warm-looking red bricks of the favourable description just quoted. The cement coating we refer to, in addition to its benefit from a sanitary point of view, gives a more pleasing appearance to the otherwise bald-looking byre; moreover, it helps to withstand tear and wear a little.

The Grip. The grip should never be less than eighteen inches in breadth. That breadth suits the circumstances of the average country dairy farm. The cows undergo no forcing treatment there. At the farms where they do, however, the grip is all the more effective if made a little wider. It may with advantage be increased to the width of two feet. The bottom is laid with a slight hang to the edge next the walk. This allows the fluid excreta to drain to that side of the channel and get away past the solider stuff, which for most part is deposited close to the other side. To put it plainly, therefore, the width of the grip should be ruled by the amount of excreta that is likely to be deposited therein between the times of cleaning out the byre. The narrower breadth mentioned is sufficient in the case of Ayrshire cows under ordinary management, while the greater is needed where the same class of cows is more generously dealt with than usual. The atter is also needed to meet the case of breeds of bigger cows than the Ayrshire, as well as for animals which are being fattened. One cannot pretend to construct a building that will adapt itself to the niceties of hypothetical cases, so perhaps the best thing to do, when the breadth of the grip is matter of debate from an ordinary dairying point of view, is to strike a medium and make the channel one foot nine inches across.

As regards the depth of the grip, six inches at the side next to the animals and four at the other is a workable conformation. This enables the walk to be kept three inches or so below the level of the lairage. The two inches of difference between the depth of the respective sides, together with the fall outwards of the bottom of the grip, makes up the difference, whatever it amounts to, in level between the walk and lair. Stock owners prefer to have their animals elevated n this way a little above the standing-point of those who come to have a look at them either in a friendly way or with a view to a deal.

The different Inclines of the Byre Floor.

The run or difference of level in the sole of the grip lengthwise is one that cannot be dictated with the same amount of confidence that can be applied to the lateral dip. While one inch may be laid down as sufficient allowance in respect of the latter, the other is ruled very much in accordance with the configuration of the ground occupied by the byre. An inch of fall to every six feet, or the breadth set apart for each pair of cows, would serve sufficiently to drain the urine to the outlet. Should the byre, however, be built on sloping ground, more than this would be apportioned in the fall of the gutter.

The Lairs to be as Level as practicable.

But the leveller, comparatively speaking, that the byre can be constructed, the better will it conform to the comfort of the cows that come to be housed therein. There is no necessity, so far as the animals are concerned, for the lairs to be off the level either in the length or in the breadth. For an animal constituted like the cow, the leveller is her standing-place the better is her chance of maintaining health under the rather unnatural circumstances she is subjected to. It cannot be conducive to an animal whose bulk is carried largely in the hinder half of her frame to stand in such a position that her hind feet are constantly at a lower level than the fore ones; more especially when we bear in mind that the organs of an animal such as she are so large and vascular and so slackly knit to her carcase. In fact, if there is a difference at all it ought in accordance with analogy to be in the other direction. There is little risk, as we have said, of urine falling on the lair occupied by a cow, therefore there is no need of giving it an inclination from the wall to the grip with the view of keeping it dry. At any rate, if any is allowed it need only be the very minimum—an almost imperceptible difference in level will drain off any liquid that may happen to find its way on this part of the byre floor. None is, indeed, likely to do so unless when the place is being swilled down.

If slope can be dispensed with in the length of the stance, much more so can it be in the breadth, for should it get wet the liquid will be all the longer in gaining the grip. Instead of running or trickling direct to the part of the grip immediately connected with the affected stance it will, before it reaches the gutter, have crossed more or less of the others on its lower side. But each stance should as far as possible be independent of the others. To a certain extent, however, the lairage of the byre must be given a dip broadwise even when the house has the chance of a level site. The grip is not fully efficient if water will lie in it, and the floor of the byre must conform to the run that is given to the grip. It would not answer to have the sides of the channel deeper at one part than another. The channel must be of the same depth all through, and the remainder of the byre must be in conformity therewith. For sake of the animals, however, the dip given to the grip should, like that given to the lairs lengthwise, be the least that will admit of efficiency. This is, perhaps, a less important point than the other. Standing at an angle to a slope can hardly be so prejudicial to the cow as standing parallel to and facing the slope. And in lying down under the former conditions the animal has opportunity of reversing matters, for while on one side her body be downhill, on the other it is against the incline. But the one circumstance helps to aggravate the other; and when both are well pronounced we have the animal all the time she is on her feet not only down in the stern, as a sailor would say, but, as he would add, with a heavy list. The list is the lesser evil, which is fortunate, because it is the one less easily avoided.

This lateral hang being then unavoidable, nothing remains but to take the sting out of it so far as we can. All that we can do, however, is to reduce both inclinations, one as already suggested almost to *nil*, and the other nearly to the minimum that will cause water to flow. Very little inclination in the channel will serve this end, and here comes in one advantage of making the channel a little wider than usual, for the wider it is the less likelihood is there of the solider excrement blocking up the waterway therein. A broad grip, therefore, allows us to do with less inclination lengthwise in the building than we would be obliged to provide for in the case of a narrow one.

Under-drains in the Byre to be avoided whenever possible.

Were it allowable to have under-drains in the byre the difficulty in question could easily be overcome by having a drain running underneath the grip, and making connections between the two at short intervals. A series of gratings in the bottom of the grip would allow the liquid matter to disappear to view ere it had proceeded far; and so long as the drain had ample fall the grip might be kept almost level. But then, as already pointed out, covered drains either in byre or stable are inadmissible. It serves a bad end to get rid of the liquid excreta in this hidden manner. To render matters safe we must keep our eye on it until it gains the side of the doorway outside. We must deal with it as we would with suspicious characters found prowling around our

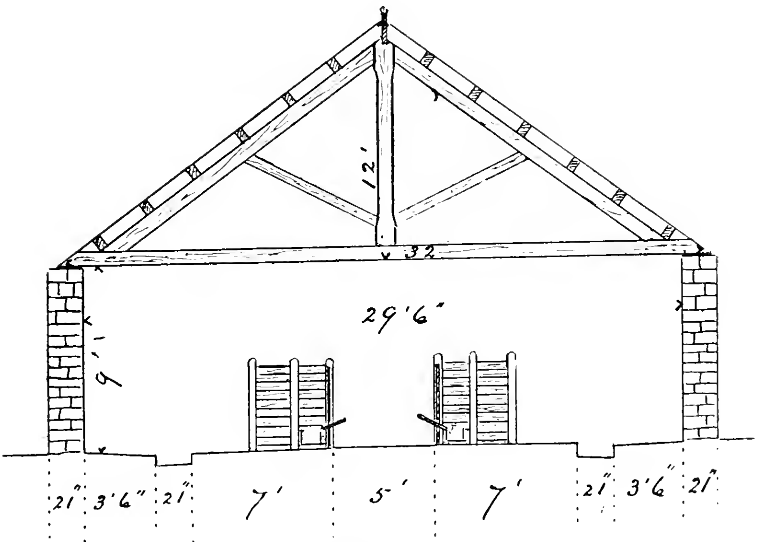


Fig. 209.

premises. Under every circumstance, therefore, we have to face the longitudinal slope of the byre floor. Whether the site of the byre be on sloping ground and running with the decline, or whether it be on level ground, it is all the same—we have to provide for the difference of level under discussion. In the one case we have to tone down the natural slope; in the other we have to make a slope for ourselves.

The Byre Passages.

The walk or pavement behind the cows we would advocate not to be less than five feet wide. It might be better if made wider, but all that can be saved in this way means reduction in the item of roofing as well as in flooring and wall-building. If the byre be of the type represented in section on Fig. 209, four feet would be a liberal allowance to set apart for each of the side passages, seeing their purpose is principally for the removal of droppings. They are, in addition, the ways of access by which the animals pass to and from their respective places in the row. But the breadth we have figured, three and a half feet, is quite sufficient for either purpose. Feeding is overtaken from the central passage, which necessitates that five feet at least be allowed for it. Here we have thirteen feet of the breadth of the byre set apart for passages alone—little short of what is occupied by the cows. The stalls, however, can in this type of byre safely be made a few inches shorter than in the other two, the cattle being better able to stand well up in them.

The Byre with a Central Feeding-passage.

This byre, it is needless to say, is much more expensive in erection than the other two, the sections of which are depicted in Figs. 207 and 208. Without doubt it has advantages over the others, but it is possible to pay too dearly for these. It means saving of labour to be able to feed the cattle from a central passage instead of having to pass up between each pair from behind. The fodder can be tipped over the boarding at either side of the central passage, and the roots and the prepared food be slid down the sloping shelf into the troughs right and left, as one proceeds along the byre with barrow in front. The animals, too, one would think, are under healthier conditions when ranged with their heads in the part of the building where the column of air is highest. It must be better for them to be placed so than face to face with a cold wall. Towards the centre of the building the expired air has room to spread out, but close to the wall, before it can get far away, the animal is inhaling some of it over again.

This in fact is, in our opinion, the one advantage that tells in favour of byres arranged in this manner. We question very much if the cattle settle so well tied thus as they do when facing the wall. They are full of curiosity, and there is more to be seen in the former position. Every movement in the passage at their heads is suggestive of rations, and therefore conducive to distraction—mild, no doubt, but unsettling all the same. And, after all, the saving of labour is more apparent than real, at least when we compare it with the double byre with the one passage, that in Fig. 208. The one with the feeding-passage down the centre of the byre has the advantage at meal times, but it necessitates more coming and going in the work of cleansing. It comes to this, therefore—is the extra expense involved in the erection of the larger byre worth gaining what, after all has been said and done, is but a hypothetical point? for it has never been proved that healthy cattle suffer on account of being housed after the manner implied in Figs. 207 and 208. We hardly think it is. If the byre is finished on the lines we are suggesting, the cows are not exactly close to the wall, and the wall being hard and smooth on the internal surface is easily maintained in a sanitary condition. And what the combined passage of the two-rowed wall-facing byre loses in the matter of feeding the animals, it gains, as we have said, at cleaning time. On the whole the balance in respect of economical working is in favour of this byre.

We sometimes see a feeding-passage between the cows and the side wall in byres after the plan both of Figs. 207 and 208, but unless it serves to keep the animals back from the wall, we fail to see its use as an economiser of labour. Another four feet added to the breadth of Fig. 207 brings it within five feet of the width of Fig. 208, which may as well be overtaken, and the benefit of a double byre be obtained thereby. And to form passages of the same sort in Fig. 208 brings us to the same width as Fig. 209, with no advantage over the latter. A passage of the kind is shown in Fig. 212 and in Fig. 213.

The Single Byre with One Passage. The one-row byre is the least efficient of the three represented. It is one we would never recommend unless only a few animals were to be accommodated therein. Exactly twice the distance has to be travelled up and down the service passage of the one-row byre that has to be gone over in the two-row one, both in the work of feeding the animals and cleaning up after them. On Plan I., indeed, we show a long single byre immediately to the west of the barn. In this instance the building is likelier to be filled with fattening heifers than with milk cows. Not that this makes much difference as regards the working efficiency of the byre. In fact it makes matters worse in that respect. More food has to be handled when beef is being produced, and, of course, more stuff has to be wheeled to the dunghill. And fattening cattle are rarely denied a good littering, while it is the exception to see dairy cows lying on straw.

The Double Byre with Single Passage. There is nothing, however, to prevent the single byre referred to being doubled as on Plan II. This would reduce the adjoining food-preparing sheds a little, but not very much, if we bring the side wall towards the north flush with the barn gable. By doubling the byre, a part of it at the west end might be spared to serve as a root-house, and in consequence be able to dispense with the one shown against the side wall of the loose-boxes; and the coppers, did such happen to be in use at the place, might be placed there. We show it doubled on Plan II., because it is meant to be typical of a homestead where both fattening cattle and dairy cows would be kept. And we have the byres doubled at the farm where dairying is the leading agricultural industry practised.

Communication between Byre and Barn. In both cases we show a doorway between the byre and the barn. Many will object to this. At times it is bound to be a convenience. If such a communication, however, is undesirable, the door can be kept locked, or, for that matter, the opening can be bricked up. Straw could be brought that way under cover, which is a boon in stormy weather;

and temporarily stored cake or meal could sometimes be fed directly from the barn by the doorway in question. These conveniences would cause even the greatest sticklers for keeping each place to its own uses, and observing general order, to stretch a point in these little trespasses.

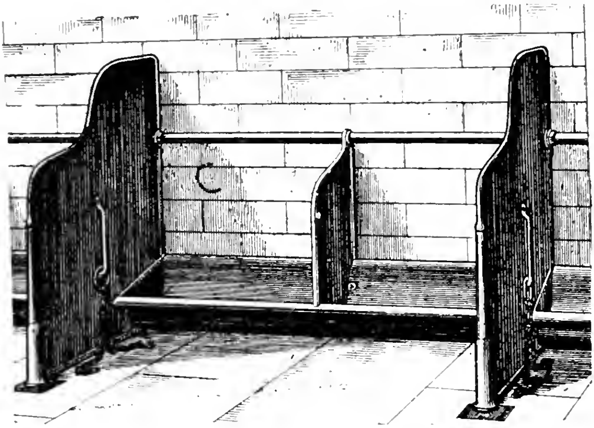


FIG. 210.

On Plan III. representative of the homestead for a dairy farm we place the dwelling-house in the corner filled by the byre we have

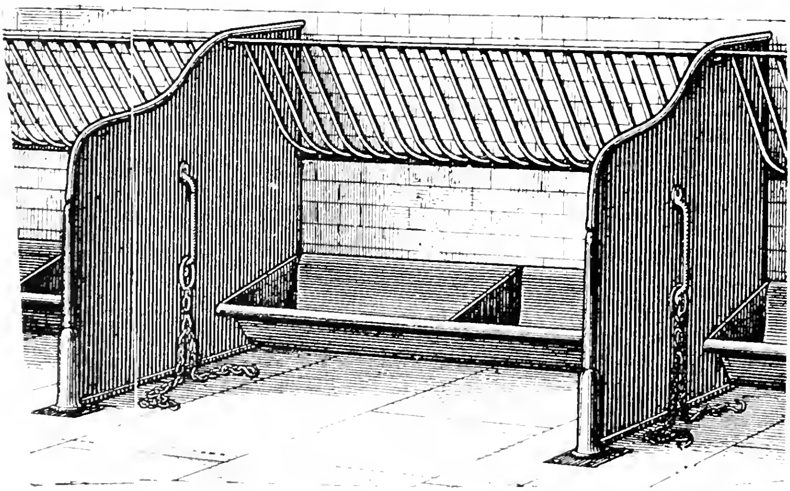


FIG. 211.

been specially dealing with, the cattle accommodation taking up the adjoining side of the square. This arrangement gives the occupants of the house easy access both to byre and dairy.

The Byre Fittings: The Troughs. We have little to add here with regard to the fitting up of the byres. We have already gone fully into the matters of flooring, roofing and lighting under their respective heads, and about all that remains to be discussed is the subject of the stall and its fittings. We gave our preference for a concrete floor and the reason thereof. And so with the roofing and lighting. Feeding-troughs we have not touched upon. It will have been gathered, however, by our readers, that our preference lies towards those manufactured out of fireclay. These are made with a glazed surface which renders them impervious to penetration on the part of food matters, either liquid or solid. In consequence, they can never be permanently tainted. When the surface is clean they are fresh and pure as articles of that kind go. And they are not difficult to clean. A wisp of straw carefully applied leaves little behind it. But far more effectual in that way is the tongue of the cow or other member of the cattle classes. When judiciously fed it would take a good eye and a sensitive touch to find much in the trough after the animal has licked it out. There are no corners where particles can lurk. In addition to all this, the troughs are strong and easily set and maintained in position. And given fair play, their resistance of wear

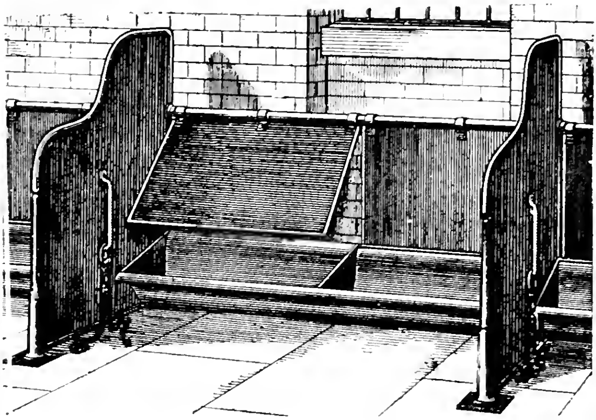


FIG. 212.

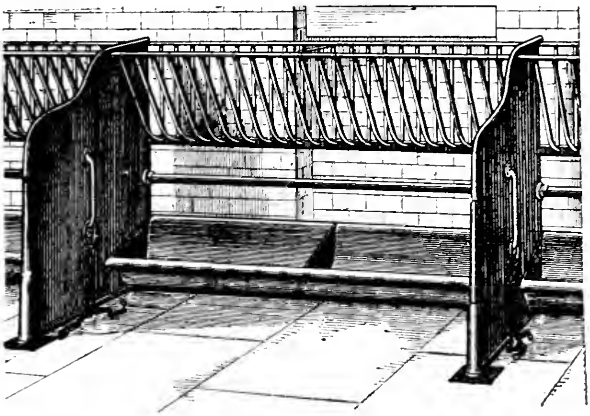


FIG. 213.

and tear is invincible. Wood cannot compete with fireclay in any one of the points mentioned; stone can do so but in the one of easy setting; iron approaches close in some, but unless the byre is planned to be fitted throughout with cast-iron appliances, troughs of that material are inapplicable by themselves. Complete appliances of that description are, however, in our opinion, far from being suitable to the average homestead. They make a neat job, however, and are well adapted to the home farm and similar places where money is not scrimped in these matters. In Figs. 210 to 213 we show some good examples of these as supplied by Messrs. Steven, Glasgow. In the first two the cows are ranged close to the wall, in the others a feeding passage runs alongside the wall. One of each pair shows a fodder-rack in front.

The Travises. Coming to the ordinary byre, the travises or partitions that divide the lairage into the several compartments that each hold a pair of cattle are, we consider, best when made of wood. We have no objection to iron posts, but the remainder of the erection we would have of boarding. Stone, unless it be of the nature of Caithness flag or Welsh slate, we do not care for. Stone of a kind other than these two requires to be so thick in order to withstand the bumps it so often receives when set up on edge in the position indicated, that, besides being clumsy, it takes up too much of the room that the cattle have at best little to spare of. The six feet we mentioned as being allotted to the pair of cows measures, be it remembered, from centre to centre of the travises. The thicker, therefore, the travis is made, the less room each cow has at her disposal. Concrete we see occasionally in use as a travis-forming material. But it possesses similar faults to stone in this connection. Concrete, like the class of stone that can be put to service in this way, is too brittle for the purpose. Either, when in bulk, will withstand enormous compression, but when set up in comparatively thin sheets, as in this case, they are easily snapped under cross pressures. From their thickness they are apt at times to act the part of masses of cold material intervening between the animals. Moreover, the surface of either is rough and therefore objectionable. The cement surface can, of course, be polished pretty smooth, but there still remains the objectionable thickness of the

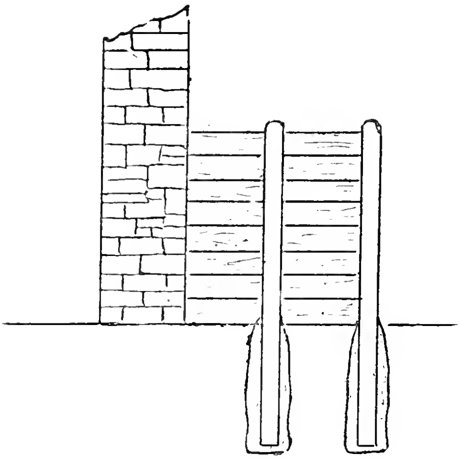


Fig. 214.

erection. Flag and slate, when of good quality, that is to say, are tougher than either stone, such as we are referring to, or concrete, consequently thinner sheets of these can be used without risk of their being fractured. The surface of either is easily made smooth ; and the thinner sheet is not so cold, neither does it take up so much space

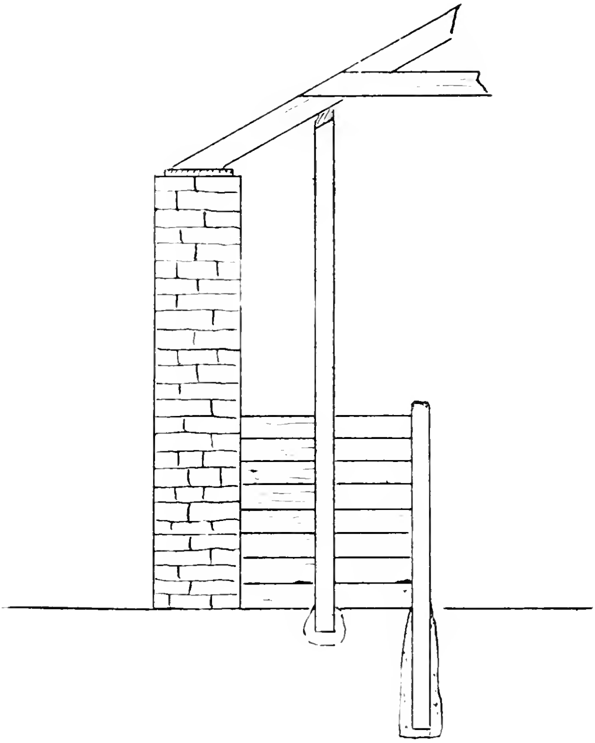


FIG. 215.

laterally. But it is only in exceptional localities that it is practicable to turn flag or slate to account in the manner referred to.

The Wood Travis.

Wood is procurable everywhere, and it responds better to the general requirements of the situation than any other material. It is easily put together, and in such a way that it will not occupy an undue share of the space at disposal ; and, another thing, it will never chill the animals.

The various Methods of Arranging and Fixing the Travis Posts.

The board travis is usually set up in connection with two posts as in the Figs. from 214 to 216. One of these —the one nearer the wall—is termed the shoulder-post, and the other the hind or heel-post. In Fig. 216 both of the posts are carried up and secured to the roofing timbers, being fastened to a runner, a beam or batten which stretches along under the bottom edge of the rafters. One end of each of the posts is slightly checked into a dressed stone with the top just clear of the ground, and the other is made fast to the runner overhead. This makes a strong enough erection, but it offers one great objection in so many posts being stuck up interfering with the circulation of the air within the house and blocking one's view of the byre and its inmates as a whole.

As arranged in Fig. 214, the objection referred to is got rid of. The ends of the posts are sunk about three feet in the ground, and they stand no higher than to clear the uppermost board a little. The hole for the reception of the posts is made large enough to allow the posts to be embedded in and surrounded by a body of Portland cement concrete. This, while it most effectually preserves the wood, at same time gives stiffness and stability to the post. And if the cement be carried up an inch or two above the floor all round the post, the latter will not be likely to succumb to decay induced by wet. It is at the neck of the post that air and moisture together set up decomposition of the wood. Most kinds of wood can resist the attacks of either of these agencies acting singly, but when they combine it takes stuff of the nature of heart of oak or prime larch to hold out against them. The part of the ordinary post, that has been long in use, sunk furthest in the ground, will be found far less affected than that which adjoins the surface. Thus the two extremities, the one buried in the soil and the other exposed to the air, are longer lived than that part of the wood that is half and between as it were. Down in the ground there is plenty of dampness but little air; clear of the ground there is air all round but no appreciable quantity of moisture (it does not get leave to remain long enough to do harm); where, however, the two merge, there is sufficient of both to promote chemical reaction and decay in the wood. This applies, perhaps, more strongly to wood in the open than to wood under cover of a roof, as in the byre. But the conditions are similar in the two cases, only a little slower in the latter. The casing of concrete puts matters on a different footing however. It keeps the buried part of the post quite free of damp, and if continued upwards for an inch or two round the neck, as we indicate, the upstanding part of the wood is out of danger from moisture that may be spilled upon the floor. Not that there is ever much of this about in the byre lairs; it is only, indeed, when the byre is being washed out that there is likely to be any.

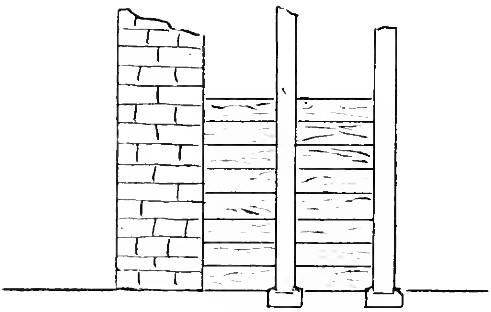


FIG. 216.

Fig. 215 shows a compromise between the two methods we have been describing, but in our opinion a half-hearted one. Sometimes in this modification it is the hind-post that is continued to the roof, but oftener the arrangement is the one illustrated.

The usual Size of the Travis. The customary size of the travis in Scottish dairying districts is four feet long, inclusive of hind-post, and four feet high. Five inches square, or its equivalent if round, is a suitable scantling for the posts. The square hind-post is chamfered (has the corners planed off) something in accordance with Fig. 217. The latter shows, too, how the boards are secured to the post, being let into a groove in the front part of the same. Held thus behind, and butting against the wall at the other end, the boards are effectually prevented from moving backwards or forwards lengthwise; and to keep them equally firm against lateral movement the fore-post is made of two pieces, each five inches by two inches, set wide enough apart to fit close to the boards, as in Fig. 218. It makes the firmer job when the two parts of the fore-post that are sunk in the floor are joined together. This necessitates a piece of wood the same thickness as the travis boards being placed between them. It is an easy matter, once the posts have been fixed, to slip the boards into the groove on the hind-post, and between the two halves of the shoulder-post. And all that remains thereafter to complete the job is to bolt the separate parts of the shoulder-post together and fill up the blank between the two where they project above the top of the boards (as we suggested could with advantage be done with the posts underground). When the fore-post reaches to the roof one half is erected, after which the boards are put in position and the other half of the post fixed up. In this case, too, it may be advisable, though it is not altogether necessary, that the vacancy between the posts be filled up as before. At the bottom of the post there is none of course, the end being coincident with the floor of the byre. What vacancy there is in this instance lies between the uppermost of the boards and the runner to which the halves of the post are attached.

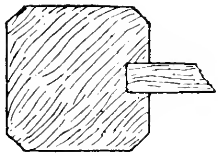


FIG. 217.

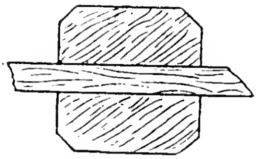


FIG. 218.

Boards from three-quarters to one inch in thickness, supported as above, form a sufficiently strong barrier to separate the cows into pairs. These as well as the posts we would advise, for the reasons already advanced, to be planed on their exposed surfaces; and so, we repeat, would we have done with all the roof-wood surfaces exposed to the byre.

Travises with Iron Posts. Iron posts are sometimes substituted for those of wood, at least as regards the hind-posts. These are provided with strong bases for sinking in the ground and thereby ensuring their rigidity. Flanges are cast on the posts for the purpose of fixing the ends of the boards. The shoulder-posts put to use with these are of wood, either the same as or something after the style of those above described. The shoulder-post part of the travis might be dispensed with, and some contrivance for fixing the boards against the wall be substituted were it not necessary for it to be there as a point of attachment against which to secure the cows. The boards could be so arranged as to be rendered secure and fit to do their part in the way of dividing the byre were they fixed at each end, but something more is needed when in addition they have to hold the cattle in their respective places.

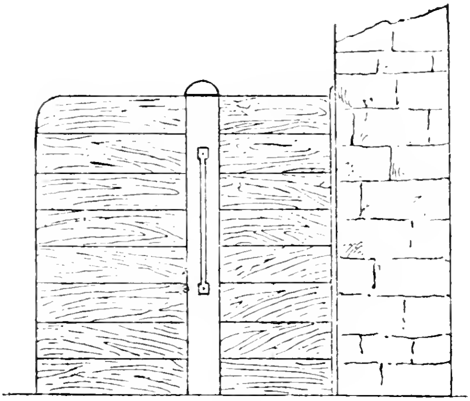


FIG. 219.

We have introduced an arrangement whereby the travis can be erected with a shoulder-post alone, and a most efficient one it makes. Fig. 219 gives the side elevation thereof, and Fig. 220 a horizontal section through the same. The hollow post, it will be seen from the latter, is cast with a slit that cuts it above ground into two equal segments. The boards fit into the slit, their heads at the same time dovetailing into an iron plate attached to the wall. An iron cap, which may be a little ornamental if required, fits on the top of the divided posts and holds the two parts tightly together with the boards between. The bolts which secure the travellers up and down, which slide the ends of the chains that hold the cows to the posts, when tightened up help further to stiffen the erection. Boards a little thicker than those already quoted are needed, seeing that in the absence of the hind-post there is no stiffener at the free end of the travis. Inch-and-half boards are strong enough for the purpose.

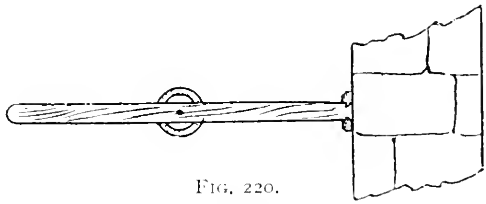


FIG. 220.

A travis of this kind may be more expensive to start with, but it will be the cheaper in the long run. It is one eminently suited to the concrete-floored byre. Given fair play, the iron post may last indefinitely. The wood may need renewing in the course of time, but if the boards are well selected to begin with even this will be a remote eventuality. And another advantage that goes with this travis is that it leaves a little more room for the animals when they lie down. A five-inch post takes considerably more from their bed space than an inch-and-a-half board is likely to do.

A Fodder-Rack seldom fitted up in the Cow Byre.

It is seldom one sees in Scotland fodder-racks fitted up in front of dairy cows. And the seldomer the better, we think. The cows are generally fed in such a way that little remains over from one meal to another. With a rack for ever more or less full the fodder cannot at all times be sweet; and an obstruction of the kind attached to the wall in front of the animals is bound to interfere with the wholesomeness of the building. The air exhaled against the wall we have spoken of as apt to be hampered in the act of diffusion. and some of it ere time has been given it to spread out has been inhaled again. How much worse, therefore, must matters be when a rack is fixed up on the wall not far above the level of the muzzles of the animals as they stand eating therefrom. There is less to say against it when fitted up in a byre with a centre or a side-service passage. It is less in the way there. And where fattening and store cattle, in loose box and court, with plenty of room to spare are concerned, it is almost a necessity. And so too, perhaps, in respect of the tied-up animals which are being fattened. But the milk cow under the straitened circumstances of confinement that apply to her is better without such an adjunct to the byre.

The Air Space of Byres.

So much uncertainty and so many conflicting ideas prevail over the matter of providing a due amount of air space for each of the cows housed in a byre that it is hardly one to enter upon here. The subject is still in the early stages of evolution. Authorities, in their very praiseworthy anxiety to make sure that milk-yielding cows are placed under sanitary conditions in order to be certain that for one thing enough of good air will be at the disposal of the animals, seek to enact that each must have so many cubic feet of air space within the building in which they are housed. But once, as we have seen, that we pass a certain limit in this direction we begin to render the house too cold for the welfare of its inmates. And the limit is usually far under the proclaimed figure. And what makes matters more unsatisfactory is that separate authorities differ over where the limit ought to stand. It is impossible, of course, to fix a limit that will suit all circumstances. What breathing space is little enough for a cow housed among close packed streets or lanes may be quite out of proportion to the wants of another tied in a byre on some upland wind-swept farm. Moreover, on what assumption as regards atmospheric conditions is the limit for any special locality to be based? As the two byres we have instanced are under totally different weather conditions, even more so do the conditions which affect any single byre vary from day to day. A windy day succeeding a calm one renders as much change in the atmospheric conditions of the individual byre as takes place generally between those that affect the former two. The authorities in question are on the wrong lines when endeavouring to mend matters in this way. The right direction lies along the path that leads to a controllable system of ventilating the byres and thereby making them easily adaptable to the continually varying phases of our fickle climate, a point which we have already gone pretty closely into, and therefore need not follow up again.

Before leaving the subject, however, it may be interesting to note what air space each of our respective sections of byres are indicative of. That in Fig. 207, according to the various dimensions figured, affords 543·75 cubic feet of air space to each cow. Section Fig. 208 gives 491·25, and the one in Fig. 209, 686·25. It is evident there is more outcome in a byre after the type of the last one than in the others. Adding to or taking from the width of the separate passages gives us more scope to come and go in than is the case with the other two. They have but the one passage each which, on the one hand, will hardly stand any curtailment without loss of efficiency, and on the other if enlarged much beyond what we have set down simply means a waste of room and more work for the attendants. But with the three passages, and these more elastic, so to speak, than the single one, it is easy to stretch a point and enlarge the cubic contents of the building. A foot more than we have allowed added to the respective passages will not affect them adversely from a working point of view, while it swells out the air capacity of the building. And, similarly, if we add to the space by raising the walls a little more, that which is broadest to begin with responds soonest in the way of increase. This is the one, therefore, that is best adapted both to those places where it is compulsory to have much air space in the byre and to those where some considerable show is desired. It is the one for the suburban dairy, as well as for the home farm perhaps.

The Floor Space.

The floor space of these several byres is respectively 42, 34½, and 44¼ feet to each cow. The floor space, however, is a matter of minor importance. So long as the animals have room, and so long as the attendants are not hampered in their movements, and the building is efficient otherwise, nothing further is required. It is better to provide for air space beyond the customary amount, by heightening the walls, than by putting them further apart than is needed for the general efficiency of the byre.

Byres for larger Cows than Ayrshires.

The byres we have been describing, we need hardly mention, are such as are adapted to Scottish dairying. Cows of the Ayrshire breed are the all-prevailing animals used in that industry. But a byre that suits them only needs to have the travises set further apart and the lairage lengthened between wall and grip, in order that cows of a bigger frame may be accommodated. We do not for a moment wish to infer that those we have been recommending are capable of being remodelled in this way.

They are put together too substantially to admit of that; and they must continue to house the same class of cattle that were in view when planned and constructed. Concrete floors, once they have become firm, cannot be cut and carved to suit one size of cow one season and a different one at another. If erected according to the rules we have laid down, the cattle will have to be adapted to suit the byres, not the byres to fit themselves to varying sizes of animals. The houses will not permit intermittent modification of beds. There are big and little, ill-favoured and good, specimens in all breeds, of course. The conformation of the byre, however, will cope with this without annoyance to man or inconvenience to beast.

But it is different when we take other breeds, either larger or smaller, into account. A smaller breed we may leave out of count, not forgetting, all the same, that it is necessary to lodge the young females in quarters adapted to animals of their years. They may be allowed to go loose in a shed during their first winter, but in those that intervene between that stage of their existence and promotion to the byre proper (other two, say) they are ranged in line similarly to their elders. Thus we have two supplementary byres in connection with the main building of the kind. The two may be in one, or, what is the same thing, one building may be arranged with lairs of two sizes, one to suit the younger lot and the other the more advanced heifers.

Byres for Fattening Cattle.

Larger breeds are the exception where dairying is concerned, but the animals which are tied up for beef production in nearly every instance need more room than is allowed the national dairy cow. It is only, however, in few parts of the country that fattening animals are tied by the neck. In Scotland, Aberdeenshire and the adjoining counties are perhaps the only places where it is practised to any considerable extent. Elsewhere they are privileged to go loose either in court or box. There is little to be said against the tying up of heifers during the fattening process, but when it comes to bullocks being thus managed it is usually a dirty business. With them the flat beds we have been advocating would prove a snare. The constant dribble they maintain, if not drained away quickly, makes a sad mess of the litter they are supplied with.

Variance in the Methods of Housing Fattening Cattle very much a Matter of Custom.

It seems, as we have already pointed out, nowadays very much a matter of custom, this variance in the manner of housing beef-producing cattle, that marks one district from another. And the reasons that have brought about these differences of custom seem to us to have been, on one hand, the amount and kind of fodder, or rather litter, available, and on the other, the house accommodation at disposal. Where straw was abundant and not all of it fit for fodder, it could never all be converted into farmyard manure unless it were trodden under foot by cattle in open courts. Where all the barley straw and what of the wheat straw that could not find a market, which, we daresay, in earlier times than the present, meant the whole of it, was made into manure of a kind, the oat straw, ere it reached that stage, had first to serve as food and run the course of the alimentary canal. Where straw was less abundant, and where oats was the principal, if not the sole, cereal crop of the farm, and, further, where farms were smallish, the open court was found too wasteful an institution, and recourse was had to closer confinement of the cattle. Failing loose-boxes, which imply more building than suffices for byres, no other method remained but ranging them rank and file. Customs die hard, and now that different conditions apply than when they came into force, they still stick to their respective places of origin. The loose-box is perhaps less urgent in its demands for litter than even the byre, and the dung formed in the one is superior to that derived from the latter; at least, there is less chance of waste in the box manure, which need never be exposed to sun or rain until the time is opportune for its conveyance to the fields.

The Loose-Box Advantageous.

The wants of the cattle are unquestionably more easily attended to in the box than in the byre; but then, as already remarked, more space is needed in the box than in the byre system of treatment, and, consequently, more building material is needed. The fittings proper of the box are certainly less expensive than those of the byre, but the enclosing shell of the former is much the larger of the two, and if well constructed, the floor is no less expensive, while it, too, is bigger. Once, or at most twice, in the season have the boxes to be cleaned out, whereas the byre lairs have to be attended to twice or thrice a day. More ground has to be traversed by the attendants on animals in boxes, seeing they are thinner on the ground than is the case in byres, but this distinction is perhaps a little fine drawn. At any rate, few, we think, will dispute that the loose-box is preferable to the byre for the accommodation of cattle undergoing the process of fattening. When the byre is still observed as the field of operations in beef producing, it is either because boxes are denied by the proprietor, or through force of habit the farmer prefers the byre, and expresses no wish for a change of system.

On Plan I. a range of loose-boxes for cattle forms the west side of the square. Besides this, however, we have a set of open courts south of the homestead, and completely detached therefrom. We have set down only a single row of boxes. There is no reason, however, why the row should not be doubled if increased room is imperative. There are ten boxes in the row, each twelve feet square, and capable of holding two animals and two root-houses, one towards each end of the block. One or either might be dispensed with perhaps, but to have both would be advantageous. The upper one would serve the byre that connects the head end of this range with the barn as well as the boxes adjoining it. Or if pulping of roots was exclusively practised, the shed in the angle could be used as a subsidiary store for straw, being filled up on thrashing days. Yet again, if both pulping and "chaffing" were the rule, the building in question could be set to serve as a temporary store for the different stuffs so treated. It is there, too, on account of its position, well fitted to serve the ends of a calf-house should such be in demand. As for the one at the end of the range, should it not be considered necessary, there are many useful purposes it can be put to if its space is not thrown into a continuation of the boxes. We are not, of course, tied to the size of box mentioned. By widening the house a little we can make them large enough to accommodate three animals each.

The Arrangement of the Loose-Boxes. As the boxes are represented on the plan, they are ranged against the back wall of the building, a service passage, four feet wide, running the whole length thereof in front of them. The frontage of the boxes and the partitions as well are almost always of wood. The front is sometimes formed of boards within touch of each other. At other times it is

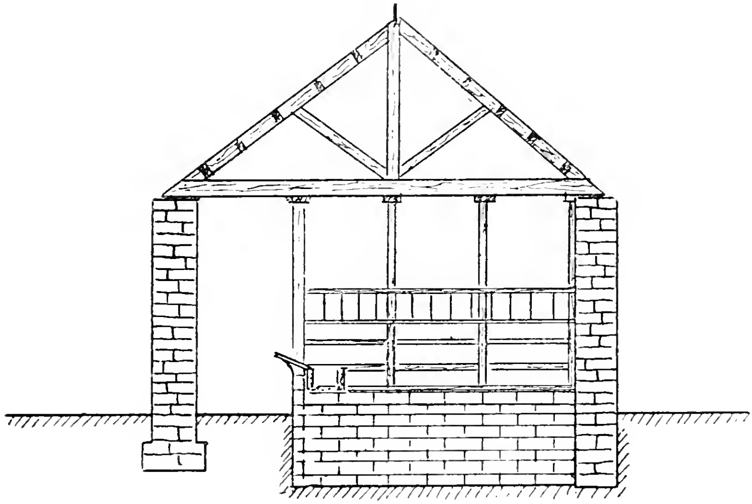


FIG. 221.

formed of stout rails; and nearly always the partitions are constructed in like manner. Either a gate or door is necessary in the front, and also some form of shoot or inlet in the same, through which the feeding-trough within can be replenished. A fodder rack is also a necessity. It is possible to arrange the racks so that one can be common to two boxes. These can be filled from the passage, and one big one is easier attended to than two small ones, with the same joint capacity.

Their Manner of Construction. The floor, as Fig. 221 will show, is at a lower level than the service passage on one side and the general level of the outside ground surface on the other. This is necessary to allow for the gradually accumulating litter as it becomes trodden underfoot by the cattle. The floor of these pits, as we may call them, and that of the passage we would lay with concrete—the concrete of the passage floor to withstand the wear and tear incidental to the working of the place, and that of the boxes to prevent the liquid matter of the box-made manure from being absorbed by the subsoil. The floor of each box is cut off from those adjoining it by means of brick-built partitions carried up to the level of the passage floor. Above that level, because then pretty well out of reach of the dung, wood makes an efficient division. One or more supports for the dividing rails (which at one end are secured in the wall and at the other to a post in the front line) can be in the line of the partition, their ends sunk far enough below the level of the floor to give them stability, and, like the travis-posts above, well safeguarded with concrete from the soil up to above dung level. The inner sides of the back walls of the boxes would require to be plastered with cement as far up as the top level of the brick under-partitions, this coat of plaster being merged into the concrete of the floor. There being no way of escape for the fluid at the other sides of the pits, the same precautions against leakage need not be observed. That next the walk would, of course, have to be faced up either with stone or brick.

But Fig. 221 further shows a better method of fitting up the wood part of the divisions between the boxes. A wall-plate is laid on the brick partitions, and uprights attached to it at foot and to runners overhead fixed to the principal rafters. These uprights give support to the crossbars of the division. Finished thus, all woodwork sits clear of the manure.

The walls and roof of the loose-box range we would have constructed on the general lines we have been advocating. With regard to the former, however, it would be of great advantage were there doorways formed in the back wall—one opposite each of the boxes—for the purpose of loading the accumulated manure directly into carts. These are not shown on the plan, but all the same their presence in the completed building would render it much less exacting of labour.

The place would be lighted by way of the roof. Dead-lights would, however, be sufficient in this instance. Fewer than usual would be required because subdued light is more conducive to animals settling down peaceably than a full glare is. We do not advocate semi-darkness, but a medium state of light.

But as many ventilators would be required here as in any other of the buildings containing live stock, and preferably of Craig's pattern. And in the front wall we would have a series of the wallhead openings described on p. 139. When doors are in the back wall there would be little need for these wallhead openings at that side of the building; but failing the former, we would be inclined to have them there, too.

On Fig. 222 we show an elevation of part of the front of the boxes as these face the passage, finished in like manner to the partitions. Sometimes, as we have said, the front is closely boarded, but for our part we would have it railed as depicted. Less wood is then required, and the end equally well attained. Unplaned wood generally does service in this connection, but here, as elsewhere about the homestead, we have the woodwork made smooth of surface. Estate-grown timber, if available and of a fitting quality, properly prepared, would here come in as a very suitable substitute for imported wood. Larch, Scot's pine, silver fir, and spruce would either singly or together make efficient fittings for the boxes. But then, as already hinted, in the absence of proper facilities on the estate, which is the rule, taking the country as a whole, imported converted timber is cheaper than the home-grown article.

It is essential that the feeding-troughs be so fitted that they can be raised or lowered in accordance with the amount of manure there is in the box. This can easily be managed by having the boxes in a frame, the latter fitted at each end to a vertical post in such a way that it is capable of a certain amount of play up and down its supports. Holes at fixed distances through the parts of the posts on which the frame is movable, and pins to insert therein, give us a ready means of adapting the height of the troughs to changes of level of the floor of the box. There is nothing to hinder fireclay troughs being fitted up in the manner hinted at. One, of course, is requisite for each animal the box is supposed to accommodate.

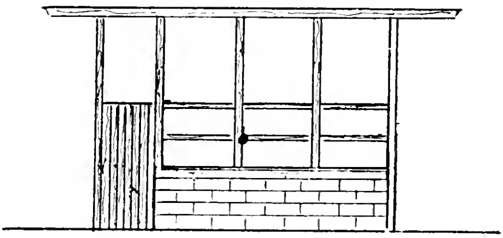


Fig. 222.

It is hardly so practicable to make the fodder-rack on the same shifting principle as the troughs, but that is a less important matter. Only for the first week or two after the manure has been removed out of the boxes will the cattle have to stretch very far up in order to draw fodder from it. Gradually, therefore, will they be able more easily to avail themselves of the contents of the rack; and by that time if all is going well with them they will be lazier, and not so disposed to expend exertion in reaching for food.

Supplying Water in the Byres and Boxes.

We have said nothing in respect either of byre or box with regard to supplying water to the cattle confined therein. To lead water directly to the several animals in their winter quarters is easy enough, no doubt, where the expense is not considered; but it seems a little out of place in connection with the types of homestead we are dealing with in these pages. Doing this implies so much extra outlay to start with, so considerable a cost both in money and attention in the upkeep, and withal the results are usually so disappointing, that we think it almost unnecessary to discuss the matter. With enough of roots at disposal cattle have little need for water when in confinement. At the dairy farm, where roots are scarcer than where fattening cattle are concerned, the cows are daily turned out to water, but generally as much for the sake of a little exercise as on account of necessity.

How the Single Row of Boxes may be Doubled.

If the single row of boxes should be considered rather short measure, it is, as we have said, a simple business to double the same as on Fig. 223. Here we keep the service passage in the centre of the building, and have a row of boxes the same as before on each side of it. A double house of the kind is certainly easier worked than a single one: and its

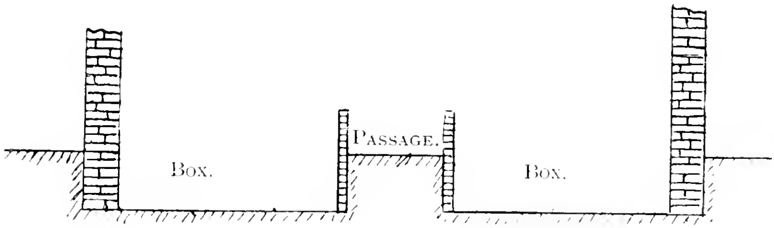


Fig. 223.

erection costs less in proportion than the narrower one. The same number of boxes are easier attended to in the matter of food supply when arranged along both sides of a passage than when strung out along one side thereof. Some readjustment of the root-sheds would be necessary, and also an access through from the outside to the passage for the purpose of conveying straw or hay thereto. Doors communicating with the boxes would then be in the side wall next the courtyard as well as in the outer wall of the building. We sometimes think if the cattle in the boxes were bedded with roughly chopped straw, how easily the resulting manure could be removed from them when emptying-time came round! How easy too would it be to spread manure of this nature when deposited on the land!

CHAPTER XIV.

Buildings East of the Barn.

The Power or Motor-House.

These to begin with until the angle is turned we set apart as the power or motor-house, the implement-shed, and the hospital or loose-box for animals out of sorts. The first-mentioned is continuous with part of the shedding built against the barn, and, on the other hand, it is more or less in touch with the implement-shed. But these are details which will evidently be ruled by the form of motive power that circumstances render adaptable to the requirements of the homestead. Alongside that part of the barn, however, one would naturally think was the most suitable place either for engine or water-wheel. The room we provide is, no doubt, scant enough for the old-fashioned horizontal boiler and detached engine to which we have referred. But it is very unlikely that in these days of oil-engines, and when the application of electricity and condensed air to country work is beginning to exercise the minds of engineers we shall see many more of these cumbersome installations of power introduced at homesteads. At any rate, we have left no space on our several plans for their accommodation. There is room and to spare for the oil-engine in the portion of the range set apart for storing the source of power. There is room, too, for an upright steam-engine if such be selected, and for a subsidiary boiler as well if steam be wanted for cooking and cleansing purposes—for steaming food, or bringing water to the boil, and for scalding dishes in the dairy, and so on. And should a traction-engine be in use on the farm, there is ample room for it to back in and set to work alongside the barn. In the event, too, of the feasibility of leading water past the homestead and deriving power from it there, it could be led through the part we are discussing as easily as elsewhere: and the wheel, whether of the ordinary type or a turbine, could be housed in the space we are referring to. Besides, it is easy to encroach on the implement-house a little should more room than is shown be required for power-giving.

The placing of the Doorways thereof.

The arrangement of doors and partitions would, of course, largely depend on the power that was in force, and might in consequence differ from that shown on the respective plans, because no plan can be adaptable to all manner of conditions. It might, for instance, be essential to separate completely the power-house from the implement-shed. As laid down, however, the fact of the two being mutual, as it were, enlarges the scope of both. It would be a convenience to have a way of communication between the barn and the motor-house. This, in fact, is almost a necessity, and ought to have been referred to under the head of The Barn Range. It could be placed near to the feeding-board of the mill, and thus be free of interference with the storage of sheaves. The doorways of the implement-shed all lead to the courtyard, but so long as this place is common with the outer portion of the motor-house, it has communication with the roadway between the north side of the homestead and the rickyard. It might, of course, be a convenience to provide the implement-shed with a big door of its own at this side, especially should it be separated from the motor-house; but we would not recommend one. The majority of the implements are not housed during the season they are called into action, and it is no hardship having to take them round by the yard twice or so in a year. There might, however, be one in the partition dividing the hospital from the implement-house for the purpose which we will hereafter mention.

The Floor of the Motor-House.

The floor of the motor-house we would have made of concrete as before; and we incline to recommend the same in the implement-shed. The latter might, of course, be done off with gravel or with sand, but this is a house that is capable of occasionally being devoted to some temporary purpose other than its original one. We have not hitherto referred to any places about the homestead wherein sheep could be dealt with at such times as dipping and shearing occur. This shed, we consider, might easily be set to fulfil this end as well as to protect the implements of the farm from the effect of weather when not in use. The implements that were in store could readily be drawn out and left to take their chance for the short time the shed was required for handling the sheep. Those that might take harm from exposure could be run in temporarily somewhere else.

The Implement-Shed.

The implement-shed, as so many of us know, is not a usual accompaniment of the homestead. It is full time now, however, that it be considered an essential part thereof. The various implements concerned in the work of the farm are both more complicated and more expensive than they used to be, and it will not do to leave them outside exposed to the elements as, until lately, was so often the case. The implements of tillage are, perhaps, not very susceptible to damage due to the effects of weather, but even they—the ploughs, harrows, grubbers, and rollers—are surely more lasting if kept under roof when not in use than if left alongside some fence among long grass and other rubbish. If they are the better for shelter, how much more will the implements that have to do with seeding and the still more complicated machines that take part in harvest operations repay attention of the kind! We give the carts a fixed place of shelter at the homestead. The cart-shed has always been a well-known building in the group. In future, therefore, the implement-shed will have to acquire an even more important position among the buildings. It speaks ill for proprietor and occupier alike to see a self-binder, for instance, huddled into some odd corner of the buildings, a prey to damp at one time of the year and to dust at another, and all through liable to be speckled by the poultry by day and by the sparrows by night. Worse still, is to see one housed where the mixing of artificial manures is in full force. It is bad enough when the manures are merely being stored in the same place until the crop or the ground is at the proper stage for their reception. Then, even, the close presence of so much stuff, most of it highly charged with sulphuric acid, is detrimental to the machine; but when mixing proceeds matters become much worse in this respect, and although noiselessly accomplished, more tear and wear results to the machine therefrom than can happen to it during its short season's work carried out under ordinary circumstances. There are men, it is true, who, if supplied with proper accommodation of the kind, will not think twice about turning it to account in some other way—withdrawing the implements and stocking the shed with pigs, it may be. But the many need not be victimized on account of the few.

Other Purposes to which the Implement-Shed and the Hospital may be occasionally put: the Dipping of Sheep for instance.

We ourselves are advocating the adoption of this shed to other than its original intent, but only in a mild and very temporary fashion. A day or two now and again (twice or thrice a year) would be all we would make requisition of. Constructed, however, as we would have it, no harm would result either to the building or to the implements from the occasional short turn aside from its regular sphere of usefulness. The floor being hard and smooth could speedily be got rid of all traces of the presence of sheep thereupon, consequently no harm need afterwards come to the implements on that account.

In order that full advantage could be taken of the building in its combined functions of implement-shed and occasional house for the handling of sheep, it would be necessary to construct a dipping-tank somewhere in the floor. Our idea would be to have it where we have dotted it on Plan I. In that position it would be possible to pass the sheep direct from the tank into the hospital, making the latter serve for the time the purpose of a dripping pen. The dipping-tank, being sunk below the level of the floor of the shed, would offer no obstacle to the full use of the shed for the storage of implements. The tank and the side pits would be covered with close-fitting boarded lids or hatches when not in use, hence their presence in the building would offer no impediment to the moving about of implements and machines on the floor.

Arrangement of the Inner Doorways of this Range.

We are rather against the idea of having a door in the partition that divides the hospital from the implement-shed. The door proper of the former we have placed in the outer wall of that corner of the homestead, so as to render the isolation of the place as complete as possible. The making of an additional one, however, rather mars the isolation of the house; but not, we daresay, to any very serious extent. This extra door is certainly not far from the door of the adjoining loose-box, but when the shed doors are closed there is little chance of the occupant of one box being influenced by the one pertaining to the other.

Too many Inner Doorways Often a Source of Danger during an Outbreak of Fire.

It is well to remember in this connection that so many doorways leading from one building to another are all additional sources of danger should an outbreak of fire take place. But one is hardly justified in letting fear of that rather remote contingency override the matter of convenient, and therefore economical, working of the group of buildings. There is nothing, of course, to prevent these casual doors, such as the one last referred to and those giving access to the barn from the wing at each side—from the byre at the west side and from the motor-house on the east side thereof—being made of stoutish sheets of iron attached to a wrought-iron frame, something after the style of Fig. 224 or 224A, according to the width of the opening. Doors of this description would effectually check the passage of flames from one building to another by way of these openings in the wall. Only where there is a break in the roof, however, is there likely to be much chance of fire being arrested once it has caught hold effectually of any separate portion of the homestead. By a break in the roof we mean

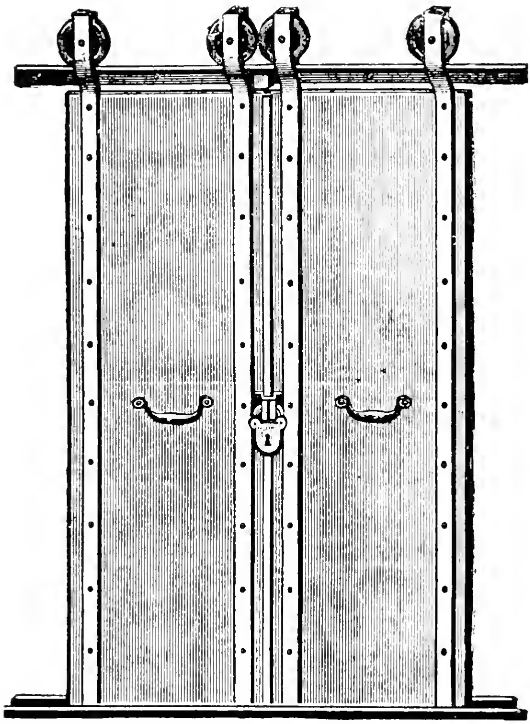


FIG. 224.

either where a partition is carried up clear of the slates, or where it stops against a higher wall without communicating with the roof in connection with the latter. We have an incomplete example of the latter at each side of the barn range, where the respective one-storey buildings run into it at right angles. These two roofs are a little too high for their ridges to strike the barn beneath the level of its wall-head, therefore the roofs of all three communicate slightly. But, as we remarked at an earlier stage, breaks in the roofs of the homestead mean weak spots in defence against the elements and places that are difficult to keep in repair; and we took credit for a minimum amount of these being shown on our plans.

The Outer Doorways of the Implement-Shed.

As regards the outer doors of the implement-shed—those communicating with the courtyard—nothing beyond what will indicate that there is no right of way within, no admission except on business, is called for. Air is to be freely welcomed within, but rain and trespassers generally to be hindered entrance. A sparred door will do; but, better still, one constructed of a light skeleton framework, with small meshed wire netting tacked to the face of it. This will keep men, beasts, and birds from gaining admittance (unless, indeed, the first two are not averse to use violence), and nothing further is required. It could not turn rain very effectively, but on account of their sheltered position in the corner the doorways would rarely be affected by rain.

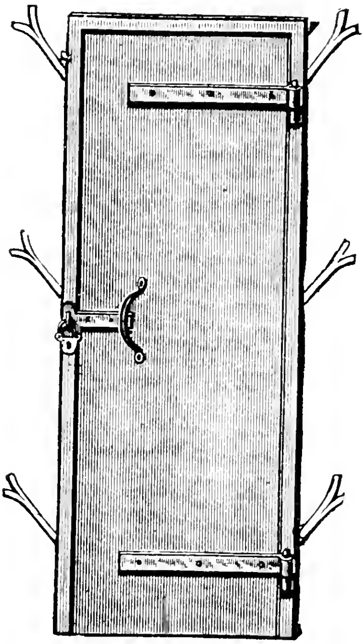


FIG. 224 A.

The outer Doorway of the Motor-House and of the Hospital.

Something more substantial is essential at the outer doorway of the motor-house; and also at the north side of the implement-shed should it be decided to have an opening therein. At each of these places a good stout door, framed in accordance with the size of the opening, and hung from the top on wheels, would be the suitable finish. And the hospital door, the one leading to the outside of the courtyard, would be such as we show in Fig. 120, p. 126. This is divided horizontally into two, the under portion being made the larger. The horse, if not so inquisitive as the ox and the sheep, is equally loth to be left in isolation; and the door in question, when the upper part is undone, enables the animal to get its head out and have a look about, if nothing further. It admits of this and also insures a sniff of fresh air when sought for, while at the same time it retains the animal in its allotted quarters. The two parts of the door open outwards. The fastenings are on the outside of the door, and it is well to take care that the one which secures the lower part is of such a description that any knowing old horse is not able to undo. Some of them have a wonderful knack of opening gates and doors.

The Roof of these Buildings.

The roof of this range we would continue on the same principle of construction as before. It might, for the sake of economy, be made a couple roof, but the difference between the two is so small that we would stick to what we started with. And, as before, we would have all the exposed surfaces planed smooth. We would have it ventilated as usual, using the zinc ventilators shown on Fig. 141 for the implement-shed, and that represented on Fig. 143 for the motor-house and hospital. Here, too, we would have all the lights in the roof. Dead lights would do for the implement-shed, but opening ones would be an advantage in the other places we are dealing with.

The Roof of the Shed Supplementary to the Motor-House.

The roof of the shed which forms a continuation of the motor-house would, perhaps, under some circumstances, almost require to be slated to ensure any degree of permanency. We have spoken of the sheds that lean against the barn at each side as being roofed with galvanized corrugated iron. But if this part of these sheds happened to contain either an oil engine or a steam engine, galvanized iron might not be a suitable material to cover it in with. Escape pipes and miniature chimneys of some sort or other are certain to be carried up through the roof, and the proximity of fittings of this kind is very prejudicial to iron roofing. The galvanizing will keep intact for a long time provided it get full play, but when in touch with iron pipes that jut through the roof and at times are pretty hot, the zinc near thereto soon succumbs, leaving the unprotected iron sheeting a ready prey to the elements. What is emitted from these outlets is also trying to the zinc upon which it falls. Iron roofing, therefore, is not a good material to use at places where it is liable to receive much soot from chimneys, or the ejected matters that more or less emanate from the escape pipes of either oil or steam engines. Where pipes are projected through the roof, and where the roof is liable to receive emissions from these, it had better be covered with slate. But head room here is limited, and slating hardly practicable, consequently the most would have to be made of matters as they stood.

The Sheep-dipping Tank.

The sheep-dipping tank being by way of convenience in handling the sheep, and in this instance, for sake of being out of the way when not in use, sunk with the top flush with the floor of the shed, it is requisite that a pit, in which a man can stand, so as to have command of the tank in so far as being able to reach easily from one end to the other, be formed at each side thereof. Fig. 225 shows a plan of the tank and pits, which may be considered in its relation to the implement-shed and the hospital, as ticked in on Plan I.; and Fig. 226 is a cross-section of the tank and pits.

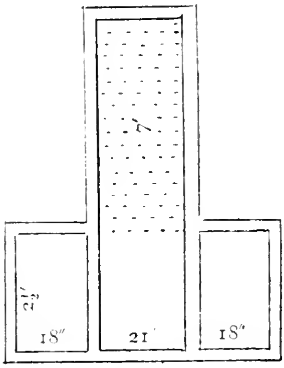


Fig. 225.

Sawn slate or flag makes an excellent tank. Good ones of a small size are now to be had, made of glazed fireclay, as in Fig. 227. It is so difficult, however, to bake articles of this nature without their becoming twisted during the operation, that large sized ones manufactured out of this material are hardly to be looked for. But with brick and cement as good a tank can be constructed as need be wished for. If enamelled bricks are used to line the interior, a smooth and easily cleansed surface is obtained. These are, of course, much dearer than ordinary bricks, but not very many are required, so this extra need hardly be questioned. Only the end and the sides are built with brick. Concrete does for the bottom of the tank proper, as well as for the sloping continuation of the same that leads up from the tank. This part, if grooved, as in Fig. 225, allows the sheep foothold as they emerge from the dip stuff, without hindering the return flow of the liquid as it drips from the sheep.

The Dimensions of the Tank. The breadth of the tank need be no more than will admit a full-sized sheep easily, without, however, its being able to turn end for end therein. Very little, indeed, suffices, for a sheep is not very broad. In length a little more room has to be given. The sheep is introduced feet upwards, and when liberated its position is reversed and its forefeet applied to the inclined plane which ascends from the bottom of the tank. This slope, it will be seen from Fig. 228, which is a longitudinal section of the tank, serves to lengthen the tank. The fuller the tank happens to be filled the longer it becomes. There is no use, therefore, in having the level portion of the bottom thereof any longer than will serve easily to dip a sheep when the tank contains sufficient of the solution to cover the animal effectually. If the exit be made too steep, it causes a great strain on the animals as they struggle upwards under the heavy burden of their moisture-laden fleeces. A suitable relationship of the various sizes would seem to be something like what we have figured on the plan and sections.

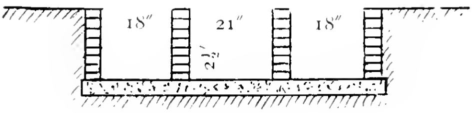


Fig. 226.

The pits need be no longer than the level part of the bottom of the tank. Past that the shepherd at either side can when necessary reach far enough to guide the animals clear of the tank as they flounder and stagger upwards. And otherwise the trench, if so constructed, affords him room to grasp the unwilling sheep and drag them forward to undergo the ordeal of the bath. We show the tank twenty-one inches in breadth, and eighteen inches is a suitable width to make the pits or wells. The latter may be faced up at sides and ends with brick neatly

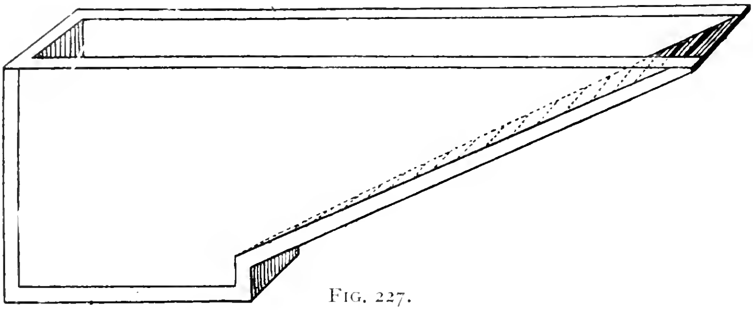


FIG. 227.

pointed with cement, and be bottomed with concrete. The coping of the sides of the tank may be worked out of concrete, and be very efficient. But we prefer a finish of wood there. The men press on the cope as they bend over the sides of the tank, and a surface of wood is less severe on their bones and muscles than one of such a hard material as concrete. Stone is not very suitable for the purpose. It is quite practicable of course to have a portable wood cope on either side, which is, perhaps, the preferable plan. At that rate the top edge of the sides of the tank finishes with the brick (or slate or concrete, it may be). And when the tank is about to be used, the wood cope

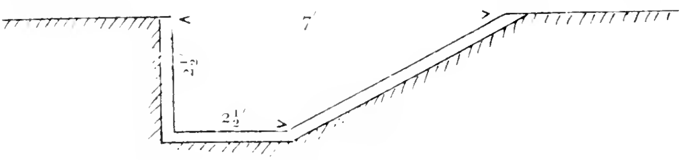


FIG. 228.

can easily be adjusted in position by means of clips, which embrace the bricks (or other material) and hold it firm. The movable cope, when lifted, enables the lid or hatches to fit down close on the top of the bricks when the tank is not in use. The sides of the tank—that is to say, the portions dividing it from the walls or pits—we have set down as being nine inches thick. Four-and-a-half or single brick thick might be sufficient, but it is better to err on the safe side, and have the bath sides strong. Besides, the broader the cope the easier is it on those who have to bear their bodies against it as they stretch over. Should the tank be constructed of some other material than brick the thickness of the sides will of course be governed by the nature of the material.

A Drain from the Bottom of the Tank almost Necessary.

One drawback there is in having the dipping tank in the floor of the implement-shed, and that as regards the draining away the liquid both from the tank and the wells. Their efficiency is much impaired where this is impracticable. It is possible at any time to bale out the liquid contents of either place, but this is a tedious process when they have to be carried away to a suitable place of disposal—at some distance more than likely. Not that there is any chance of much liquid ever finding its way into the pits, unless what happens to be spilled therein. The bottom and sides of each are watertight, therefore no water can leak in from the soil, should it be of so wet a nature as to render this possible, which is hardly very probable. In the tank there is a residue of the solution left after every occasion of dipping, as much indeed as sufficed for the immersion of the last sheep. It is not perhaps necessary that the tank should be emptied at all times after use, but if not done so pretty frequently, what remains therein is sure to be offensive on account of what has returned to the tank in company with the drippings from the fleeces. From the same cause it is bound to have lost much of its original efficiency. It is evident, therefore, that in order to derive full benefit from the tank, it requires to be provided with a drain that will serve to empty it completely of its contents when this is desired.

The Formation of the Drain.

The forming of the drain need, however, be no serious obstacle against the construction of the tank. This can be kept in view when the foundations of the shed are being laid, and a passage accordingly be left for the pipes beneath the wall. The laying of the pipes would precede the formation of the floor. We have been condemning any but surface drains in the several buildings of the homestead, but this is one of the exceptional cases, and with due care the drain under notice can easily be rendered innocuous. The drain will be in service only some three or four times in a year, and although there is a large proportion of animal excrement in what flows through, it is pretty well disguised in the constituents of the dip, and not at all like what passes from the byres. A three or a four-inch fireclay glazed spigot and faucet pipe drain carefully jointed in the manner already mentioned answers the purpose well enough. This, communicating on the one hand with the bottom of the tank in such a way that the latter has a clear drop into it, and on the other led clear of the building, is an easy matter to see through, and all that remains to make it harmless so far as being a nuisance goes is to fit it with inspection eyes and a disconnecting trap. The latter shuts it off from the drains outside the building, or at any rate from the one it is joined to. Shut off is hardly the right expression to make use of. It is shut off from the outer drain only in so far as gases are concerned, not, however, in such a way as to interfere with the passage of water from one drain to the other.

How it may be Trapped.

A trap of the description of the one shown in Fig. 229, which is known as Buchan's trap, is a proper one to use in a situation such as the one in hand. The diagram almost explains itself. Any gases that originate in the outer drain fail to get past the water which lies in the hollow formed by the bottom of the trap. But water coming from the inner drain flows easily through the trap into the outer drain. The water that flows in at one side of the depression forces the water that lies therein over the other side into the escape drain, and thus the flow is maintained. And so long as there is water contained in the trap—sufficient to keep the tongue *a* immersed a little—gases cannot escape that way. But the trap offers no obstruction to the entrance of air into the inner drain *b* by the opening *c*. It is so arranged, in fact, as to encourage the passage of air through the same.

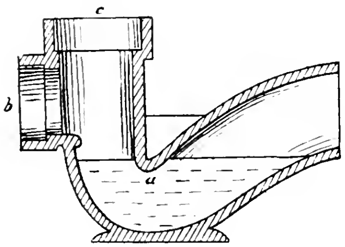


FIG. 229.

Traps of this kind were invented to prevent the access of gases from the outer drains or sewers into the drains that empty into them from dwelling houses. The soil pipes or inner drains are fitted with shafts that are open to the atmosphere, which have the effect of maintaining a constant through current of air from the trap to the outlet of the shaft, which is usually well up on the roof, and clear of windows and other openings into the house.

A trap of this kind, therefore, shuts off communication between the outer and the inner drains so far as gases are concerned, while it in nowise interferes with the flow of water from one to the other. Consequently it is well adapted to the end we have in view of breaking communication between the outer drains and the tank. In this case, however, there is no need for a shaft leading from the head of the inner drain to the outside of the building. The drain will be short, and what it affords delivery of is not of a fermentative nature like the stuff that pertains to house drains, hence there is not the danger that follows the latter when they are either faulty in construction to begin with or allowed to get out of order. We would, in fact, let the outlet of the tank communicate directly with the drain. A bent pipe could be made to join the two, the faucet thereof being made flush with the surface of the concrete bottom of the tank. There would be little chance of leakage from the tank were the pipe thus embedded in the concrete. And a wood plug or a good-sized bung inserted in the faucet would keep the contents of the tank from escaping down the drain. A bent pipe arranged similarly would serve to keep dry each of the pits or wells, the mouth being covered by a grating of some suitable sort. A three-inch pipe drain, or at most a four-inch one, would be of ample size. An inspection eye attached to the drain close to the last of the junctions of the pit drains, continued to the surface of the floor, would, together with the "Buchan" trap outside the building, enable one at any time to see if the drain was clear between these two points. And the inspection eye would serve to do the same with regard to the continuation of the drain, both to the tank and to the two side pits. The air would be at liberty to course through the drain from the trap to the three openings inside, but that would be no drawback in a building such as the implement-shed. It is an action that ought, indeed, to be encouraged, therefore the hatches that cover tank and pits need not be very close fitting. The three places will keep all the more wholesome the brisker the air circulates through them, and the implements will not suffer from draught.

How to Deal with the Effluent from the Tank.

The drawback connected with this drain does not, as we have said, lie in the part we have been dealing with. It lies more in what has to be done with its effluent. What it discharges is almost always of an extremely poisonous nature. Some few sheep-dips are non-poisonous, but the great majority of the dip solutions are too dangerous to be left exposed about the homestead. The waste substances from the dipping tank require to be disposed of somewhere out of reach of the live stock of the farm. It does not do to let them into the other drains about the homestead if that can be avoided. Indeed the drain where we are planning it will be deeper than the other drains, therefore it will be impracticable to lead it into them, at least to those near to it. But all depends, of course, on the configuration of the ground. Failing, however, any suitable means of disposing of the stuff, it is sometimes practicable to lead it into a hole or well filled with stones, through which it may percolate into the subsoil, and in that way be got rid of.

The sheep-dipping tank is sometimes constructed on the principle of making the sheep walk through it in single file. When this is the case both ends require to be inclined planes. But it is only at the big pastoral farm that this occurs. At the homestead we are dealing with the handling of sheep is on a much smaller scale. The numbers are comparatively so small that they can be accommodated within the buildings we are referring to, which is a considerable convenience. When the dipping place is situated away from the homestead there is none of this trouble with regard to drains that we have been discussing. It is easier on the hillside or on the rough ground of the farm to let loose with impunity the lees of the dipping solution than it is within the immediate precincts of the homestead.

The Hospital.

The hospital is intended for the reception of any animal that shows symptoms of being out of sorts, and which it would be desirable to isolate until its trouble could be declared. It is advantageous to have a place of this kind in which to house an animal suffering from some contagious malady away from contact with its fellows: or one that is under necessity of being lodged in quarters out of touch with the stir of the homestead. The finishing and furnishing of the hospital is on the same footing as applies to the loose-box succeeding.

The Loose-box. Following up our present group of buildings and turning the corner, we come to another loose-box for horses, either young or old—a place meant to be of general convenience in this respect. The doorway thereof is next the court-yard. The floor of this place may be either of rough-surfaced concrete or be paved with suitable hard clinker bricks. It is not usual to provide for drainage from the horse loose-box. The litter is generally plentiful enough to absorb the urine voided by the animals, so that there is seldom any fluid matter to be led therefrom. But if provision be made for this, no underdrain should be laid. Let the floor be laid with a hang to the doorway, or, better perhaps, to one of the corners, so that liquid will trickle there and make its escape, a pipe being led through the wall at the latter place a little below floor level. An underground drain is a dangerous contrivance to have in a place of this sort. There would never be sufficient fluid to cause a flow through the drain, and in consequence the pipes would very soon get so full of semi-fluid matter that the channel would be incapable of acting when liquid did find its way to the inlet thereto.

Very few fittings are required in this building. Two fireclay troughs built on brick foundations, one at each side of the doorway close up to the corner, and a fodder rack between it and the door, comprise the lot. The rack may either be low set with its top on a level with that of the trough, or it may be attached to the wall pretty high up from the ground. It matters not very much which plan is adopted. The former, however, allows of the tying up of an animal at an odd time when stall room is scarce. And a horse feels more at home tied to the front of a manger (which the former arrangement corresponds more closely to than the other) than it does to a ring fastened to the bare wall. The loose-box thus fitted is capable of housing a single animal or a pair of young ones.

The door we should have made on the same principle as for the hospital. The building would, of course, be open to the roof; and the wood thereof, as hitherto recommended, planed smooth. Dead-lights in the roof would be effective enough—one being in each side. One ventilator of the pattern shown in Fig. 143 we would have on the ridge, and we are done.

The Hay House. Next in order comes the hay house, which is even simpler in detail than the last mentioned. A concrete floor, one dead skylight, a zinc ridge ventilator, and two sliding doors are all that we need enumerate here. The wide door at the back is to allow of the tipping up of cart loads of hay within the place. This might, without blame of extravagance, be supplemented with a narrow one in front to admit of an occasional armful being taken out at the courtyard side of the house. The doorway leading into the stable is, of course, put there to place the hay house in direct communication with the stable, for the convenience of serving which it has its position as indicated on the various Plans. The wider door we place at the back of the house, as there being nearer to the rickyard than it would be at the other side. Were we to have it at the courtyard side one outer door would suffice. Indeed, the suggested front one might be dispensed with, and any hay wanted in the courtyard be carried through the stable. But we prefer the additional door. The back door, we may say, we have in view to work in unison with a special hay shed large enough to supply the wants of the stable, can such be got. Ranged alongside that building, or, better even, end on to the hay house door, much saving of labour would thereby be ensured. There would be no need then for a wide door. What would easily let through a goodly armful of hay would suffice. A four-foot doorway would do that.

A Hay Shed in Connection therewith.

With the shed so placed the hay house would, indeed, be almost unnecessary. It could then be narrowed down to a mere passage from the hay shed through to the courtyard. No wide door would then be required. The two outer doorways would coincide with the passage, or, like them, it would be four feet in width. More convenient still, it might be left as on the Plans, but with wide doors at each side, so that hay could be carted from the shed right through to the courtyard. Hay might occasionally be wanted at the other side of the courtyard, and to be able to cart it there would mean economy of labour. A great deal of hay is consumed at the dairy homestead, but it is of a different kind to that given to the horses, therefore this cart passage would not be of much benefit there. The cows in this case need a shed to themselves, whether or not the horses get one set apart for them. The former is, indeed, the more needful of the two, the cows consuming so much more than the horses. The latter are given hay made out of rotation grasses, while the cows get so-called meadow hay—the meadow in this instance being ground of a half marshy description occupied by a very mixed group of plants, many of them without any claim of relationship to the family of grasses. If the dairy byre is accordingly to have a hay shed as tender, this must be placed in some position as handy thereto as we are proposing to place the one in connection with the stable. But whether the place is to be a hay house or merely a passage, we would have means of communication between it and the stable. We have spoken of a sliding door for this position, but, perhaps, a hinged one opening into the stable back towards the front wall would be less in the way. Of necessity, the sliding door would be at the hay house side of the partition, where at times it might become obstructed by the hay. In the passage it would be less apt to be interfered with in this way. If at all practicable, however, we would here, as we have often implied elsewhere, give our vote for the sliding door.

The Stable: The Floor thereof.

We are now at the stable. Commencing with the floor, concrete, while a thoroughly effective medium to use for laying the passage behind the horses, is not, as we said under the head of "Floors," to be recommended for use in paving the stalls, at least on the parts thereof on which the horses stand. The rough and heavy shoes of the work horses are too trying on concrete for it to withstand such a severe ordeal. Granite or whin "setts"—that is, handy-sized square blocks—make the best job here. Placed close together on edge, end, or bottom, according to the shape of the blocks available, on a bed of fine ashes or sand, these hold out a long time against the wear and tear due to the frequent pounding and friction caused by the horses' heels. But at the head of the stalls, where the feet of the horses have not much effect, we would again have recourse to concrete. It is there, as we have seen, that rats love to frequent, or, at any rate, like to have the run of. They fight shy of that quarter, however, when they are not at liberty to burrow there. And nothing prevents this so completely as a floor of concrete. All along the back wall of the stable, therefore, in front of the horses we would lay a border of concrete at least eighteen or twenty-one inches broad. The rats would be powerless against this, and they would not venture on a footing out from the wall beyond the distance we have stated. Were the stone blocks continued up to the wall, we would have no surety against rats establishing themselves under the mangers, because they can easily circumvent obstacles of that kind.

Failing convenience in obtaining these blocks of whin or of granite, there are the clinkers we have already spoken of to have recourse to. Unless, however, these are of the best quality, they will not stand the test of the situation very long. The ordinary paving bricks that we sometimes see doing service in byre and pighouse are of no use in the stable. They are out of place, we consider, even in the passage behind the horses.

The blocks or clinkers which happen to be selected for the pavement of the stalls should be continued to form the gutter. This is a very shallow affair compared to the grip of the byre. But the horse when stabled receives dried food, and in consequence the waste matters it voids are scant in comparison to what proceeds from the cow or ox which is being fed on the sappy food that is characteristic of the byre. In fact, all that is needed by way of gutter in the stable is the slightest depression in the floor, as much for the purpose of forming a line of demarcation between the stalls and the passage as for anything else. Iron gutters, such as are represented on Fig. 230, are a common accessory to the better class stable for harness and saddle horses. These are fitted, it will be seen, with gridded covers set flush with the surface of the floor, thus leaving the latter continuous in its gradients. But unless these gutters are frequently flushed with water, they are certain to become objectionable. As we remarked when speaking of the horse loose-box, there is never sufficient liquid draining away from the stalls to keep these channels clear. Indeed, what does find its way therein evaporates before the outlet is reached. Should there be enough to begin with to run unobstructed the course of the gutter, it is stopped on the way by the matter that has dropped through the openings in the covers while the stable was being swept out, or the litter was being tossed up and re-arranged.

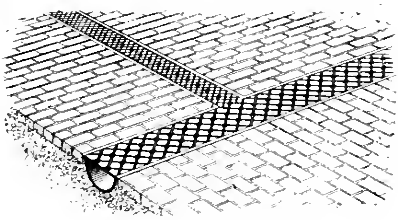


FIG. 230.

The Drains. It is clear, then, that in the stable where the surface drain will hardly act, or, rather, where the excretory matter that proceeds from the animals contains too small a proportion of fluid to force the whole along the gutter, an underground drain is altogether out of the question. Where it is introduced it can but act as a receiver for stuff that ought to be removed from the stable by means of broom and shovel. A festering sore of this description, if we may use such an expression, wherever it has been allowed to develop should be eradicated at once.

The covered iron channel, such as in Fig. 230, is now giving way before the open one, after the principle of that in Fig. 231. This is a much better arrangement than the covered one. Decomposing matter has every chance of lurking unobserved in the latter. But the former is constantly open to inspection, and always accessible to the broom. Besides its utility, it makes a neat distinction between the stalls and the remaining part of the floor, whatever these respective parts may happen to be paved with. And it serves as a well defined border against which to finish either pavement. This is quite a strong enough article for introduction to the work-horse stable. It is common to run, as the two figs. show, a branch from the gutter a short distance up each stall. This makes sure that the animals of the male sex will at all times have a dry bed.

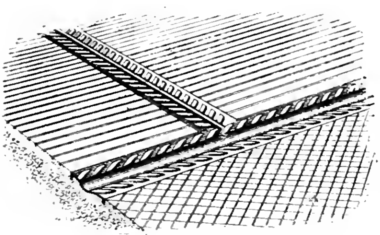


FIG. 231.

It seems rather absurd to particularize about the gutter, and yet make no provision for an outlet thereto. Seeing that we are altogether discarding the underground drain, we are completely breaking off communication between the channel and the exterior of the building. Were it absolutely necessary the open gutter might be continued at right angles down alongside one or other of the partitions, and thence through the outer wall. In our case, however, this is not very feasible. It is impracticable to lead it out under the manger, and to take it the other way means passing over a gutter every time one enters either the hay house or the harness room. It is quite practicable, however, to cover, as in Fig. 230, the part of the gutter that passes in front of the door either of hay shed or harness room. But the gutter, as we have said, really acts more as a break to the end of the stalls than as a drain proper. There is, it will be found, little or nothing to drain away. And what does at times happen to collect in the channel, can almost always be sopped up along with the soiled litter. A little sawdust or prepared peat litter sprinkled in the channel is generally always sufficient to drink in the urine that trickles into and along the gutter. But this is a precaution that is hardly to be looked for in the farm stable. It is further practicable, of course, to form a blind cesspool—one with no outlet—at the low end of the channel, in which liquid that got so far could collect. A suitably constructed one would be easy to clean out. For our part, we would dispense with it, and leave the open channel to be dealt with alone. Unless attended to frequently the cesspool would degenerate into a nuisance. It would never be so dangerous a one, however, as the underground drain is capable of becoming.

The Dip of the Floor. There is no necessity for much fall backwards in the length of the stall floor. What will ensure the passage of urine channelwards is sufficient. It may not be so detrimental to the horse as to the cow to be kept standing with the forequarters at a relatively higher level than the hind ones, but whether or not, there is no use in making a greater difference in this respect than serves to keep the floor dry. The difference in level lengthwise of the stable need similarly be no more than to keep the liquid that can run moving to one or other end. If, however, it be not provided with an outlet, it may be kept level. Preferably we would give it an easy dip to an exit leading through the wall to a gully trap outside in connection with the sewer drain, so that should any stuff ever get so far it has then a way of escape without causing a mess.

A little over ten feet from the front wall is a suitable length of stall, inclusive of gutter, for the farm stable. And six feet from centre to centre of the travises gives breadth enough for the horses' comfort, and room for their food to be carried to them.

The Usual Form of Travis. The travis, if nine and a half feet long inclusive, keeps the horses from plying their heels at one another when so disposed. The hind-post is thus bordering upon the edge of the gutter, which will run about nine inches in breadth. Fig. 232 gives a very common pattern of travis. This is on the same principle as some we referred to when discussing the byre divisions. Very often, however, both of the posts are carried up to the roofing timbers. In that case the bases are let slightly into stones sunk almost flush with the pavement. The hind-post is always solid with a check in front, as in Fig. 217, for retaining the ends of the travis boards, while the fore one or shoulder-post is in two parts bolted together, as in Fig. 218, with the travis boards held tightly between. The hind-posts, if square, require to be about six inches on the face: and if round, sometimes of a corresponding scantling or cross area. The pieces which form the combined fore-posts are six inches by two

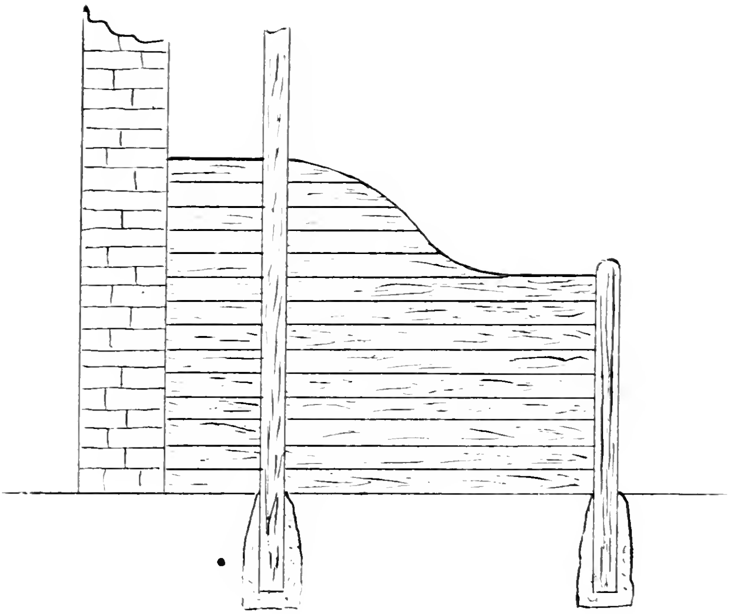


FIG. 232.

inches or so, the space between them—from the travis boards upwards—being filled up by a piece of wood of the right thickness.

But this seems a cumbersome arrangement for stable as well as for byre. The short hind-post arrangement we show is preferable, we consider. The better looking plan, however, is to carry neither post to the roof. This requires the posts to be sound and stout and firmly fixed in the ground. The horses sometimes press heavily against these stall divisions, and it takes some degree of stability to withstand such pressure as they can exert. But if the posts are set up in the way we suggested for those in the byre they can easily be made firm enough to resist the side thrust they are apt to encounter from the horses. In this case the posts should be at least three feet in the ground, with abundance of concrete both under and around them.

An Improved Form of Travis.

Improved travises of wood and iron combined are nowadays readily available. With these the shoulder-post is dispensed with, a short heel-post of iron together with both a top and a bottom runner for the attachment of the boarding forming the complete framework of the travis. Some persons object to iron posts in the farm stable as not, in their opinion, being sufficiently strong. Kicking horses are apt to break them, they say. We never saw one broken through that cause. And certainly they will last long enough otherwise. We have known them turn slack in their fastenings to the stones that acted as bases. Where properly attached to the stones this will not occur. Better than stone bases, however, are now being afforded them in the shape of iron ones constructed so as to give the posts a firm hold of the ground. They go deep, and are wide-spread as well, and consequently strong against overthrow.

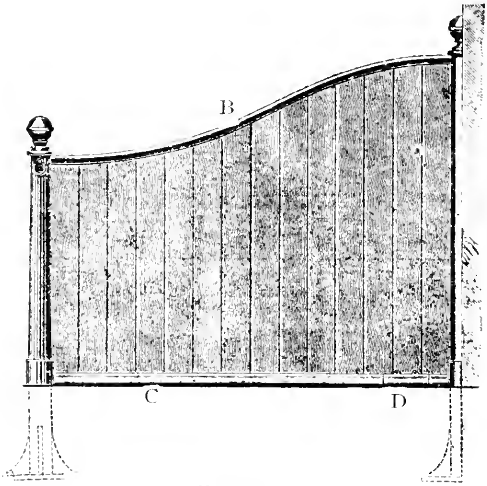


FIG. 233.

A good travis of the sort depicted in Fig. 233 is fitted with a ramp rail B, and a sill C (the runners above referred to), both attached at one end to the post, and at the other to a half post or pilaster fixed to the wall. These stiffen the erection, and at the same time hold the boards in place. In each there is a groove for the latter purpose. Part of one edge of the groove in the sill D is movable for the purpose of arranging the boards in their place, which manner of doing so can be inferred from the fig. When the boards are all home the piece D is again screwed on, and the travis is complete. The sill is perhaps the weak part of the arrangement. We confess to have seen instances wherein it was fractured. It can be made extra strong, however, if called for. For one thing, there is less strain on the boards under this plan. Placed according to the first methods we referred to, the boards run the whole length of the travis, each being about nine feet long. As arranged in the latter, they run from between four and five feet at the hind post to seven or so at the wall. In the former case the shoulder-post comes in, of course, to stiffen them, but even with that support they are much less favourably situated for withstanding side pressure than the shorter ones set upright and fixed both at top and bottom. The latter kind of boards suffer quicker, however, at the heels of kicking horses than do the others which have more spring about them. Thinner boards are, notwithstanding, almost always used in connection with the ramp rail and sill than according to the more primitive double-post system. Extra thin boards are now and again fortified by means of slanting runners stretching from fore post to hind post. Boards an inch and five-eighths or an inch and three-quarters thick answer for the older plan, while boards one and a half inches or even slightly less do for the newer.

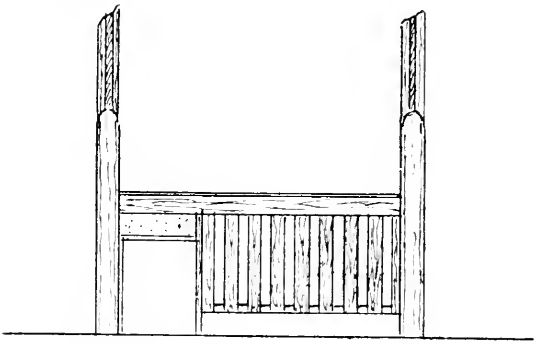


FIG. 234.

The Stall Fittings.

The remainder of the stall fittings are few, and like the travis itself, exceedingly simple. Something is wanted to secure the horse to. It, therefore, and two feeding places, one for corn and another for hay, comprise the lot. We prefer to have these as simple and inexpensive as possible. The hay-rack and the corn-box we place on a level coincident with the top of the biting-rail or cross-piece which holds the ring through which the halter-rope or chain is passed. This rail stretches across the stall about eighteen inches from the wall and thirty inches from the floor, its ends being secured to the travis on either side. In that position it both serves for the attachment of the animal and acts as front to the mouths of the corn-box and rack. In Fig. 234 we represent the front elevation of the head of the stall, and in Fig. 235 we give a section of the fittings there. It may be noted, however, that although we show the corn-trough at the near side of the stall, it is found oftener at the off-side thereof in

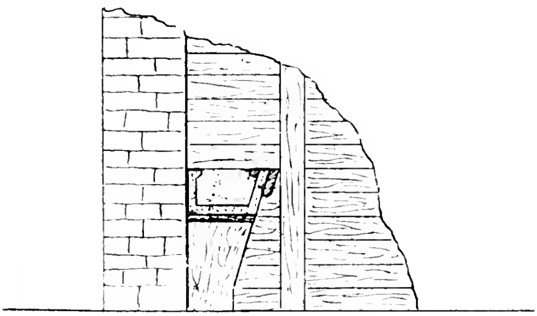


FIG. 235.

the homestead stable—the latter position giving the men more freedom to strip the animals during their greedy attention to the corn.

The hay-rack we keep below instead of above the level of the horse's breast. The horse, like the cow, prefers to eat with his head down. At least, he does the greater part of the mastication of his food in that position. When he happens to be confronted with an overhead fodder-rack we do not see him chewing the hay with his head in the position he is obliged to hold it while plucking the fodder from between the spars. He raises his head to snatch a mouthful and then lowers it to the pendent position. The overhead rack is only permissible in those stables that carry a loft. It is convenient, no doubt, to fodder the horses in such a simple manner as forking or throwing the hay from the loft floor directly into the racks implies. But the opening at the head of each stall down which the hay is pitched remains there to allow the spent air and the unpleasant odours of the stable to ascend. This state of matters is bound to affect the quality of hay that is subjected thereto for any length of time. Most horses are very sensitive with regard to the condition of their fodder, and it is not fair, nor is it good policy, to feed them with stuff that already tastes of the stable. Economy of labour in this instance runs contrary to the welfare of the animals.

A Hay Loft over the Stable not at all desirable.

For the latter reason alone is the presence of a loft in the stable to be condemned. It is wrong, too, we maintain, on sanitary grounds generally. Proper ventilation cannot in the majority of cases where it is met with be maintained. It is in some, but not at the ordinary run of homesteads. When built, as we suggest, without obstruction between floor and roof, it can easily be kept in good sanitary condition by following along the simple lines upon which we have been recommending that it and the adjoining buildings should be constructed.

In the absence of a loft one would never think of erecting an overhead fodder-rack. Such a step would only be leading to extra labour for which no reason existed. The fodder would all have to be raised by fork into the rack to a position wrong in principle. The one indicated in Fig. 234 can be filled by hand, and in it the fodder is placed more in accordance with the habits of the animal than is the case with the other.

The corn-box is best when constructed of glazed fireclay similar to the feeding-troughs for the cattle. It can be fitted in between the biting-rail and the wall at the near side corner. The remainder of the space at the head of the stall is taken up by the hay-rack, the biting-rail serving as the top edge thereof. As Fig. 235 shows, the rack slopes back in front as it is carried to the floor, thus being deeper at top than bottom. This keeps the horses' knees clear of the front of the rack while the animals are eating therefrom. The bottom of the rack is kept clear of the floor. The travis forms one end of the rack, giving support to the framework there, while the other end of the framework rests upon the floor. But there is little framework required. The biting-rail does for the top, and two rails, one in front and another next the wall, constitute the bottom part. These rails, as we have said, are secured at one end to the travis, while at the other they are born on upright pieces that rest upon the floor.

It is usual to spar both the front and the bottom of the rack. But the front, so far as we can judge, may as well be boarded. The horses never reach down to pluck fodder from between the spars; they always eat from the mouth of the affair. The idea may be to make the manger look lighter, or perhaps to let air into it and keep things in a more wholesome condition. Likelier than either reason, however, spars may have been preferred on account of their revealing how the rack stands at any time as regards contents. It is wise, however the front is finished, to have the bottom sparred, and in that way let sand and refuse escape from the rack. If the bottom is six inches or so clear of the floor, any rubbish that falls through can easily be removed. The rack may taper from eighteen inches in depth at the top or mouth to nine inches or so at the bottom. The breadth will, of course, depend on the length of the fireclay trough. This had better be of good size in order to be capable of holding a fair amount of chaff when such is administered to the horses.

It is necessary that a cross piece, either of wood or iron, be fixed on the top of the manger between the biting-rail and the wall. When this is awanting the horses are almost certain to toss out a great deal of fodder from the rack. They cannot settle down to the steady work of reducing the hay to pulp without first investigating the lot and making sure that it is all good alike. If they believe it to be better at the bottom than at the top, then, in the absence of the check we suggest, they will soon, with a side jerk of the head, toss out the inferior stuff, and perhaps trample the most of it underfoot. But the check referred to prevents this improvidence. A similar check is an advantage in connection with the corn-trough. A fastidious horse often acts with his oats or other feed in the same way as he inclines to deal with his hay. If, however, the trough be of a fair size, he has less chance of being able to dislodge its contents in any other manner than the one intended.

The Ridge Ventilators.

Two ridge ventilators of Mr. Craig's pattern, Fig. 143, to three horses, taken in connection with the wallhead openings referred to in Fig. 147 (two say for each horse that can be accommodated—one at each side of the house), would permit of a good circulation of fresh air throughout the stable. At that rate dead lights would suffice. One for each pair of horses might be sufficient. But this is a matter that would fall to be decided by circumstances. It is better, however, to err on the side of plenty than of scarcity in this instance. Light, as we indicated before, is an enemy to dirt, therefore a friend to health.

The Harness-Room.

We make no provision for the stowing away of harness within the stable. The harness-room is there for that purpose, which is an advantageous arrangement for horses and harness alike. Harness hung up in the stable is placed under circumstances anything but conducive to its being maintained in good order. Even when hung up dry it will soon become damp in the humid atmosphere of the place. But when put away against the stable wall damp, either on account of rain, or because of the perspiration it has absorbed, it is there a sure prey to causes of early decay.

The harness-room ought, we consider, to have a boarded floor with efficient ventilation as described on page 103. And the walls all round we would have covered with lining boards. The wood surface of the walls ensures a dry background for the harness, and at the same time makes it easy to attach shelves and pegs thereto wherever wanted. The method of lining the walls of the granary we gave on page 263 is suitable to the harness-room also. Seeing that the harness-room has usually to do duty as club-room for the ploughmen and other men about the place at odd times of the day—is, in fact, the only shelter they have at disposal on wet days when outside labour is at a standstill and they are kept hanging on, waiting events—it is but right that it be made somewhat comfortable. To this end a proper fireplace is necessary. A stove is often made to do service, but an open fireplace is more satisfactory.

The room will be more comfortable, too, if in this case we erect a ceiling about wallhead level. When the room, therefore, is not to be open to the roof the latter may as well be of the ordinary couple and baulk type. This will enable us to make the under edges of the bottom collars or ties serve as the framework of the ceiling. The consequence of this will be that, as Fig. 236 shows, the ceiling will, as it follows the outline of the couple feet and the ties, be above the level of the wallhead, which, however, is rather beneficial than otherwise. Lining boards, similar to those applied to the walls, nailed to the ties, will answer admirably, and when the job is finished give a neat and comfortable appearance to the place. A controllable ventilator between ceiling and ridge is almost essential. A zinc ventilator, same as Fig. 141, will be suitable in this instance. The shaft will require to be continued down to the ceiling, where the opening can be controlled by means of a sliding cover made movable by means of string and pulley. A mantelshelf may be erected over the fireplace; and a strong grate with side hobs and brick back be fixed in, after which we have a decent sort of place both for men and harness; in which the "orra" or handyman may take his piece, and both he and the ploughman take a smoke at any off-time.

The door will have to be a hinged one opening back into the stable. And since we have blocked out all chance of light by way of the roof, a side window looking to the courtyard is a necessity. An ordinary sash window with both parts hung is the proper kind. Should, however, the walls be of brickwork, an iron casement window would be quite applicable here.

The Cart-Shed.

The cart-shed is the simplest building of the whole group. It needs a no more expensive floor than one of gravel or of ashes, and no doors are required. It may perhaps be too much to leave the openings the whole height of the side wall minus the depth of the lintel, whether it be of wood or iron. It is handy, no doubt, to have a place in the courtyard into which a loaded cart can be backed and the contents be protected from rain, but it would be bad

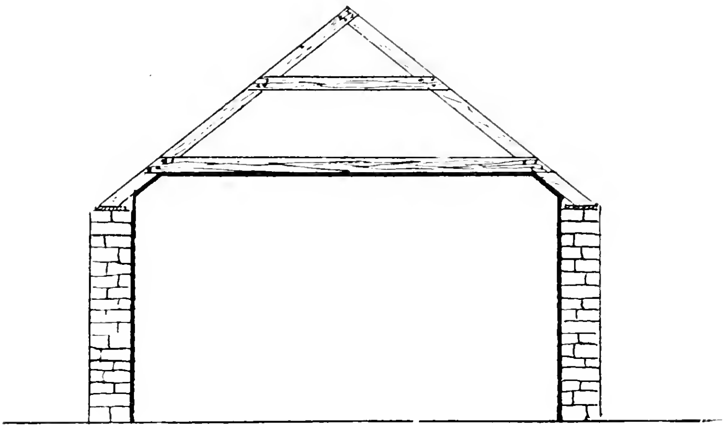


FIG. 236.

policy in order to attain this to subject the housed carts to the influence of drifting rain. Much depends, of course, on the exposure of the front of the cart-shed. If it be such that wind and rain can beat upon it, then it is necessary to keep the openings lower than would be quite efficient in a more sheltered situation. The carts nearest to the openings would be certain to get wet more or less where the latter were high and rain occasionally had that side of the building at its mercy. Seven feet, or at the utmost seven feet six inches, would be height enough for these openings in walls that were any way exposed.

The lowering of the openings does not imply much extra cost. A beam or girder is essential, whether it has to act as support to the roof alone or to the extra building over the openings in addition: and there is very little in the latter item. We would prefer an iron or steel girder to a beam of wood, for the reasons we mentioned on page 118.

The supports to the beam or girder may be of stone, brick, or iron.

A stone pillar takes up most room, a cast-iron column the least. Our choice would be the iron column. This, it is needless to say, needs a large and properly-dressed stone for base.

No roof lights are required here unless it happened that doors for some valid cause were fitted to the openings; but we should erect two or more of our ordinary zinc ventilators in order to make sure that the roofing wood was maintained in good condition. Here, if anywhere about the buildings of the homestead, ridge ventilation might be dispensed with, but we would prefer to have it even here; and the wood surfaces we would have as before.

The Odd Place. With the odd place at the corner this group of buildings comes to a finish. A sliding door, a concrete floor, opening roof lights, and one of Craig's ventilators, are about all we can specify for it without knowing further what its uses are likely in reality to be.

CHAPTER XV.

The Dairy Buildings, Pig-House, and Dungstead.

We have now been the round of the homestead proper. But there still remain the dairy buildings, the pig-house, and the dungstead. And besides these are the various subsidiary sheds. The former by themselves are sufficient to afford matter for a chapter, and this one we shall accordingly set apart to their discussion.

The Position of the Dairy Buildings with regard to the other Houses.

The dairy buildings are set down on Plan II. and Plan III. at the north-west corner of the homestead. In that position they are not far removed from the byres, nor from the house on the dairy farm, but still far enough to be practically isolated from the remainder of the buildings. They are handily situated enough in relation to the latter for economy of labour, and yet cut off from them as regards their tendency to react unfavourably on milk and the products of the dairy that come under their influence. Where we place them they are pretty well out of reach of the odours that are liable to arise from the dungstead, pig-house, and cooking-shed, which three are the worst offenders in this connection. Neither can the byre in the one instance, nor the byre and the house in the other, have any adverse influence over the dairy affairs.

In both cases represented the arrangement of the dairy is the same. We have the scullery or washing-up place to begin with. This leads into the churning and making-up-room if butter-making is the method of utilising the milk, or the vat and press-room if cheese-making is adopted. At the other end of this, and furthest from all the other buildings, is the milk-room. Another place is wanted should cheese-making be the industry selected, viz., a ripening-room. This we can best obtain by adding a half-storey or loft to the milk-room.

The Scullery.

The scullery makes small demand in the matter of fittings. One or more coppers are essential for the heating of water with which to scald the dishes, either steam or fire being applied for the purpose. Another is needed for a supply of hot water to the jacket of the milk-vat. This one is sometimes placed in the vat-room itself. It is better, however, to have it in the scullery. The latter is rendered no worse by the extra vapour this arrangement implies, and the vat-room is kept rid of this form of moisture. It is easy to obtain a copper, such as shown in Fig. 237, fitted with an offset or outlet at bottom from which the water can be drawn as wanted at the other side of the wall. It shows a better class, being of tinned copper, than is likely often to be used, one of cast-iron being good enough in most instances. A hose can, if required, be coupled to the offset and to the vat and direct communication thus be made between the two. Where steam is used in the dairy the arrangement referred to is unnecessary, and one copper is enough in the scullery.

The walls of the scullery, if built of stone, are better to be plastered with cement. They will then be able to withstand the knocks that are likely to fall to their lot at times. They will also be smooth enough to hinder the accumulation of dust or dirt of any kind. Dust will not often indeed have a free hand in the scullery; there is too much moisture about for it to be able to manifest its presence in the house when the customary operations are in force. On the other hand, the impervious surface of the cement plaster will suffer no harm from the abundance of moisture that characterises the interior of this room. If built of good, hard, well-formed bricks, it is quite sufficient to leave the brick surface unprotected otherwise than by having the joints thereof neatly pointed with cement. This also gives us a firm and smooth wall surface. There are no openings other than the doorways required in the walls. We would have it lighted by way of the roof. The floor we would have of concrete, but no drain therein. The floor should be laid with a hang towards the outer doorway, so that all water that is spilled upon it may gain an outlet in that direction. Outside it could be gathered in a gutter and led along it to the nearest gully trap. The room we would have open to the roof as so often referred to, and the roof wood we would, if practicable, have cleaned and varnished. Three opening roof lights—two at one side and one at the other—and one of Craig's large-sized ventilators, not forgetting the doors, complete the place.

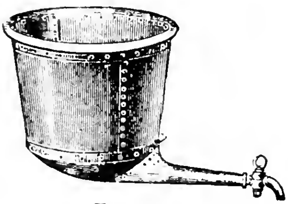


FIG. 237

The Vat-Room, or Churning-Room.

The midroom, whichever of the two purposes it is set to fulfil, may be almost identical in character to the scullery. Floor and walls may be the same. It too may be devoid of ceiling and be lighted and ventilated in similar manner to the last mentioned. There is not so much water being spilt on the floor of this room as in the scullery. Almost the only water that is introduced into the place in cheese-making is in connection with the vat. What is run into the false bottom and sides of the vat must of course have a way of egress appointed for it. But there need hardly be a drain formed for this alone—not one in the floor, at any rate. There must be no chance of odours arising from drains within the dairy buildings, and the most effectual manner of preventing this is to have none inside the premises. An opening through the wall at floor level will admit of a hose connected to the outlet of the jacket that encloses the vat discharging into an open gutter outside and the water being led away as before. In butter-making there is certainly more water thrown about, but as with the scullery, the level of the floor can be so arranged that water will run therefrom to the outlet just mentioned.

A Drain for leading the Whey to the Pig-houses.

But cheese-making renders necessary another kind of drain in connection with this room. The by-product whey is utilised as food for the pigs. And in order to economise labour it must be led to their quarters by way of an underground drain. To have to carry it all from the dairy to the pig-troughs would be a serious matter—more than it was worth in many cases. A watertight drain is essential for the purpose. Either a three or a four-inch spigot and faucet cement jointed drain answers well. At the far end it is requisite to have some kind of tank in which the whey can accumulate and be used out of as needed. It may be constructed with such a covering or lid that the attendant can lift the whey with a can or bucket and pour it into the pig-troughs. In some instances the tank is substantially covered and fitted with a hand-pump for raising the whey. Like the other drain, the inlet to this one needs to be placed outside, and then no ill effects as regards operations in the dairy can arise therefrom. A hole in the wall will as before admit of a runnel discharging the whey from the vat into the head of the drain outside. The drain can be led where it is least likely to do harm should it ever require to be lifted. But if well laid at the start this eventuality need not be dreaded. It is wise, however, to have it fitted with inspection eyes wherever these are practicable. Accidents may arise to interfere with its efficiency, and inspection eyes here and there will serve to locate the fault.

The Milk-Room.

The milk-room of necessity gets more money spent on it than does to complete the others. It hardly answers to dispense with a ceiling here, and thereby leave the room open to the roofing boards as with scullery and midroom. In their case it answers better to have the extra space thrown in. They can then be lighted through the roof, which is cheaper than having recourse to side windows, and they are so much more easily ventilated when ridge openings are available. The rough-and-ready ventilation that door and ridge ventilators afford suits the nature of these respective rooms, more especially the scullery where so much water is vaporised. In the milk-room there is no less demand for ventilation, but on a more refined scale so to speak. So long as the air in the milk-room is kept from stagnating not much else is required. We do not want it left at the mercy of the wind altogether. If a steady exchange of air in the room is maintained, nothing further is called for. This can perhaps be better obtained with than without a ceiling in the room. But the ceiling is more effective in giving one control of the temperature of the air within the room, and that is its principal office in this place. The slates and roofing boards quickly heat up under the sun's influence; and on sunny days the air of a room that is devoid of ceiling soon responds to the rise of temperature in its covering. The open door and the slit in the roof give the air in the scullery and the midroom little time to be in contact with the roof. In the milk-room, however, such vigorous ventilation would not answer. Live things, both big and little, would avail themselves of the free access which it implies. Small things innumerable come and go constantly, for without their presence our various methods of turning milk to useful account could not be carried on. We do not refer, however, to these invisible entities, but to those of a grosser being which closed doors and wire gauze can keep out, and to dust and dirt in general as well.

Provided with a ceiling, the milk-room is then less at the mercy of the sun, and the air thereof can accordingly be more easily maintained at a comparatively regular temperature. The ceiling, while it shelters the room from the sun, on the other hand goes to hinder the loss of heat therefrom by radiation in times of cold. But the latter condition is of less importance than the other. The milk-room is often too hot inside, seldom too cold. Thatch is the ideal roofing material for a milk-room, but one hardly practicable at the modern homestead.

The Floor of the Milk-Room. The floor of the milk-room is, like so many others at the homestead, best when of concrete. There are, as we have so often repeated, no joints in a floor of this description into which spilt milk can penetrate, there to become sour, and encourage the production of low-class bacteria and taints and odours generally. It is impervious to damp from above or below and is easily wiped clean. These are qualities that, even were it costly, recommend it strongly for a place in the milk-room.

The Walls. The walls, if of stone or of brick, built in the ordinary manner, should be plastered on lath. There must be no damp spots or patches on the walls of the milk-room. These become centres for the dissemination of minute fungi that work harm in milk and cream. It is all-but impossible, however, to avoid damp places on the wall surfaces if the latter are not plastered on laths. When spread on these the plaster is completely insulated from the stone and lime of the wall, and therefore out of reach of any dampness that can arise from the outer shell of the fabric. Thick though the latter is, it is bound to feel on its inner side the effects of what the outer face has to endure at the hands of our variable weather. Sun, frost, wind, and rain all have at it in turn, the last two sometimes in company, and it requires good workmanship to withstand these without occasional hurt. Actual wet need not find its way into the mass before damp shows inwardly. It will appear on the painted or whitewashed surface of the milk-room wall that is unlathed when there is nothing visible outwardly to account for its presence. The mass of stone and lime forming the wall absorbs more or less moisture according to the amount in the atmosphere. Seldom does a good wall absorb so much as to become apparent on its inner surface. But what may not readily reveal itself on the rough, unplastered surface will quickly do so on the plastered one where no lathing intervenes. When the laths are there the plaster does not touch the wall, so that even when the wall happens to be damp enough to affect plaster applied to it directly, that which is applied to it through the medium of laths remains unaffected. All the same, care has to be taken that the inner surface is no damper than is due to the state of the atmosphere. If dampness due to defects in the building is suffered to exist for long, the straps to which the laths are attached, and in turn the laths themselves, are bound in time to feel its effect and become prematurely decayed.

If the walls are built of brick and have a hollow space within from top to bottom, there is then no need for lathing. The hollow keeps the inner part of the wall thoroughly insulated from the outer part in the same manner that the lathing keeps the coat of plaster apart from the solid wall whether it be of stone or of brick. It does this more thoroughly, in fact, because the straps are attached to wood plugs driven into the wall, whereas the two parts of the brick wall are tied together with galvanized wrought-iron clips along or through which damp cannot pass from the outer to the inner portions of the wall. Damp may pass from plug to strap and from strap to lath, but it cannot pass from one part of the hollow wall to the other by way of the clips or ties. And the space in the heart of the wall lessens the conductiveness of the latter. Heat passes slower through a wall so constructed. If the bricks of the inner part of the hollow wall are hard and well formed, plaster may be dispensed with and neat pointing take its place. Even then, however, the surface may be a little rough, and therefore conducive to lodgement of dust thereon, which is not a favourable condition of matters in the milk-room. One may be pardoned, we think, if he makes use of enamelled bricks for the inner portion of the walls of the milk-room. Very little dust will effect a foothold on their surface; what does can be easily wiped off. No plastering is then required, so after all the extra cost of the glazed bricks does not amount to so very much as to render it prohibitive.

The Windows. The side windows shown on the Plans II. and III. afford both light and air to the room. Sash windows do not interfere with the space of any room they are fitted into, therefore they are the best to use in connection with the milk-room. Were the windows to project into the room every time they were opened, they would interfere with the storage capacity of the shelves, which usually are placed against the walls. Casement windows to open out could of course be used, but these would prevent the windows being safeguarded with perforated zinc or copper-wire gauze on the outside. Sash windows are therefore clearly the best kind for application to the milk-room. They can be opened and shut without first having to clear parts of the shelves on the one hand or to remove the screens on the outside. Screens of the material referred to are essential, otherwise flies and winged insects generally have free entry whenever a window is opened. A light wood frame made to fit closely into the window and covered with either of the materials mentioned, makes an efficient screen. But this is an item that falls to be provided by the tenant rather than the proprietor. So also the blinds, should any of the windows require a fitting of the kind.

The Ventilation of the Room. To augment the means of ventilation it is well, if it can be managed, to have an opening in the ceiling leading therefrom to the roof and terminating in some suitable form of protected outlet. This may not be very practicable should a cheese-room be placed overhead. Still, even then it can sometimes be arranged to make room for such an air-shaft as we suggest. And near to floor level a few air inlets such as are usually constructed to promote circulation of air under floors of wood, made through the walls, help to keep matters wholesome under the shelves. Without these air is almost certain to stagnate in the corners at that low level. Stagnant air is, in our climate, almost certain to be damp, and this is the condition that favours the growth of the bacteria and moulds referred to above that work adversely in the interests of the products of the dairy. A few of these inlets prevent the air lurking undisturbed and favouring the spread of harmful organisms. The inlets can be controlled either outside or within the building. An ordinary "hit-and-miss" covering, such as used to give control of openings of the kind, is placed at the end chosen to be regulated from, and the other, similar to the windows, is protected with perforated zinc or wire gauze. It is the better plan, where practicable, to have the controllable end of the opening at the outer side. It is easier got at there than under the shelves inside. A fireclay pipe is the best form of channel to carry through the wall. Laid with a slope outwards, there is no danger of rain being driven through. If the walls are hollow, the pipe must, of course, be continued intact across the hollow, else the incoming air will lose its way in the latter and fail to carry a direct current into the room.

The Shelves. The shelves are usually of either sandstone or thick slate. The latter is the better material. It is harder and less absorbent, and can be polished smooth enough to be easily wiped clean. Sometimes the shelves are fixed upon upright slabs of the same material or on brick supports, but iron legs are better. The former obstruct the circulation of air between the shelves and the floor, but the latter have no effect in that way, as may be seen if we compare Figs. 238 and 239.

"T" angle iron or steel as arranged in the latter figure takes up so little space as not to interfere with air-currents. But the solid divisions represented in Fig. 238 act as so many partitions in dividing the space under the shelves into a series of bunkers. They are but bulkheads, in fact, round which the air must pass from one cell or compartment to another. But not only the shelf supports would we have of a kind that would not stand in the way of air movement; we would have the shelves themselves constructed on the same principle. Instead of having them solid as at present, we would prefer to have them grated or trellised. A thin latticed iron or steel shelf would answer admirably. It would offer little or no obstruction to air-currents, and would effectually hinder the stagnation which is so apt to take place under the solid shelf. Such a thing could be got with an enamelled surface if pressed for; at any rate, it might easily be had galvanized.

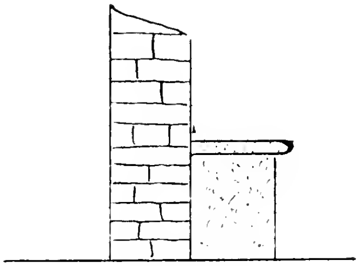


Fig. 238.

The Ceiling. No matter how the walls are finished on the inside surfaces, whether plastered on lath, or on the solid brick-work of a hollow wall, or lined with enamelled bricks, the ceiling, if the building is one-storied, had best be of lath and plaster. A ceiling of wood does not answer very well. The wood eventually shrinks, and dust from above comes through the cracks and may fall into the milk. The plastered ceiling contains no cracks—none at any rate that will suffer dust to pass, else it is but a makeshift—and here as in the house makes the best of all overhead enclosures. If, however, the cheese-room is placed above the milk-room, the combined floor and ceiling recommended on page 106 and represented in Fig. 89 may with advantage be used. The floor of the cheese-room is put to severe strain at times, and this comes to tell on the plaster ceiling that is attached to the underside of the flooring joists. The turning of the cheeses and other operations that go on in the cheese-room give sudden shocks to the joists, and the heavy weight these are set to carry as the shelves begin to fill up are apt to cause the ceiling to yield and give way in places. But the double floor just referred to affords increased steadiness in the room above, while at same time it acts as an effective ceiling to the room below. No dust can penetrate from one room to

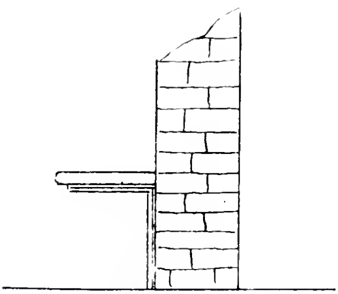


Fig. 239.

the other, because if a crack in the upper boards should happen to be opposite another in the lower set, the felt between them effectually prevents conjunction between the two. And when the joists and underside of the boards have been cleaned and varnished, little dust can settle thereupon, and what does can be easily brushed or wiped off. And let the floor above be thumped and strained to any reasonable degree, the contents of the milk-room will not be effected thereby.

The Cheese-Room.

The cheese-room is the room in which the cheeses are arranged on shelves to undergo the process of ripening. For the sake of economy, as well as of convenience, we place it in this instance over the milk-room. Fig. 240 gives a section of the two. Access is given to it by means of a trap stair or ladder

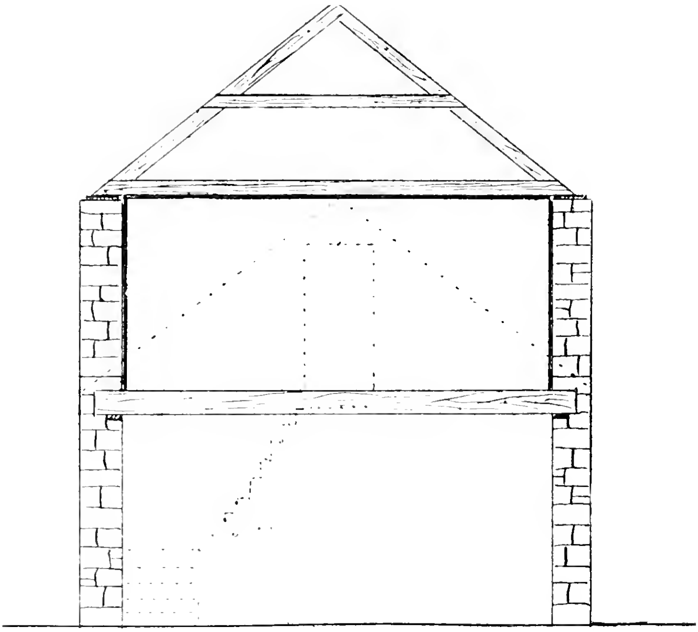


FIG. 240.

leading from the vat-room. Each cheese can then be taken directly from the chissel in which it has been pressed to the ripening-shelves. And if a door can with advantage be made in the gable of the cheese-room the ripened cheeses can therefore be straightaway loaded into carts drawn up alongside the wall beneath the same. It is not essential that the cheese-room be placed in the second storey. Some of the best cheeses ever manufactured are ripened on the ground floor; but as good ones and perhaps more in number are matured in the "cheese-loft" situated overhead of some other building. The situation of the room as regards relation to ground level or first floor is therefore seemingly of small importance, and may be left to be decided by the matter of convenience. This, it must be borne in mind, applies to the manufacture of Cheddar and other hard kinds of cheese. A ground floor apartment, if not indeed an underground one, is a necessity in the manufacture of soft cheeses. And therein provision needs to be made for the maintenance of a duly warm and moist temperature. At parts of the sunny South, a basement milk-room is considered a necesssary part of the farm house.

The Side Walls and the Ceiling thereof.

The side walls of the cheese-room shown in section in Fig. 241 are not carried up so high as to admit the ceiling being on one level. So long, however, as they are high enough to allow headroom along the wall side, no more is required in that respect in the camp-ceiled room. With this height the revolving shelf cases have room to work by reason of their being out from the wall a foot or two, because then they are brought nearer to the level part of the ceiling, and further from the coved side. There is no doubt, however, that the upstairs cheese-room is better to be so high in the side wall as to enable the ceiling to be on one level as in Fig. 240. And the reason of this is apparent if we compare the two. The more equable we can keep the temperature of the room it will be the better for the favourable development of the cheeses. But the room with the camp ceiling has a vulnerable part *a* at each side which does not exist in the one with the straight ceiling. At *a* there is not much thickness of material between the room and the sky—just the slates and the roofing boards joined together, a little air space, and the thin sheet of plaster. The sun, when it strikes on this part, makes its influence felt inside when perhaps the air of the room is over the mark to begin with. In cold weather the balance tells the other way, and radiation follows suit. The warm air of the room can part with heat to the cold air outside through *a* at a much quicker rate than it can directly through the walls or upwards into the enclosed air space above. The roof with the straight ceiling, Fig. 240, has no weak parts in its armour such as the other has at *a*. On the one hand, the sun's influence on the slates in summer is counteracted by the air-cushion contained between roof and ceiling; and on the other this body of air hinders radiation upwards from the room in winter. This body of air is in that position an effective non-conductor of heat, and in Fig. 240 it covers the whole

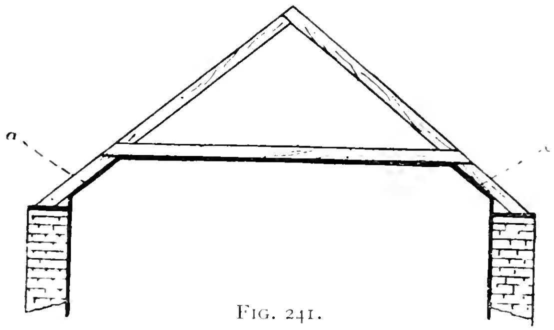


FIG. 241.

ceiling, which is only partially the case in Fig. 241. It is advisable to put felt between the slates and the boards of the cheese-room roof. This further hinders the two actions thereon referred to—the radiation of the sun's heat inward, and the radiation of the heat of the room outwards.

This may be considered a little fine-drawn, but it is really annoying when in the dog days the temperature of the cheese-room rises to a point that makes the cheeses perspire and shine. This will hardly occur in a room of which Fig. 240 is a representation. It may readily happen, however, in one after the plan of the other: and the latter is a favourable example of its class. Many a one in actual use has much more coving than it shows. This is a defect of which the ground-floor cheese-room is quite free. The temperature in one of these is less apt to fluctuate on account of the reasons given than in one on the upstairs floor. But then the ground floor is more apt to be damp than the other. A good deal, however, depends on the situation of the dairy. In one a coved ceiling may answer well enough; in another it may be mistaken economy to keep the side wall lower than the ceiling.

The Windows.

Side windows, we need hardly say, are the proper sources of light to the cheese-room. Those on which the sun plays can be mounted with blinds. The sash window is suitable as being easily fitted in that respect, either inside as a protection from the sun or outside as a guard against tiny intruders, and readily adapting itself to the requirements of ventilation, as we pointed out in connection with the milk-room. We believe in abundance of light here. This is allowed to be a condition rather unfavourable to the propagation of germ life, and the busybodies of that field of existence have a hand in what goes on here as well as in the milk-room beneath. Their work is deeper seated and more gradual in the hard-pressed curd, however, than is that which is overtaken by those infesting milk, therefore a little extra light in the room cannot be prejudicial to them. Neither can it in the milk-room; for those that induce the characteristic changes in milk are ever ready on the shortest notice to turn out in their thousands upon thousands, irrespective of the effect of an ordinary amount of light.

The Ventilation of the Room.

As a further aid to the ventilation of the room (for here, as in other places, air that is allowed to remain still favours the generation of moulds and such like) it is well to have an air-shaft from ceiling to ridge, finished at bottom with a controllable flap or slide, and at top ending in a large double-horned zinc ventilator of the description referred to further back.

The inner surface of the walls should here, too, for the reasons already advanced, be plastered on lath if the wall is not hollow built; and it may be understood that lath and plaster will constitute the ceiling.

All well-appointed Cheese Rooms are Nowadays fitted up with Reversible Shelves.

All well-appointed cheese rooms are now fitted up with revolving or reversible shelves. The cheeses have regularly to be turned end for end at least once a day during the height of the season, and as the shelves begin to fill it is no joke, in the absence of reversible shelves, having each cheese to turn over. But with reversible shelves at command, in single minutes for each ten it took before they were available, the operation can be accomplished, and at the exercise of little or no exertion. These kind of shelves are arranged in a series of boxes or cages, as in Fig. 242, which shows the elevation of a set of six boxes, in vertical pairs. The number of boxes in a line is of course ruled by the length of the room, as the number of rows is by the breadth, and the number of shelves one above the other by the height

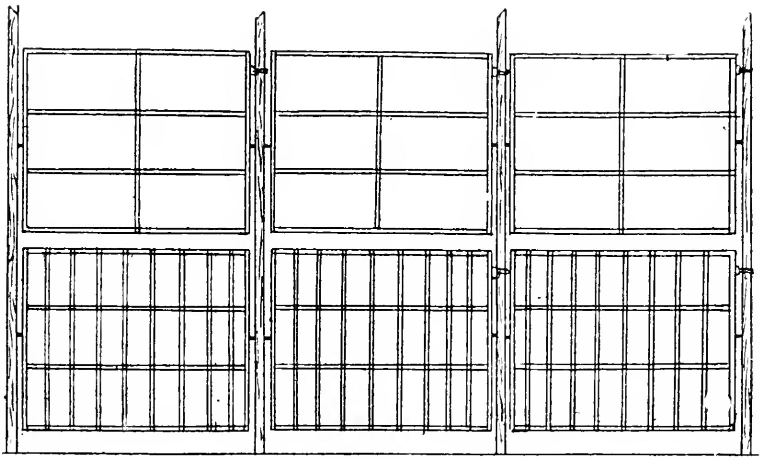


Fig. 242.

thereof. Whatever the height of the room, however, it is hardly practicable in most cases to have more than two sets between floor and ceiling. A third one would be out of reach of a person on the floor. But this depends on the depth of the cheeses made. Where flat cheeses are made the boxes are shallower, so that either an extra shelf can be introduced in the box, or if not an additional box, provided there is room, may be placed above the two.

A Description of these Shelves.

Reverting to Fig. 242, the top set of shelves have the front outwards, and the bottom set the back. The spars at the back of each box are there for the purpose of holding in the cheeses as the shelf is turned bottom up or reversed. Their purport will be better understood by referring to Fig. 243, which is a single shelf to hold four cheeses, drawn to a larger scale, the position of the cheeses being shown by the dotted lines. The inner sides of the spars, it will be seen, are shaped to fit to the cheeses so that they cannot mark them when their weight comes to bear upon the spars. They take up the weight of the cheeses as the box begins to tilt and throw them on their sides, and they support them until the box has passed the horizontal and what was the top of the cheeses is now becoming the bottom, and they are sliding into their new position. It is evident that the less difference there is between the depth of the cheese and the space that divides the shelves, the less violent will be the shock to the respective cheeses as they alight upon their new support. So long as sufficient room is left for air between the tops of the cheeses and the shelf above, the smaller the difference referred to the better. And the same applies, although for different reasons, to the side room afforded the cheeses. So long as air has room to circulate around them any further room is just so much waste of material. There is waste of material, too, in placing the shelves further apart than is necessary for the free access of air; but there is further, as already stated, the risk of damage to the cheeses in giving them too long a drop.

In the Figs. bearing on this subject we have taken, by way of example,

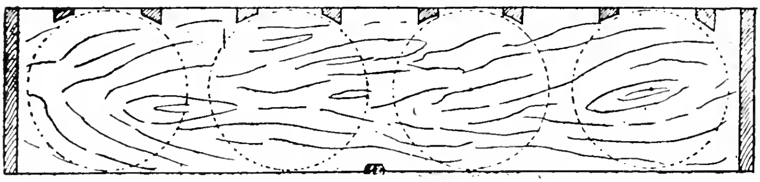


FIG. 243.

the shelves as fitted up in the cheese room of the West of Scotland Agricultural College, at Kilmarnock Dairy School. There the shelves are $14\frac{1}{2}$ inches broad, $1\frac{1}{4}$ inch thick, and the space between each is 16 inches. The length of each box of three shelves is 64 inches inside measurement. The size of the cheeses made at that institution is 14 inches deep by 14 inches in diameter, each one forming a perfect cylinder. At this rate the cheeses have two inches clear space between their tops and the shelf next above, and they sit two inches apart. The end ones, however, are only a single inch from either side of the box, which seems barely enough. Were the boxes lengthened two inches it would allow each cheese in the row the same air space around it.

A free and full distribution of air no doubt being as essential to the favourable development of the contents of the shelves in the cheese room as it is to those on the milk room shelves, we would incline to have the shelves of the former place also made of lattice work. The bottom, top, and sides of each cheese would then be on a pretty equal footing as regards exposure to air, light, and heat. There would still, however, exist the necessity of periodically turning the cheeses. This is needed as much perhaps to ensure homogeneity in the cheese as for the other purposes referred to. Were the cheeses not made to change ends occasionally, they would tend to become denser in some parts than in others, and consequently ripen irregularly.

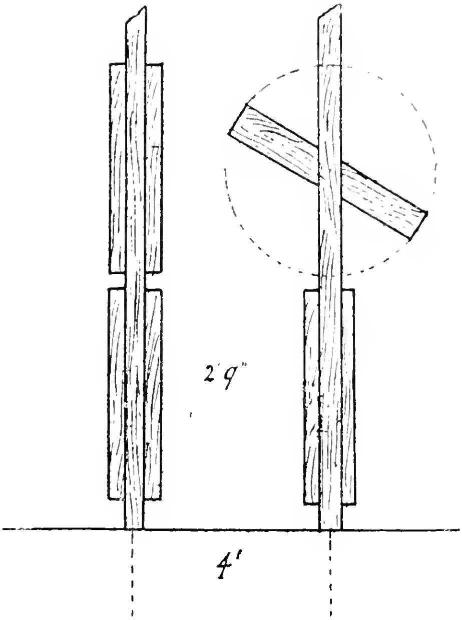


FIG. 244.

It will be seen from Fig. 243 that the vertical spars on the boxes are checked into the shelves, to which they are also screwed, thus serving to stiffen the latter, as well as keep the cheeses from falling out when being reversed. A single strap put on in front helps further to brace the shelves and hold them in position. The shelves are dovetailed to the ends or sides: the top and bottom shelves ought to be, at any rate; the inner ones may be checked thereto. Either white or yellow pine does for the construction of the boxes. The ends may be of the same thickness as the shelves—one-and-a-quarter inch.

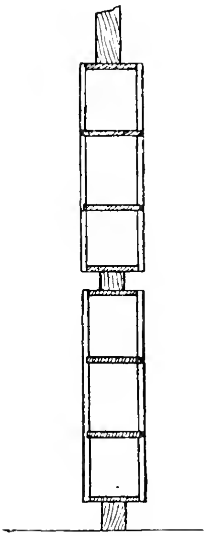


FIG. 245.

Fig. 244 shows the end elevation of two rows of three shelves. This makes plain that the rows can be placed pretty closely together. Overcrowding is a disadvantage, however. But this is a matter that will be ruled by the storage room required, and the space at disposal. Fig. 245 gives a vertical cross-section of two rows of shelves—two boxes.

Fig. 246 shows how the boxes are fixed at each end to the standards; and how they are held steady by means of latches.

In Fig. 247 are represented the iron mountings on the respective ends of the boxes. These consist of catches which enable the latches, such as shown in Fig. 246, to intercept and hold the box from making a complete rotation, and a central pivot. Should the latch happen to clear the catch and allow the box to make more than half a turn, the result is the pitching out of the cheeses upon the floor. The pivot fits into a corresponding socket attached to the standard.

Although we have somewhat fully described the shelving that is required to complete the cheese room, it is often an item that falls to the tenant to fit up.

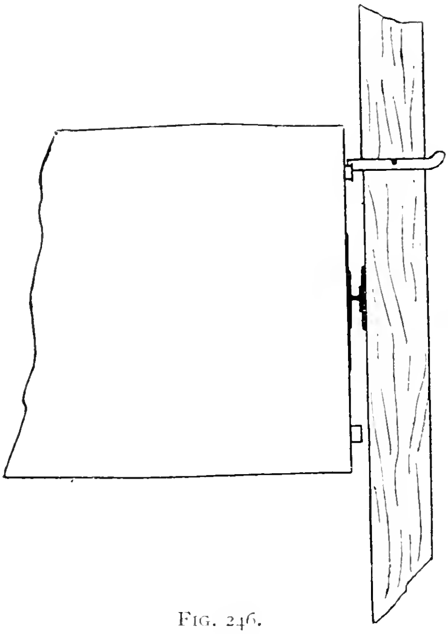


FIG. 246.

Heating the Cheese Room. And so, very often, is the item of providing some arrangement for heating the room. Hot-water pipes are acknowledged to be the best medium for accomplishing this. Steam, when available, is sometimes substituted for heated water, but it is hardly so satisfactory. A stove is out of the question in the majority of cheese rooms. But even where practicable it is irregular in action, and therefore unfit for the purpose. The most suitable place in our Plans for the position of the saddle boiler for supplying the pipes with hot water is somewhere in the scullery, near to the copper furnaces. This implies a little extra piping, but it keeps the furnaces all in one place, and properly under cover.

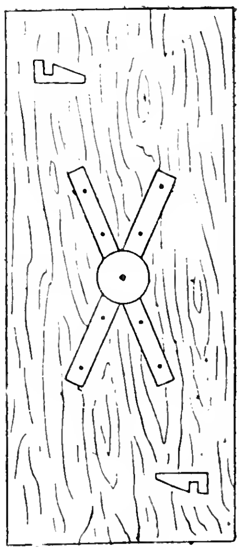


FIG. 247.

The Pig-house. We have placed the pig-house to be in touch with the dunghill, and within easy reach of the cooking shed. It is not far from the straw barn either. That, however, is a less important matter, because the pigs are not, as a rule, treated to very much straw by way of bedding; and they cannot make use of it as a food. They can turn a sheaf to good account by chewing off the ears of grain, but the straw itself is not sufficiently concentrated to answer the rather exacting requirements of the alimentary canal of the pig.

Either Double or Single, and how Arranged. The house may either be made double, as in Plans II. and III., or single, as in Plan I. In the latter case the house is built as a lean-to against the side wall of the dungstead, the latter being heightened for that purpose, or it may be the contrary way, with the higher wall next the court and the lower the side of the dungstead, as shown in the section given in Fig. 248. The pens are arranged against the lower wall, and suitable holes or openings are left therein for allowing the manure to be pitched directly into the dungstead. The liquid excrement can be led directly therein by means of an easily accessible channel or drain either inside the house or round the outside corner by preference. A feeding passage with a door at each end, or with one, if considered sufficient, runs in front of the pens. Fig. 249 gives the plan at cope level of the pens of such an arrangement as we are describing. Each pen measures twelve feet long by nine feet wide, and trough space is afforded for seven animals, which number the pens are severally easily capable of housing with comfort to the inmates. A trough for each animal is almost essential. If the swilly food which falls to the lot of the pigs is poured into fewer troughs than there happen to be animals confined in a pen, we all know the result. If poured into one common to all, or even into two, none gets a chance of taking its food in a rational manner. One to

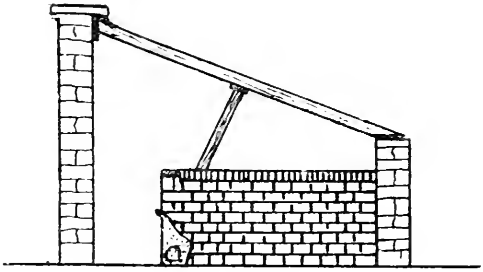


FIG. 248.

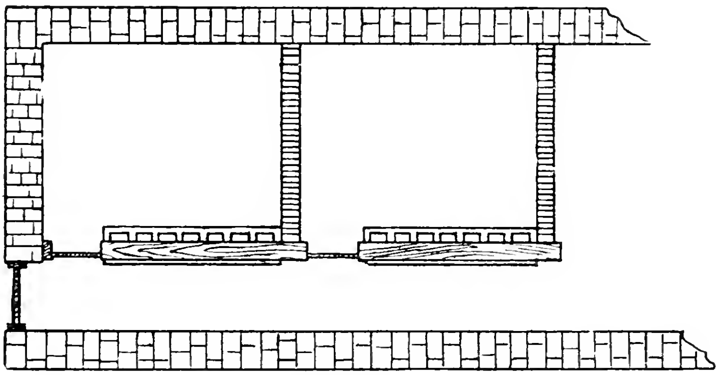


FIG. 249

make sure of room may get in on all fours, while nearly all the others, to make a good resistance, strive to plant their fore feet in the trough. Peace there is none, at any rate until the trough is emptied, or until the majority are satiated. It is easier, however, to fill one or two troughs than seven, besides, such a number of single troughs cannot be accommodated, therefore the pigs must adjust themselves to circumstances.

A good kind of Trough.

We have now, however, a trough in the market that effectually overcomes these difficulties against making matters more comfortable to the pigs at feeding time. There are single troughs to be had, of which Fig. 250 is a representation, so divided that each part thereof serves as a separate trough, and yet all being continuous at bottom, no one can be fuller than another. So long as it sits level, each division holds the same amount of fluid or semi-fluid food. The pig that, in the absence of others, essays to empty any one compartment, must deal with the whole contents of the divided trough. The trough we refer to is made of fireclay, and glazed similarly to the cattle troughs and horse mangers we have so often referred to in earlier pages. The sloping divisions and the high back of the trough are important points. The former keep the pigs apart most effectually. These obstructions prevent the animals seeing each other when engaged feeding, a condition which makes for peace to start with.

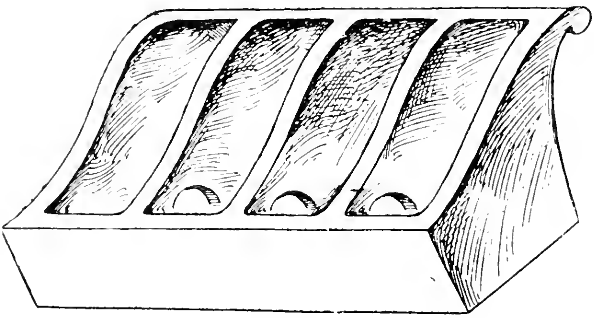


FIG. 250.

Instead of spending energy in seeking to shoulder aside a neighbour it cannot see, and can only feel behind a point that does not react by way of strife to jostling, the individual pig is more intent on overmatching the snout it hears and may see at one side or other at the bottom of the trough, but which it cannot reach, nor can others it. No doubt it thinks itself king of the walk so long as it has part of the dish to itself, and in this way each of the animals can partake of its food in a comparatively calm and philosophic mood, utterly different from the frantic manner in which it gulps the stuff over when many mouths, not to speak of feet, dip in the one dish. The high back, while it acts as a filler down which the food, as delivered from the pail, slides to the bottom of the trough, comes in as a barrier at that side of the pen. It is a barrier barely complete in itself, but one, or at most two, iron rods, as in Fig. 251 (which shows the elevation of this part of the pens), stretched parallel with the tops of the troughs between them and the wood lintel which runs level with the tops of the divisions, as in Fig. 249, serve effectually to keep the pigs from getting out at this side of their enclosure.

The wood lintel may be dispensed with, and an iron rod or pipe be taken as substitute therefor.

The Pig-house Floor.

The floor of the house we would have laid with Portland cement concrete. Tar macadam is a likely material for a pig-house floor. It requires a good stuff to withstand the snouts of the pigs. Any crack or soft part in a floor of other materials than these affords a starting point from which to undermine or overturn the surface, of which the pigs are not slow to avail themselves. But neither of the two substances mentioned is open to destruction in this way. The one—concrete—is too hard and unyielding, and the other—tar macadam—too elastic to allow of sap and mine by the pigs. The floor of each pen must have sufficient inclination to run all liquid off to one side. The preferable plan is to give the floor a good hang towards the troughs. There, at any rate, the bulk of the mess will be, what with spilled food and dribblings and droppings from the animals as they stand expectant alongside the passage. The troughs may be raised a little from the floor in order to let liquid matter escape beneath them,

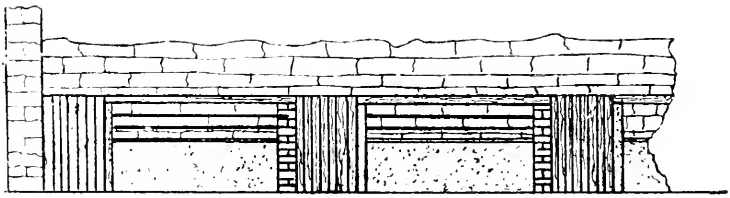


FIG. 251.

and a gutter along the side of the passage will catch all this and lead it out of the building, and round the corner into the dungstead. Unless, however, the place is well kept, matters are better when the troughs are bedded on the floor, and no liquid allowed to pass beneath, for if the space between trough and floor be not regularly cleaned out, the matter therein is apt to become offensive. Besides, if they stand too high above the floor the pigs are tempted to seek their overthrow. A shallow gutter in front of the troughs (inside the pen, that is to say) will serve to carry liquid stuff to the door, by means of which it can escape into the gutter at the side of the passage. Occasionally part of the floor of each pen is raised a little above the remainder for the purpose of keeping that part dry and clean; but this breaks the continuity of the floor too much for our liking. With a pen of the size we have quoted, and with the floor arranged as described, there is ample room for the pigs to choose a corner well away from the neighbourhood of the troughs.

Trough accommodation for seven and the narrow door take up the length of the pen. A single trough might, no doubt, be made to afford the seven spaces, and thus take up a little less space. It is better, however, to have two troughs, one of four divisions and one of three, because it might happen at a time that only two or three pigs occupied the pen, and to part the food of three into dishes for seven is a little ridiculous, as well as wasteful.

The Partitions between the Pens.

The partitions dividing the pens are of nine-inch brick-work. The cope may be of bricks set on edge or of cement, just as one chooses. The brick partition, when neatly pointed with cement, is quite capable of putting piggy's snout at defiance. Indeed, we would have none of the walls of the pig-house built of other materials than bricks and mortar. Rubble work offers too many weak parts in its armour to remain long unscathed from the attacks referred to, and once a start towards defacement is achieved, the wall soon becomes unsightly. It is not at all times practicable, however, to avoid rubble work in the erection of the pig-house,

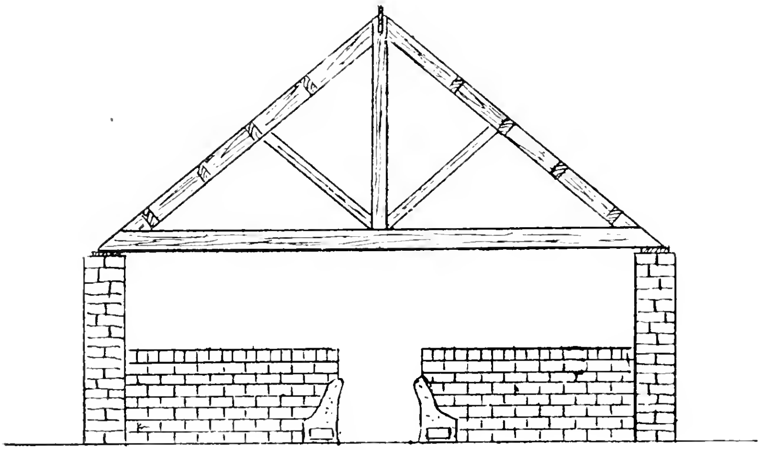


FIG. 252.

more especially when, as in this instance, it is being built against the dungstead wall. But cement can here as elsewhere at the homestead be turned to good account.

In the other instances represented we have the pig-house standing separate from other buildings, and as regards these there is nothing to hinder their being built with brick. With them we stick to the same relative position in the steading as before. More accommodation being required, we double the house, as it were, by having, as in Fig. 252, a central passage with a row of pens at each side. And instead of our keeping them broadside to the dungstead, as with the single one, we place them end on to it, so that each row of pens, with its gutter in front, is on the same footing with regard to convenience of access to the manure heap. And placed thus the pig-house has its other gable in the best position possible for convenience of service from both cooking house and straw barn. Otherwise the two kinds of houses are alike. Although the double pig-house is shown detached from the dungstead, there is nothing whatever to hinder their being united as with the single one. The gable would be coincident with the dungstead wall, as in Fig. 253. This allows more room in the court, and renders the house easier of cleansing, though it hardly adds to the salubrity of the latter.

In Fig. 252 we give a section of the double pig-house. We make the side walls eight feet in height. Less might do, but it is as well to allow the animals plenty of air so long as the house is not thereby apt to be unduly cold in winter. Here, too (in the single as well as the double house), we would have the roof wood planed smooth. Two at least, but better three, of Craig's ventilators would be required on the ridge of the double house. And four or five skylights would be needed to light the place; the single house being dealt with in proportionate lines. The skylights we would have hinged, so that when the weather was warm or close they could be opened at will. Air inlets in the side wall, as prescribed for byre and stable, are hardly needed here. One or

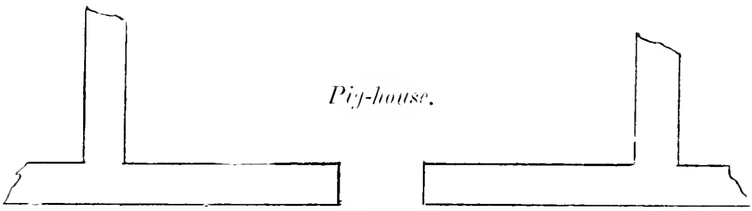


FIG. 253.

other, and at times both, of the doors can be left open when extra air flushing is desirable. With a door at each end it generally turns out that one is sufficiently in the lee to allow of its being left open without harm to the pigs.

The Pen Doors.

The simpler the pen doors the better. Two layers of boards nailed firmly together, as in Fig. 254 (which gives the two sides and end of such a door), answer better than a door of the pattern given in Figs. 114 and 115. The outstanding boards on the latter offer a purchase to the pigs' teeth, which is speedily turned to account to the detriment of the door. It is possible, of course, to keep the smooth side of the door inwards, but this is too untradesmanlike a proceeding to be recommended. The door that is smooth on both sides is the more suitable; and it is much the stronger of the two. Strong and simple ironmongery suits the pig-house door. It is as well to have both styles of stone. Wood could be used for the one to which the door is hinged, but wood is not lasting enough for such a position. Strong hook-and-band hinges—the hooks batted to the stones with lead, and a simple slip bolt outside do very well. The door should fit pretty closely to the floor, so that little leverage is afforded to the investigating snouts of the prisoners; and for the same reason that leads us to discard the cross pieces of the single door, the side of the door that is vertically boarded should be on the inner side. The outer doors would be sliding ones, such as recommended for the generality of the buildings.

The whey tank already discussed would fall to be placed in a position handy for the administration of the stuff. Some place apart from the pig-house proper is a necessity in the case of the littering of sows, when such form part of the live stock of the farm. But accommodation of this sort need not be difficult to find.

The Dung-stead.

The dungstead we would enclose within walls, as shown on the three Plans. On each we have it the same size. But its size is a matter that would fall to be decided by the circumstances that characterized the farm. At a homestead where cattle-boxes and open courts are provided, the dungstead is

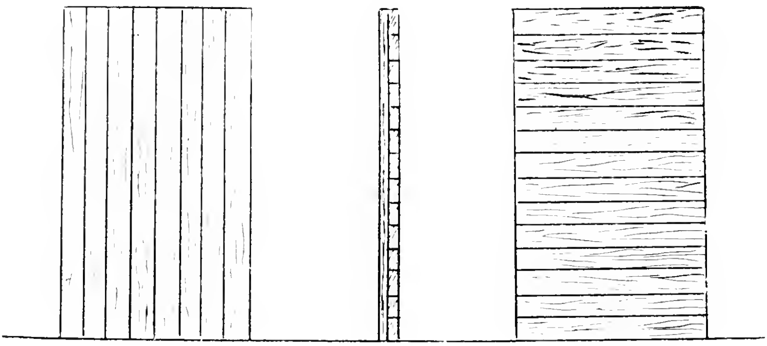


FIG. 254.

of comparatively less importance than at one intended to meet the wants of dairy farming. At the former, the litter from only a small proportion of the animals finds its way to the dungstead; at the latter, it nearly all is thrown therein before it reaches the fields. The dung that collects in the boxes and in the courts is carted direct from these places to the fields; and the greater bulk of the straw from the cropping farm is trodden down in box and court. But at homesteads where neither boxes nor courts are made use of, the dungstead is the general collecting depôt for all the manure produced about the place. At the average arable farm, therefore, the dungstead does to be comparatively smaller than on the strictly dairying one. It has to be borne in mind in this connection, however, that dairy cattle, at least as managed in Scotland, produce less bulk of manure than is left by beef producers. We have already referred to the thinness of the contents of the dairy farm midden. Walls are, in fact, essential to keep a midden of this description within bounds. A slight depression in the ground will serve to keep the drier affair in a reasonable space, and prevent the unsightly oozings stretching all round therefrom; but unless the fluxy accumulations at the dairy farm are stricter dealt with, they will in time spread out and settle down as a thin cake over the ground. It would never do, however, to have even a mildly straggling midden, far less a sort of cold lava-stream affair, such as the last-mentioned, taking up the side and entrance to our otherwise well-planned and effectively constructed homestead. An enclosed dungstead is, therefore, an essential, whether at the cattle-feeding or the cow-milking homestead—the size thereof to be regulated in accordance with the requirements of the farm.

The Formation of the Bottom or Floor. The bottom of the dungstead must be dished or hollowed in such a manner that moisture will collect therein, and not ooze away from it here and there. And the bottom must be rendered impervious, so that the liquid matter may be retained. As a rule, the necessary excavations leave a surface that proves watertight without further treatment. If we happen to strike the till or boulder-clay there is no fear of anything escaping down through it. Rock may have to be excavated, and if on edge and seamy there is risk of loss here. But whether the bottom of the dungstead be in subsoil as distinguished from rock, or in rock itself, of which the watertight effect is doubtful, a preventive against the latter condition can be had without going to much expense. A coat of clay and broken stones, or till alone if it can be had, will make matters right in the first instance. A coat of this description would not be long upon rock. The horses' feet and the wheels of the carts would work it away therefrom. But a thickish mixture of Portland cement and water, run over the weak parts and brushed therein, would prevent leakage. In any case, there need be no recourse to such expensive precautions as laying concrete, unless, of course, exceptional circumstances rendered the use of that or of some other form of pavement necessary.

It must not be expected, however, that the mere hollowing out of the bottom of the dungstead is sufficient to make it capable of retaining all the liquids that generally find their way there. The shallow basin thus formed is meant to collect and save the natural drainings alone of the dung, as wheeled from byre or stable to the dung heap. Anything beyond this it is not supposed to accommodate. Both the ordinary rainfall and the contributions from the grips should be led elsewhere, if the midden is not to be overloaded with wet or unduly diluted, with the consequence that some of its manurial matters are certain to be lost so far as the fields are concerned. When the basin is full the liquid contents are bound to spill over, and while contributing to waste they mar the appearance of the homestead, and are offensive to the passer-by.

Often, no doubt, the contents of the dungstead at some arable farms are too dry, and would be improved by wetting; not, however, by merely passing liquid through the mass, as would happen were the bottom leaky or were the bottom of such a shape that no water would lie thereon. There would be little good done endeavouring to keep a midden of this nature in a moist condition. Both water and liquid manure would pass through, and make their escape either at bottom or at sides. Walled in, however, and bottomed in the manner we suggest, the midden is quite capable of retaining a due amount of moisture. But one must be able fully to control matters in connection with the treatment of the manure that is naturally prepared in the dungstead. It is not enough just to empty the stuff therein and let it take its chance. He must be able to relieve the half-drowned one; and, on the other hand, be able to administer moisture in proper amount to the dry and fusty one. The possession of a liquid manure tank enables him to accomplish the first, and a roof over the dungstead helps him materially in the latter aim.

A Liquid Manure Tank a desirable Accessory to the Dungstead.

The possession of a tank of this kind allows the farmer at one time to keep his midden free of superabundance of moisture, and at another to apply liquid manure to the too dry and therefore chemically inert fibrous matter of the moistureless midden. The tank enables the farmer to lead the liquid directly thereto, as well as acts as a relief to the midden when it is inclined to become waterlogged. And its contents further enable him to distribute a most efficient quickener over his dungstead when it shows signs of the want of such. The place for the tank, of which we have already spoken, is one handy for the liquid being pumped either into water cart or on to the midden; account first being taken, of course, how its proposed position will suit the flow of the drains that will empty into it, and answer for draining into itself the superfluous or overabundant moisture of the midden. Long, deep, and narrow, we suggested the shape of this tank as being one more readily kept out of the way, and easily, as well as more securely covered in.

A Cheap and Simple Method of Roofing the Dungstead.

Care being taken that no rainwater drains empty themselves into the dungstead, and no eaves-gutters near at hand discharge therein, and further provided with a roof to itself, the farmer has then full control of the midden, and is therefore free to manage it according to enlightened ideas. An inexpensive roof answers as well for the purpose in view—the turning aside of rain—as a costly one. A corrugated iron roof is less expensive than a slated one; but cheaper still is one of wood. An ordinary board roof is not usually a long liver, even when tarred or felted; but one constructed as after described will last as long as an iron one without assistance either from tar or felt.

The roof we refer to is called the open-board roof. The boards composing it neither overlap nor do they touch each other. Neither do they rest solid in the purlins, but on galvanized studs (hobnails or tackets) driven into the latter. The secret of the long life of the boards framed in this manner is the keeping of the wood surfaces apart from each other. There are no joints in which water can lodge and set up decomposition. Water runs from the roof at once, and the wind is free to whisk round every board and whistle through every joint at pleasure. Situated thus the boarding is under ideal conditions for seasoning, and can hardly ever suffer severely from weather. One naturally thinks at first sight that rain must fall

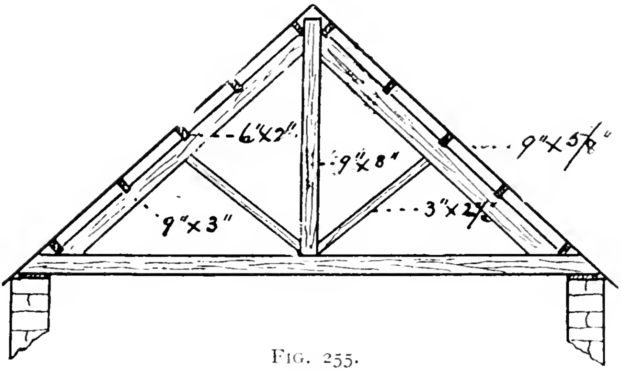


FIG. 255.

through the slits between the boards, but what gets through is hardly appreciable, not, at any rate, so far as the dungstead goes. The boards attract the raindrops to themselves, away from the openings; and to safeguard the latter from water escaping down these small grooves, as Fig. 257 shows, are formed close to the edges of the boards.

Fig. 255 represents a simple truss suitable for this class of roof. Nine feet or so apart is a suitable distance to erect these at. Pillars may be raised on the side walls of the dungstead for their support, and a strong wallplate be carried all along the sides from one pillar to the other. Twenty-five feet is about wide enough for a single span. More than one span necessitates centre gutters and supports or pillars inside the dungstead.

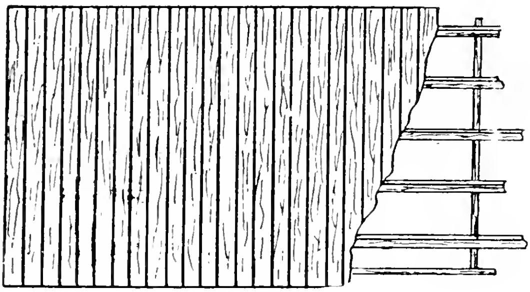


FIG. 256.

Fig. 256 shows how the boards are arranged in the framework of the roof. Beyond a certain length of boarding it is not advisable to go, because by the time the foot of the boards is reached the accumulating raindrops have grown into a streamlet ready on small occasion to burst its bounds and take short cut through the slit on either side. But boards of a length to suit the span quoted above, and laid on at an angle of 40 degrees at the eaves, do not constitute conditions of a too exacting nature. Eaves-gutters may be hung on galvanized hooks attached to the boards; or, perhaps better still, be hung on hooks screwed to the wall plate.

Fig. 257 is part of a purlin with three boards attached thereto, all on a larger scale than the others. The purlin itself is marked *a*; *b* represents the roofing board; *c*, the stud; *d*, one of the wire nails that fasten the boards to the purlin; *e*, the slit between the boards; and *f*, the side

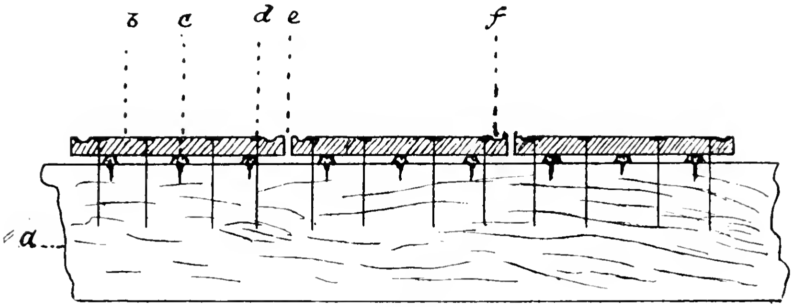


FIG. 257.

groove in the latter. The boards used are simply the ordinary sarking boards we put on preparatory to slating, nine inches by five-eighths of an inch in size. Selected boards should, of course, be chosen—those free of knots and flaws generally—and they should be planed on what is to be the exposed side. The boards are placed about one-eighth of an inch apart. Each one bears on the respective purlins on three studs driven therein, and is attached to the purlin by means of four wire nails, all as shown in the last Fig.

CHAPTER XVI.

THE CATTLE COURTS, THE HAY AND SHEAF SHEDS, AND THE SHEEP FANKS.

The Cattle Courts require a Favourable Exposure.

THE cattle courts (the "courtins" and "hammels," as they are variously termed in places), on account of their openness, need a favourable situation as regards both aspect and shelter. Where we place them they are in the best position at the homestead in these respects. They lie open to the south-west, and have the main establishment between them and the north-east. A good broad road separates them from the rest of the buildings. And this being the main access to and from the fields, puts them in easy communication either with the farm or the highway. Although detached from the other houses, they are not so to such a degree as hinders close enough contact between the two groups. The cattle courts are not so very far removed from the commissariat departments of the homestead but what, if desired, the cattle can be catered therefrom. It is no hardship the courts being at some distance from the straw barn. The straw as litter is usually supplied to the courts in big quantities at a time, as much, at any rate, as will do from one thrashing day to another, and is carted direct from the mill into the several courts, so, under the circumstances, a few extra yards distance cannot tell much on the labour bill. Besides, the courts can easily be provided with storage for roots, and hay and straw, and thus be rendered for a time almost independent of the homestead proper. There would then remain only the cakes and meals and the cooked food to be dealt with, which is no great hardship. The place of preparation of these, and the place of their consumption, as here represented, are not so far apart as to make their periodical conveyance from one to the other in bag or in barrow a serious matter.

The Number and Size of the Courts at the Homestead ruled by the Amount of Straw Available.

The number of the courts and the size of each will be ruled by the circumstances of the farm. There may, for instance, be more straw available than can be turned to account for fattening cattle, and a number of stores or younger cattle may in consequence have to be kept. This would, of course, call for extra room both in number of courts and in their size. But these are points that need not be pressed. So much depends upon the class of cattle that are kept, the custom of the district, and so on, that what suits the requirements of one place may be considered unsatisfactory at another. Even the space to allow for each occupant of the court, and what proportion of the same of roofed to open there should be, it is needless to discuss. But the broad lines that include the subject are universally applicable, and they are few, and easily followed.

The Construction of the Courts of an Inexpensive Nature.

Neither the framework nor the fittings of the cattle courts are of an expensive nature. Simple and strong are the qualifications looked for here. It is necessary that the outer walls that include three sides of the whole be high and strong. Good rough rubble work is perhaps the best. The remaining barrier, the one next the other buildings, is more convenient when constructed of wood. The various kinds of food would be administered at this side, and wood lends itself more readily than stone to convenient arrangements for this purpose. Inside the block the division between shed and yard would be similar to the outer walls, while those that portioned off the whole could either be of wood or stone. Stone is, on the whole, the more satisfactory. Wood, however, could be made to do service for a long time, more especially under roof. And it lends itself more readily than the other to a remodelling of the block, should this at any time be desired. Were the wood divisions railed, they would be more serviceable than if constructed in the manner of boarding. But barriers that allow cattle to see what is going on throughout the block may interfere with the well-being of the animals (it will with some kinds, no doubt), and, therefore, be rather out of court at places. Old railway sleepers would make a sufficiently close fence for this purpose. Set up in the usual style they would last a considerable time, and they would effectually curb the curiosity of cattle unduly disposed in that direction. But a stone fence would be cheaper in the end. It would take up more room than a wood one, but space is not expensive at this part of the homestead.

No artificial Flooring needed.

No artificial floors are called for in connection with the cattle courts. If we except a part along the front of the wall or partition next the road at which feeding would take place, which in fact is hardly a part proper of the cattle courts, the whole floor space of the latter is sufficiently good if it comes up to the standard we laid down for that of the dungstead. Each division should be constructed to retain the moisture that falls to its share. Accordingly, therefore, the floor of each must be basined out to a certain extent, so much so that it will not spill over into other divisions, but when overcharged relieve itself by way of the entrance gate. The degree of hollow given to the bottom of the court will depend of course almost entirely on the rainfall at the place. Where it is heavy the bottom will have to be all the more scooped out. The floor of the shed had better be gently inclined from all sides doorwards, and be well above the level of the floor of the yard, so that it may be able to relieve itself of excess of moisture in that direction, and be fitted to afford a dry bed to the cattle. It looks bad to see a thick brown effluent stealing away from beneath the gateway of each courtyard, and it is no doubt wasteful to allow this. If the courts are contrived as we suggest, however, there will not be much of this going on. The wetness in the deep part of the basin will call for additional straw, which will absorb the liquid and keep it from draining outwards. It will be advisable to keep all water from gaining access to the courtyards other than falls from the skies. The rain that falls upon the roofed part of the court should even be diverted from the yard, at least in wet districts. And water from beneath must be guarded against. There must be no springs suffered to contribute water to the floors of the yard. If there be such within the site of the cattle courts they must be intercepted outside,

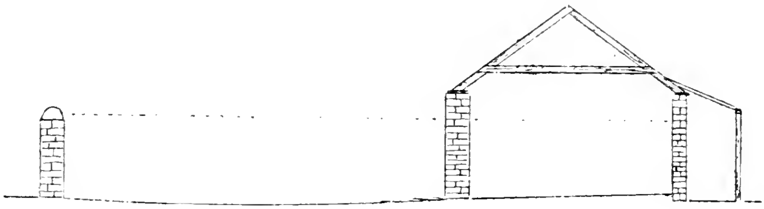


FIG. 258.

and a passage given that will prevent their doing harm in the manner indicated.

A Section of a Court and Shed.

In Fig. 258 is given a cross-section of the cattle courts. The sloping bottom of the inner floor and the dished one of the outer is easily observable. The roof, it will be noticed, we carry beyond the side wall far enough to cover the path alongside and protect it from rain. The path might further be railed off from the road, which would permit fodder and other cattle foods to be left secure there until wanted to feed the animals with. The section shows a roof intended for slates. The open-board roof is in some cases perfectly practicable, however, and so is a corrugated iron one. Six feet ought to be ample height for the courtyard walls. The end ones, that is the outer side wall of each of the end courts, might with advantage be built a little higher, as a screen from the wind. A close-boarded gate or door would be the consistent finish of the gateway into the court. But where the ordinary field gate is considered sufficient, the one given in Fig. 259 is a more serviceable affair than the hung one, more especially as there is little traffic out and in of the court this way. No gate is required between shed and court, the cattle being at liberty to go from one to the other, whether influenced by whim or motive. Two narrow communications might be better than a single wide one. They would make matters easier for some of the animals, at any rate. When the bully came in at one opening the diffident ones could slip out by the other, and should he take it into his head to lie down in the doorway, the others would still have way of ingress and egress. But the one opening is the more convenient when it comes to the removal of the manure. And perhaps it makes the more comfortable shed. If the court and shed are both of extra size, two openings might be of advantage in every way, but in ordinary cases the one is sufficient. Sometimes shed and court are in one, as it were, there merely being a part of the yard protected from rain by means of a sort of roof or covering projecting over the top of one of the walls. There is not much shelter from the blast under an arrangement of this kind, however. It may do in

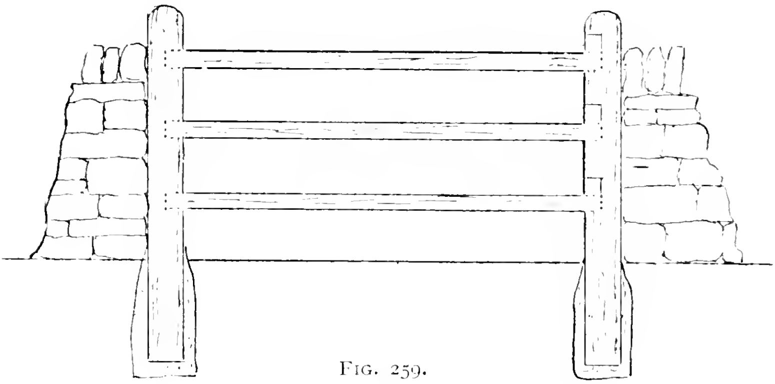


FIG. 259.

exceptionally sheltered and mild situations, but these are few and far between in our climate.

The Arrangement for supplying the Wants of the Animals in the Courts.

The cattle being fed from the road, the troughs and hecks are arranged along that side of the shed. It is quite practicable to fill both trough and heck without the attendant having to enter the shed. All the same, it is as well to have a wicket entrance at that side. It will be a handy place to get in by when a close inspection of the cattle is wanted. What is even more important is its being there to allow of access to clean out the troughs now and again, which it may not be easy to do from the outside of the shed. It is necessary, in order to gain full advantage of the shelter afforded by the shed, that this side should be pretty well closed up, consequently flaps are almost essential over the several openings through which the food is passed inside; and that the partition be boarded close up to the roof. These flaps are generally an annoyance to the attendant, but they may be dispensed with if we board up or build up the barrier between the path and the road, and thus make it a complete passage as part and parcel of the shed itself. When this is done and doors are fitted up at either end of the passage, we may then take greater liberty with the partition between it and the shed. A sparred partition, such as we suggest for the boxes, or at any rate a boarded one, would then suffice to divide the passage from the shed. This would enable anyone to see what the cattle were after. The closed-in passage would be much improved, too, as a good temporary store for fodder and other cattle food.

Food Stores in Connection with the Courts.

A fair-sized store for roots might be built at one end of the block; and another for fodder at the opposite end, as in Fig. 260. But a better plan still, did it not mean too extensive an affair, would be to widen the passage side of the shed, as in Fig. 261, to such an extent that it would serve for regular storage as well as for passage. Carts could then be backed in and discharged of their contents. Where the courts were numerous, too much room might be thrown on one's hands—more, at any rate, than was needed as service accommodation for the cattle courts. But this might be got over by placing the extra width towards the middle of the range, and narrowing the remaining space towards each end.

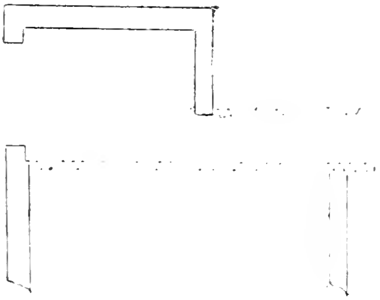


Fig. 260.

The widening of the shed would mean, of course, shifting the whole block a little further away from the remainder of the homestead than is shown on Plan I. It is as well to have a good wide road here, and it matters little to keep the yards a few more feet further from the central department, while we are making affairs easier at the side where nearly all the constant work in connection therewith is carried on. When a considerable number of courts happened to be in demand, the double arrangement, such as we show in Fig. 262, would answer well. The courts still maintain the relation to the homestead we have assigned them all through; and the centre place roofed with iron gives a commodious service passage and store in one, from which the cattle on either hand would handily be attended to. The side walls of the sheds would in this case run at right angles instead of parallel with the road, as before.

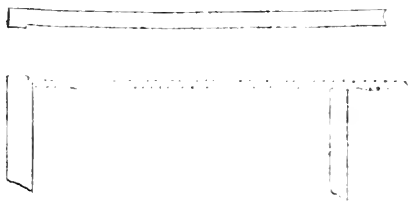


Fig. 261.

No light in addition to what proceeds by the openings to the yard is required in the shed, but lights are needed if the shed roof is extended on the other side. If merely the passage is covered and it is only railed off from the road, it will be light enough without windows. But should the side of the covered passage next to the road be built up close, a roof light or two are then required; and if extended to form both passage and store-house, more in proportion must be fitted on this mutual part of the roof.

Supplying Water in the Courts. A supply of water in the cattle courts is sometimes considered essential. If it can be dispensed with, however, one is well clear of it. When it happens to be laid on it usually leads to constant bother to the tenant. Pipes get broken at one place and choked at another, and frost, should it get them under its clutch, brings all to a standstill. And troughs and fittings are continually getting out of order. When roots are in abundance there is no need for water being put before the animals. But when roots are scarce and the food on that account dry, the cattle require an occasional drink. It is almost a pity, however, to go to the expense of installing a water supply in the courts even when water is freely available. The initial

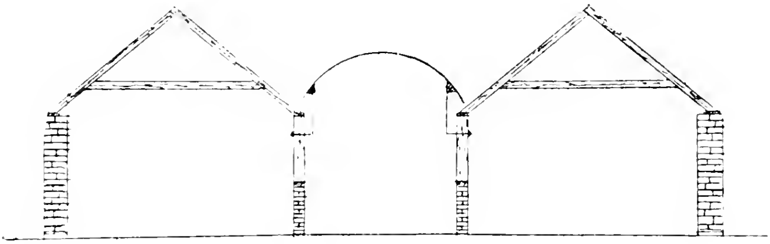


FIG. 262.

cost will not be trifling; and as we have been pointing out, the upkeep thereafter, if not very serious, is certainly annoying. If one can be sure that water will be only occasionally wanted in the courts, fitting up a special supply for them would be mere waste. It could be carried to the cattle at these odd times. When, however, it is likely to be almost constantly wanted, the matter must be faced, and its accomplishment gone about in a proper manner. Pipes and troughs are safer in the shed than out in the yard. Frost, their arch enemy, has less power inside than out in the open. The presence of a water trough in the shed means the spilling of a certain amount of water round about it, which is the worst fault we have against its introduction there. It can be so arranged, however, that one trough will serve two sheds. A hole in the mutual wall will admit of an end of the trough being in one shed and the other in the next; and if provided with a ballcock there need not be so much spilling and throwing about of water after all. Or the trough may be let into the wall in such a manner that cattle at each side of it may be able to drink therefrom without being able to butt one another. This plan enables the trough to be kept flush with the two sides of the wall, doing away with projecting corners in the respective sheds. When it is decided to dispense with water pipes inside the courts, we would prefer to fix up the troughs intended for an occasional supply out in the open courts, somewhere against the end walls. A hole in the wall and a sort of hopper or filler apparatus would make it quite easy to fill the trough from the outside, either out of water barrel or bucket. And here, as inside, one trough might, in somewhat similar manner, be made to supply two courts.

The Fittings of the Court Shed. The fittings of the shed are not of great moment, not as regards expense, we mean. They are of moment as well as those of the other buildings we have gone through, but almost solely from the point of economical working. The courts need none beyond some outer gate or door already referred to. And in the shed, if we except the front barrier, there are merely the troughs and the hecks to provide. Either one or two troughs common to all is the usual arrangement here. It depends on where we place the door or wicket between shed and feeding passage whether we make the trough in two or in one. If we place the wicket at either side of the shed the trough may then be continuous: but we prefer to place it in the middle, therefore the trough is divided in two equal parts. If we are to have an opening at this side at all it is better, we consider, to place it thus, and thereby make matters pleasanter to the cattle. They will get along all the friendlier and jostle each other less when there are two troughs in place of one, even though it be a long one indeed. Wood is the common material out of which the trough is made. Stone is sometimes used. But here again glazed fireclay is superior to either. It is to be had in lengths with open ends, which can be butted closely together. Any length of trough can thus be put together. Pieces with closed ends are manufactured to go with these when desired. An end piece can, if wished, be dispensed with next the wall at either side, but bordering the gap at the wicket end pieces would be necessary.

The Troughs. It is open to have the troughs laid upon pillars, or on a solid built bed running the whole length of the trough, just as one thinks fit. It is not practicable to have a trough of this description made to slide up and down in accordance with the amount of straw that comes to be trodden underfoot by the cattle. Wooden troughs may be so arranged that this can be done. But we question the need of such a proceeding. The troughs may be put up a little higher than usual. This, if perhaps a rather awkward looking arrangement to begin with, is daily improving as the tramped down straw accumulates. By the end of the season the cattle may find the trough as low set as it was high when they were ushered into their winter quarters, but this is a less inconvenient state of matters than the former, cattle, as we remarked in a previous chapter when discussing a similar subject, being accustomed to pick up their food from about the level of their feet.

The Fodder Racks.

The fodder rack or heck is easily made movable, if this is considered advisable. The latter plan, however, is to have it a fixture, because fixed fittings are both simpler to make and they last longer. We prefer it fixed above the trough on account of its being more easily filled there from the feeding passage than it could be anywhere else. If placed against either of the side partitions, or against the side or outer wall of the shed, all fodder would have to be carried into the shed before the heck could be reached. But placed as we suggest very little of either trouble or time is taken in replenishing it from the feeding passage. The fodder can be filled in with the hay-fork direct from the heap lying in the passage or store, or from the barrow as it is brought along the covered path.

Fig. 263 represents the elevation of a boarded barrier between passage and shed, assuming that the sheds are erected in such a manner as to admit the barrier being comparatively fragile and open

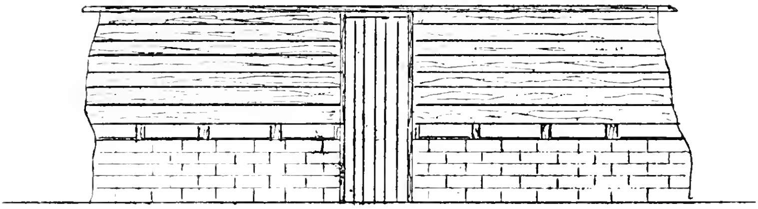


FIG. 263.

in structure, without fear of the cattle suffering from the exposure which such a method implies. It can be kept close as high up as will prevent the cattle seeing what takes place in the passage side thereof; and above that be merely sparred, or it may be boarded up the full height, as we show. It may indeed, if wished, in some places be left open altogether above trough level without prejudice to the cattle enclosed. When the doors of the passage or store are closed, the cattle are as completely shut off from draught at that side of the shed as if the barrier was carried up as a close partition to the roof.

The Court Gate.

The wicket may be of open construction, or a door may take its place if considered more suitable. A wicket that one can see through might be allowed in the boarded barrier, for all the width of view it would afford (two feet or two-and-a-half at the most, being meant only for occasional use by the attendant or the farmer) would hardly tend to distract the cattle which happened to gain a peep thenceforth.

A slide or hopper arrangement for guiding food into the troughs when delivered from the passage is an essential fitting at that side of the barrier. Each trough requires a thing of the kind, and it must be carried along the whole length of the same. But it is a simple contrivance, only an inclined shelf or board supported on brackets on which the contents of bucket, box, or basket can be emptied with the assurance that they will find their way into the trough in the shed.

The kind of Timber that may be used in the Construction of the Shed.

Such are the simple fittings of the cattle courts. Rough unplaned wood is quite good enough for the timbered parts. Here, indeed, is the first part of the homestead where estate-grown timber can, we consider, be used to advantage; and we have all but completed our round of the buildings. If matured and well-seasoned it matters not much what kind of wood it is—oak or sweet chestnut among the hardwoods for posts; and larch, Scots pine, spruce, or silver fir among the soft woods for boarding (the former two for either). But if neither well-grown nor properly seasoned, it had better be used for firewood than put to the purpose indicated. If the estate on which the homestead is being erected is one of the larger sort, and is well planted and well manned, there can surely be no difficulty in turning out some suitable wood for finishing the interior of the cattle courts. We do not advocate its use in the framework of the roof (though even that is also capable of accomplishment), but only for the rough fittings we have been referring to.

The Hay and Sheaf Sheds: home-grown Wood effective as Pillar or Post.

In the construction of the hay and sheaf sheds, which are the next erections to claim our attention, we come to another set in which it is quite practicable, to a considerable extent, to make use of estate-grown timber. Larch or Scots pine make excellent posts for these sheds. So, of course, does oak; and perhaps sweet chestnut might do too, but we cannot speak from experience on that head. Larch and Scots pine have this advantage over the others, that if the trees selected be sound and well grown, and are seasoned somewhat, the trunks can be used as posts just as they grew. It is sufficient to strip them of their bark, and erect them in the positions they are intended to occupy. The outer skin of wood soon hardens, and if the trees happen to be straight and regular in taper, we have a range of columns far pleasanter to look at than cast-iron ones. They are better fitted, too, to stand the hard knocks that these sort of erections have occasionally to put up with. A wood post is quite capable of standing a knock from a cart that would fracture a cast-iron column, or bend a rolled one. And it is a simple matter to fix them up in such a way that they will be subject alone to the gradual forces that induce decay in timber. By the exercise of a little precaution to keep them dry at ground level, there is not much danger of rot attacking them at any other part. They could be fixed to heavy stones sitting clear of the ground, and in this way kept clear of stagnant dampness at bottom. Were we to do this, however, they would then serve as mere carriers of the dead weight of the roof; they would offer no resistance to side pressure, and a stiff wind might upset the shed. Side stays would be required to counteract this weakness. But these, to be of much use, must project far out, which means their being in the way. If we sink the posts three or four feet in the ground, however, the shed will not upset so long as they hold their own. Sinking them unprotected in the ground means a short life to the parts at and near the surface, for there they are certain to give way very soon to decay. If the underground part be embedded in and surrounded up to a little above ground level by a good body of concrete, it will last as long as the rest of the stick. But the end that stands in the concrete must be dry and thoroughly seasoned, otherwise it may easily succumb to rot.

Should oak be chosen for the posts, it is not practicable to use the trunks in their natural form. There is always a large proportion of unmatured wood on the outer circumference of the stem of the oak, so that, if the naked trunk be set up exposed to weather, this decays, leaving, however, the ripe wood of the centre untouched. This inner part—the well-known heart of oak—will stand the weather undaunted for a long time. Many of us are familiar with old ship timbers that have done duty as gate posts as long as we can remember, and apparently little the worse for wear whether in or out of the ground. If we set up the oak stems as posts, the unmatured wood we have referred to will keep mouldering away; at some parts quicker than others, but the posts will go on reducing in size until the ripe wood is reached. There can be no assured stability of the erection under these circumstances. The post may soon become loose in its setting, and matters thus be aggravated by water getting down between the wood and the concrete; and other pieces of the structure that may be attached to it are liable to become loose too. Instead, therefore, of allowing natural causes to remove the outer casing of imperfect timber from the post, thereby, as we are pointing out, endangering the strength of the building, it is necessary to remove this source of danger before we set up oak posts as pillars of support to the hay or sheaf shed. This implies a much thicker tree to begin with than would be required were we dealing with larch or Scots pine. The oak trunk would have to be run through the uprights in the saw mill before the sap wood could be got rid of, and by the time this was effectually done the trunk would be considerably reduced in section. But once the bone was well exposed, we have then a subject that is well qualified for the position we are assigning to it. The same applies, though in lesser degree, to the sweet chestnut. On many English estates it is turned extensively to fencing purposes, which speaks well for its weather-resisting properties. This is a tree, however, that is hardly representative enough on Scottish estates to be taken into account in the present connection. The larch and the native pine ripen their wood as the concentric layers become deposited; at any rate they keep better up to date in this respect than the oak, and we can safely use them as posts in their natural form, without the risk that is run in doing likewise with the other tree.

The Fixing of the Posts. The side posts or columns of the shed are, as we have said, better to be sunk in the ground about three or four feet. Set up in this manner the posts make the erection quite stable enough without the aid of cumbersome side stays. If the concrete by which the ends of the posts are surrounded is continued till well clear of the ground, there is little chance of damp causing harm to the wood at this critical part. It is there, we repeat, rot first begins on the post that is set in the ground without a safeguard such as concrete. As a rule the part of the post that is farthest in the ground keeps best. It will be wetter there than nearer the top, but is further removed from air, and it is the two together which induce rapid decay. At a point just beneath the surface the post is neither very wet nor is it dry, and air has almost full effect upon it. There it is, therefore, that the sunk part first succumbs to decay. The air and the moisture combined are too much for the woody fibre to cope with, and decomposition sets in. But with concrete to sit upon, and surrounded by the same as described. the buried end of the post is kept clear of the damp earth, and out of harm's way therefrom. Were it not set on as well as in concrete, the end of the post would be in contact with the ground, and damp would be free, under certain circumstances, to ascend among the fibres of the wood. It might be long before this brought harm to the part involved, but the slight precaution of having a little concrete underneath the end of the post is worth taking in order to make sure on that head, and so leave nothing to chance.

Height of the Sheds. The height the shed is to be will depend, of course, on the length of the available posts. Assuming we are to make the shed fourteen feet high to the underside of the wallplate, this means posts eighteen feet long. It is needless to say that this implies some shapely trees if we are to be supplied from the estate, a condition which will bear a little heavily on the rather slipshod methods of sylviculture prevailing on the average class of estate. It is an advantage, however, to keep the roof well up. Adding to the height is proportionately far less expensive than increasing the length of the shed. Sixteen or even eighteen feet is not too great a height for the side of the shed. The sheaf shed, it is true, has a limit above which it is not very practicable to go, seeing the sheaves have to be pitched up by means of hand forks. It is different, however, with the hay shed, for by the aid of a horse fork it is competent to lift half a cart load or so at once, and run it along suspended from the roof to the part that is being filled up at the time.

Their Width. The width of the shed, whether meant for the storage of sheaves or of hay, is ruled as much by the weather that prevails in the district as anything else. If the climate be a moist one neither corn nor hay will suffer to be put together in the same bulk it is feasible to pack them where the air is dry, and crops are nearly always easy to win. From sixteen to twenty-two feet runs the width of these barns. It is evident that the broader the sheds are, no matter what the height is, the greater is their stability. But a shed of this kind, if well put together, can defy wind pretty effectually. It is when empty that they are put to the greatest stress. When the shed is filled up the wind has no separate part to lay hold of, but when empty, or partially so, the tendency of the wind is to lift the roof from its attachment and overthrow it. But with the posts secured in the ground in the manner described, and the wallplate firmly attached to these, and the framework of the roof in turn well fastened to the wallplate, the shed, whether full or empty, can with confidence be left to hold its own with the stiffest of gales.

Their Roofs.

These buildings are for the most part roofed either with galvanized corrugated iron or with wood and slate. The wood or the iron pillar is suitable for both kinds of roof. Our preference is for the wood pillar when there is a pick of trees to be had. When it comes to buying the pillars, however, the price ought to rule the selection of the material. It is quite competent to build brick pillars when the roof is to be slated; and in some situations these may be cheaper than either wood or iron ones. If built fourteen-and-a-half inches thick and, say, two or two-and-a-half feet broad, they would be quite strong; and were the corner bricks rounded off or "bullnosed," the pillars would look neat and tradesman-like. The brick pillar is not so well adapted to the iron roof. The latter is so light, and, therefore, so easily uplifted by the wind when in dangerous mood, that it requires to be bound down firmly to the pillars. The slated roof is so much heavier that its own weight alone is almost enough to hold it steadily in position. Even it, however, requires more or less firm attachment to the pillars. If the latter are of wood it is sufficient that the wallplate be well spiked to them; and the couples or rafters being fastened to the wallplate, the whole erection is thus kept bound together. It is easier, however, to make a firm attachment between the wallplate and the wood or iron pillar than the brick one. There are many ways of fastening it to either of the former two, but the only practical way to secure the wallplate to the brick pillar is to build in a bolt in the centre of the pillar. This, terminating at the free end in a screw and nut, enables the wallplate to be screwed tight down on the heads of the pillars. But the cross-section of the pillar is not so large in area as to afford much weight or much resistance to a snapping force. It is different when a bolt of this kind is built in a wall. We then have a strong point of resistance against both a lifting and a pushing-over pressure. Considering the weight of the slated roof, however, such strength of attachment as we are able to obtain from the bolt built in the pillar is in its case ample to give the necessary degree of stability. But it is different with the iron roof. It needs a firmer anchorage than the bolt in the brick pillar yields. Roof, wallplate, and all will on occasion be riven away from the posts, if the attachment is not of the firmest kind.

If the posts be set up at twelve feet apart ample room is thus allowed for the getting in and out of loaded carts, and for the running in of rick

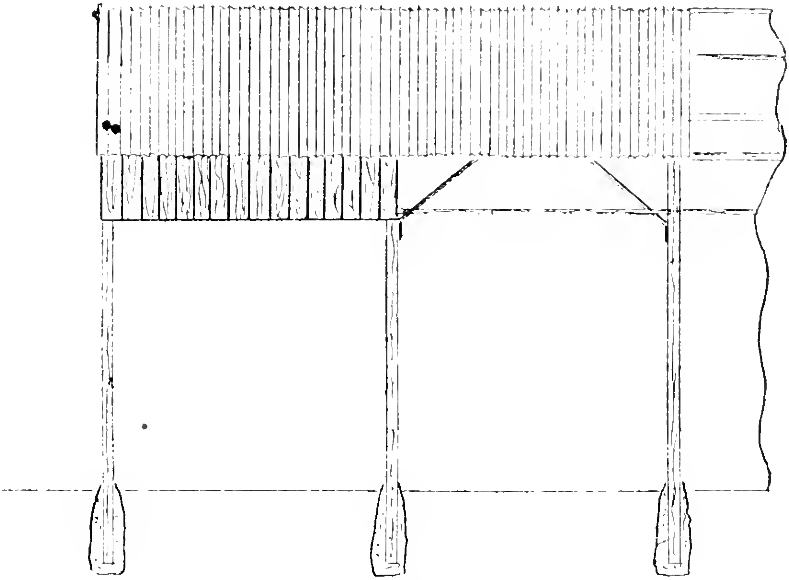


FIG. 264.

lifters with their loads direct from the fields. The height of the shed and its breadth will, as we have said, be ruled by local circumstances. Nine inches by three is, perhaps, as small a scantling for the wallplate as it is advisable to use. With the posts at twelve feet apart the wall-plate is given a good space to bridge over, more, indeed, in the case of

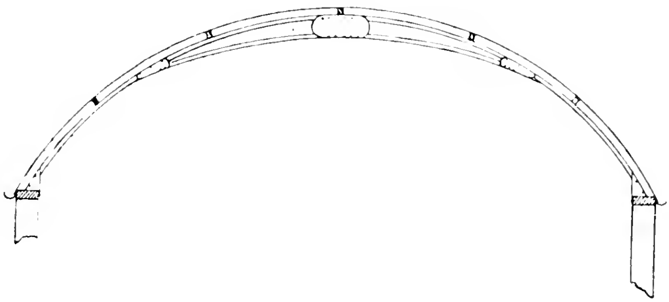


FIG. 265.

the slated roof than it is right to subject them to, unless they are supported by side struts, as in Fig. 264. The struts are advantageous, if not, indeed, necessary, even in the instance of the iron roof. Its own weight is sufficient to cause it to sag down a little between the posts; and besides counteracting this, the struts help considerably towards holding the wallplate down firmly.

An important Point is to keep the Roof as clear of Ties as possible.

It is a most important matter to keep the roof as clear of projecting ties and stiffeners as possible. These are much in the way when it comes to filling up the upper tiers either of sheaves or hay, and they prevent the use of the horse fork in filling the shed. In Fig. 265 we show an excellent form of roof girder (the one in connection with Fig. 264),

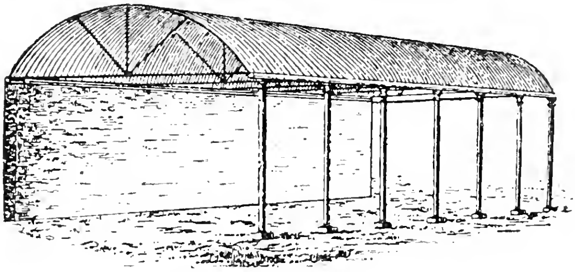


Fig. 266.

which serves to keep the shed entirely clear of all impediments such as we refer to. It is of T angle malleable iron, three inches by two inches by three-eighths of an inch, and wrought to the form the roof is intended to take. One of these sits over each opposite pair of posts. They are fitted with plates, by which they are screwed firmly to the wallplate. And to further strengthen each there is a supplementary girder fitted under the crown of the main one, the two held together by a central fishplate and two gussets of three-sixteenths-of-an-inch steel plate. This, we consider, can easily be dispensed with in narrowish spans.

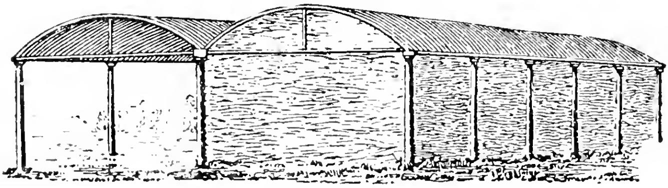
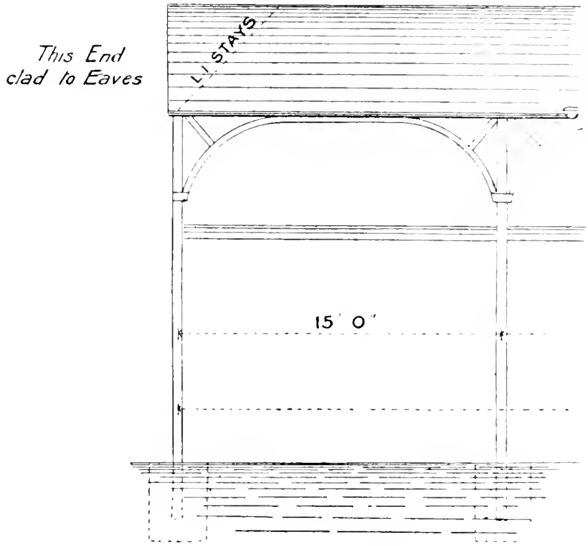


Fig. 267.

The one depicted is for a shed twenty-two feet in width. The purlins, three inches by two inches or so, bear on the girders, being screwed thereto, and to them and the wallplates in turn are screwed down the sheets of galvanized iron. In passing, we may remark that no less a gauge of sheet than twenty-two should be used for circular roofs. One of twenty we would prefer; and for ridge or pitched roofs we would advocate the same.

The circular roof, of which this is a representative, is, in our opinion, superior to the ridge roof for shedding in which sheaves and hay are to



ELEVATION.

FIG. 268.

be stored. The circular roof gives much more headroom than the

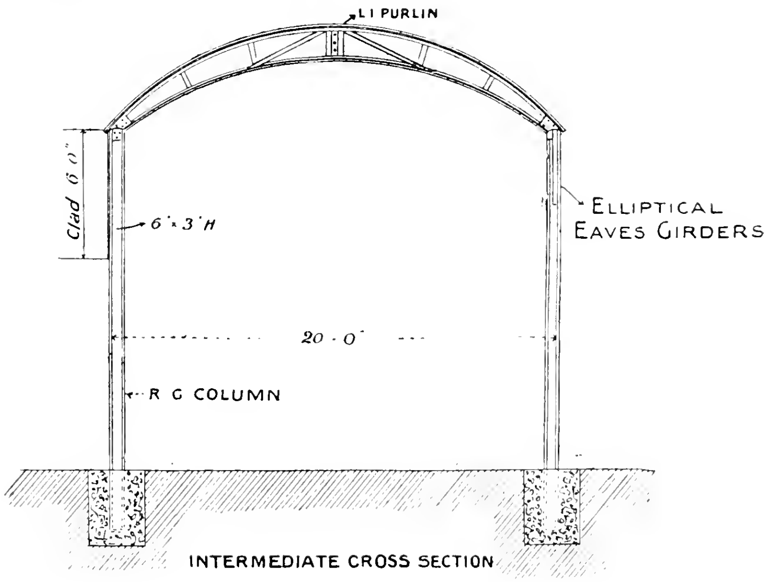
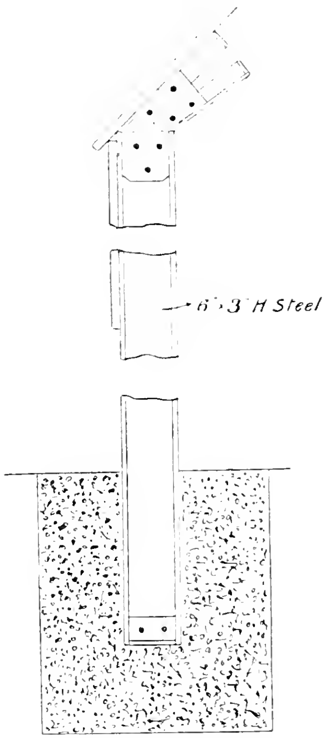


FIG. 269.

other, and enables the shed with ease to be filled almost up to the centre part of the roof.

The Iron Pillar.

The round iron column, when used, is generally bolted to a heavy stone at the base. At the top of the column there is usually a broad flange, upon which the wallplate can get a good bearing and be screwed down to; and lug pieces are formed on it for the support of struts with which to stiffen the wallplate. H angle-iron is now common as a pillar of this kind. They are usually set in concrete, after the manner of the wood post as described. The concrete protects the buried end from rust, at the same time giving it increased weight and stability. It has no need to be sunk so far in the ground as the wood post. All we want is to give it a sure foundation. It is impracticable to attach it to a flat stone on the surface, as we do with the round column; in place of this we sink it in a concrete block embedded in the ground. The angle-iron column has less adaptability for attachment to the wallplate. Some sort of flange has to be fitted to it in order that the two may be securely joined together. A column of this sort is, in fact, better adapted to a barn or shed that is wholly constructed of iron.



Column and End of Roof-girder enlarged.

Fig. 270.

Common Types of Sheds.

Figs. 266 and 267 are common types of shed, all of iron The arrangement of the roof supports are against its utility, however. But the manufacturers of these are beginning to recognize this, as Figs. 268, 269, and 270 manifest. This shed, as manufactured by Messrs. Main, Glasgow, seems almost to have reached the limit of cheapness with efficiency. It can be erected for about £1 a running foot, in accordance with the distance which the materials have to be sent, and the amount of sheeting or lining placed on the ends and along the sides of the erection.

Our preference inclines, however, to the composite shed—the one partly of wood and partly of iron. We prefer to have it all of wood, excepting the roof proper—wood posts, wood wallplate, wood purlins, and wood lining; the only iron parts being the girders, the roofing sheets, and the eaves-gutters and drop pipes. The wood posts lend themselves very readily to the fixing up of lining and the putting in of supports, and so on, and can stand a bump without much ado ; and to us a shed of this kind never looks so harsh and out of place as the complete iron affair. If the wood posts have to be bought, very efficient ones can be made out of either pitch pine or red pine, say, nine inches by four-and-a-half inches, which, if fixed as above suggested, leave little to be desired.

The Slated Shed usually hampered with roofing Timbers.

The slated shed is usually hampered with the roofing timbers overhead. One with the roof framed in the ordinary manner, as in Fig. 271, is very unsuitable, as interfering seriously with the available head room. A principal roof, with the trusses bearing on the opposite pairs of pillars, is generally the adopted plan. But the resulting tie is both

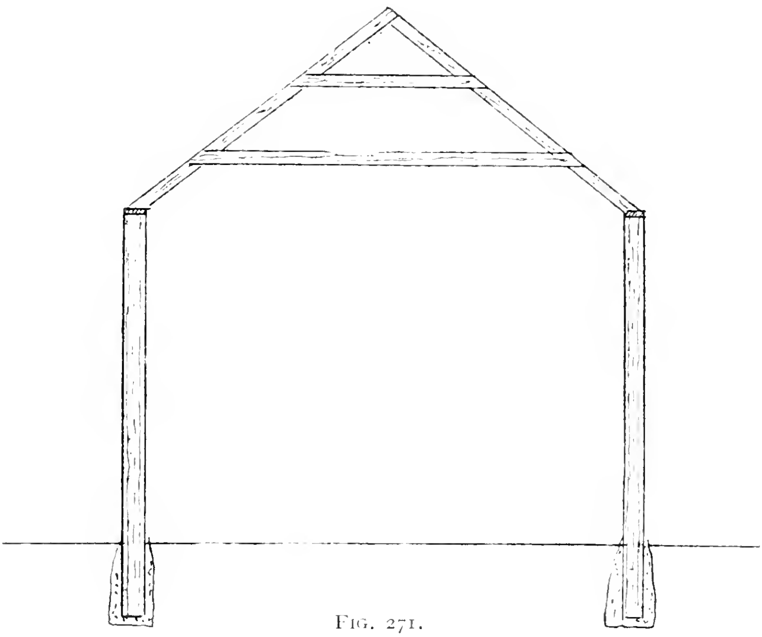


Fig. 271.

a source of annoyance when the shed is being filled and a source of danger to the stability of the shed when it is standing full. If the shed is filled well up to the roof, it is almost impossible to keep the sheaves or hay clear of the tie, and as the stuff begins to settle down great stress is at times brought to bear on these ties, much to the detriment of the erection. The section in Fig. 272, which shows a modification of the couple truss, affords a class of roof that is less apt to come under this risk. Its tendency, however, is to thrust out the wallplate but if the several pieces constituting the truss be firmly bolted together, and the pillars be made stable, this can be fairly well counteracted Comparing either of the last sections with the previous sorts depicting the circular type of roof, brings clearly home to one the truth of our remark that the latter gives more storage room than the other. The men's heads are bumping against the roofing-boards of the ridge roof, unless almost on the very centre thereof, long before wall head level is reached. The rounded roof gives far more freedom in this respect, and can be filled nearly to the iron sheets with a minimum of work on all fours. Figs. 270 and 271 serve also to demonstrate the advantage of

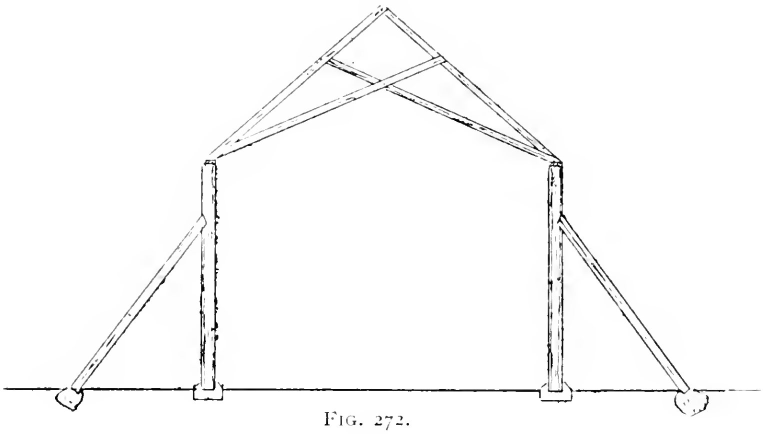


FIG. 272.

sinking the posts in the ground over setting them on stones and falling back on side stays for their support.

A little Ventilation in the Roof beneficial. A little ventilation is almost essential in the roof of the shed, especially if it be an iron one; but it must be of such a nature that snow cannot drift into the shed thereby. A sheet here and there may, by the aid of washers, be so raised a little above the others that a slight draught may be induced, and yet rain and snow be refused entrance.

Eaves-Gutters and Conductors essential. Eaves-gutters and conductors are clearly essential. It would never do to allow the roof water to run down the hay and straw. This occurs in the case of the rick, but the thatch yields it gradually, while the slates and the iron sheets run it off at once. Moreover, the contents of the shed are not usually so well stowed as those of the rick, and the exterior of the one may not therefore be so able to ward off the aggressive attacks of wind-impelled water, consisting not only of rain pure and simple, but with drippings from the roof in addition.

The Lining of Parts of the Shed. In nearly every case the shed is lined down a foot or so from the eaves, and round the gable ends in unison, the tops of the latter to wallplate level being, of course, closed in whether or not. This lining at the eaves is almost a necessity, because as the contents of the shed settle down into smaller bulk an open space is apt to show below the wallplate. This does not matter so much in the case of hay, although even as regards it rain and snow may be blown in at the vacant places referred to; but with sheaves, birds, as well as barn-door fowls, are not slow to avail themselves of the opportunity thereby afforded of gaining both shelter and food. In exposed districts it is usual to see one side and both ends of the hay-sheds completely boarded up; in the case of iron sheds these are usually lined with corrugated sheets. The Ayrshire farmer very often has his hay shed completely closed in, entrance thereto being gained by means of large doors. If hay is being daily taken from the shed, there is certainly less waste under an arrangement of this sort; and tramps are prevented taking free quarters in the place at will. It is unnecessary to put this extra expense on the corn sheds. If they are kept right about the eaves in the manner suggested, they need nothing further in respect of lining or enclosing. Sheaf sheds are not yet, however, much in evidence at our homesteads. We are bound to see more of them ere long. As we remarked towards the setting out of our present work, labour is now becoming so scarce that the building of sheaves into ricks and the after thatching of these is yearly growing a greater strain upon the resources at the command of the farmer. The erection of a series of these sheds on the lines indicated above, means a considerable addition to the cost of a homestead; but it is one, we suspect, that will have to be faced before very long, whoever has to shoulder the burden, whether it be the landowner himself or he and the tenant between them. A lighter and less substantial affair than we have been advocating might do for the storage of sheaves. What we have been dealing with is more for hay than for sheaves. North country farmers can do with a narrower shed for corn than is required for hay. One, say, 16 feet wide could be erected for a good deal less money than another 22 feet wide. With pillars at 12 feet apart, a wallplate $6\frac{1}{2}$ inches by 2 inches, a **T** angle girder in one piece, three purlins $2\frac{1}{2}$ by $1\frac{1}{2}$ inches, and sheets of 22 gauge, an efficient yet effective shed would be the result. But once either our farm implement manufacturers or the makers of hay and sheaf sheds become alive to the demand for such an article, we may perhaps see something developed on the lines of a movable shed or barn for the storage of sheaves.

The Position of the Sheds relative to the Homestead.

With regard to the position of the hay and sheaf sheds at the homestead, their place is, of course, near to where their respective contents are to be disposed of. The site of the sheaf sheds we have already referred to under the head of the thrashing floor. Where we show them on the different Plans, they are handy either for the farm mill or for the itinerant thrasher. It is not so easy to locate the hay shed. At most places, in fact, it is, as we have already noted, more convenient to have two sheds instead of one of their combined capacity. Dairy cows, if they form part of the live stock, consume a large amount of hay of one kind or another, and almost need a shed to themselves ; at least it would be a saving of labour were the hay shed placed nearer to the byres than to the stable. The cows consume more than the horses, therefore more has to be carried to the former, and the nearer the shed is to them there is all the less labour spent in that operation. It may be different when all the hay is chopped before it is given to both cattle and horses. Then the proper place for the shed is somewhere near to the chaff-cutter. At the dairy farm proper, however, meadow hay is saved for the cows and given whole. In a case of this kind, therefore, it is the better plan to let the cows have a shed to themselves, and the horses another. A smallish one may serve the horses' wants.

Other kinds of Shedding at the Homestead.

There can hardly be much need, one would think, for other kinds of shedding about the homestead. We have been dealing pretty freely, we consider, in the matter of accommodation for farm stock, alive as well as dead. Any tenant who gets what we have laid out for him in the past pages need not grudge the expense of any additional casual room he may think necessary in his special case, and we can safely, without blame to ourselves, leave him to his own resources in this connection.

Conveniences for the handling of Sheep.

Before we finish, however, we think it but right to say something more on the head of conveniences for the handling of sheep stock. In discussing the implement shed we pointed out how it was feasible to turn it to account occasionally for this purpose—at clipping time and for dipping. But there are other occasions on which the sheep, if a breeding stock be kept, have to be mustered and examined individually, a process that cannot well be conducted within a building. The ewes and lambs have to be gathered together not long after the birth of the latter, in order that the little ones may be subjected to the mild mutilations that follow on their domestication. Again, when the weaning season has come round, dam and offspring have once more to be penned for close inspection and assortment into classes of different sex and quality. At other times the ewes themselves have to be collected and graded, and otherwise dealt with as the management of sheep renders necessary. Operations of this nature cannot very well, as we have said, be carried out in such close quarters as an ordinary building affords. Plenty of room is required within the muster ground proper, but connected therewith must be numerous pens in which the sheep can be closely packed, so as to be easily within reach of one's hand. And these pens must be so arranged that each can be made to communicate as desired with one or more of the others. Without convenience of this sort it is, of course, utterly impossible to handle a large sheep stock in the manner dictated by good management.

The "Fanks," or the Mustering Place of the Sheep.

This mustering place of the sheep is termed by the shepherd the "fanks." But before we go further with their description and suitable mode of erection, it will make matters easier if we show a plan of a suitable place of the kind. We represent one in Fig. 273. There is first the collecting court (the figure shows one at each end, which is, perhaps, a little extravagant), which requires to be of a considerable size. The sheep are not handled in it, therefore there is no use in crowding them unduly. It is only when we want to be able to touch and closely inspect the animals at our leisure that they need to be packed a little tight. One can then follow up any individual sheep without much exertion, and if thought necessary draw it out from the others and place it in a separate pen. Without some arrangement of the kind it is, in fact, impossible to deal thoroughly with a large flock; and a well-planned and commodious one makes matters easier, both to man and sheep. The work of inspection and assortment can be gone about in suitable enclosures at a minimum of bustle and noise on the part of the men, and of hustling and terror on the part of the sheep; not to speak of the very subsidiary place the fussy dogs have then to take, much to the peace of mind of the operators and to steadiness of nerve of the operated upon. In touch with the outer enclosure are the various pens which are needed for the assortment and separation of the sheep. At the majority of places—

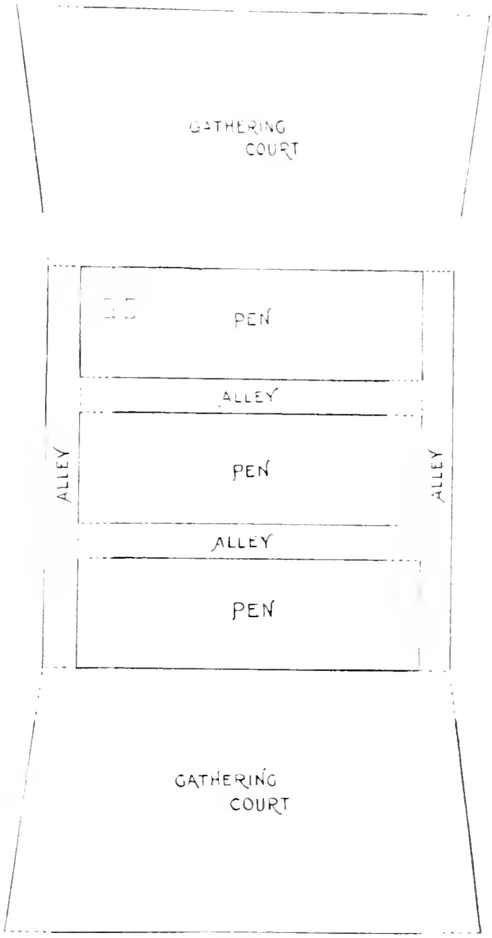


FIG. 273.

at nearly all the hill farms, we may say—the dipper forms an adjunct of the fanks. Its position will of course be where likely to be most convenient. In not a few cases, indeed, clipping also takes place at the fanks, which means either that they are supplementary to the hill farm homestead, or, if at a distance from it, that there are some sheds erected in connection therewith. These are points, however, that are settled in accordance with local circumstances, and do not lend themselves to be dogmatized about. But a good set of fanks is a great boon, no matter whether in close connection with buildings or standing alone. A less complicated set of enclosures answers the end on the arable farm because the lowland sheep are more domesticated and easier handled than their wilder fellows that gain a living on moor and mountain side. Some of the buildings can, as we have seen, be used on some occasions for the mustering of the sheep; and for the other occasions on which they have to be penned a very modified series of enclosures, compared with the fanks proper, answers the end.

The Fence of the outer Enclosure.

The fence enclosing the collecting court—the outer corral of the ranche—is, perhaps, as suitable when in the form of a dry-stone dyke or wall as any other. It needs to be of a fair height if hill sheep are to be gathered and retained within the court. Both the Blackface and the Cheviot are nimble, and if they have been allowed to acquire the bad habit of scaling fences, which they very soon do where the dykes are suffered to become dilapidated, it then requires a very high one, even if pretty plumb and built regular, to keep an old ewe within bounds. And if one gets over, many others will follow suit; they will try, at any rate. A wire fence, or a post-and-rail one of medium height (say three-and-a-half feet), will restrain these active breeds of sheep better than a rough dyke five or five-and-a-half feet high. But the dyke has the advantage of preventing the sheep from seeing beyond the court and thereby adding to their distraction. They settle a little better when unable to see the paths to freedom at the other side of the fence.

The wall needs to be more smoothly faced on the inner side than usually falls to the lot of the dyke. There must be no ends of throughbands left sticking out to show what they are. These would hurt the sheep when squeezed against the wall by their fellows in some frantic rush. Pains must, in short, be taken to build the inner side of the wall as smooth and free of projecting points and corners of stone as possible. These, as well as the throughband ends, while apt to injure the sheep, are at the same time so many points of vantage to any of them that are prepared to scale the obstacle. A ewe well practised in that sort of work will run sideways at a rough wall, making use of the projecting stones, and thus surmount what she would be helpless in undertaking were it built without any projections that could afford her foothold for the moment. To point the joints of the inner face of the wall is in many cases worth the expense it involves.

The Pen Divisions.

A wall is not a suitable fence, however, for the smaller enclosures. Pens divided by means of dykes become close and stuffy when filled with sheep. No air can get in amongst them, and the thick-coated animals suffer in consequence. Open partitions, such as those of wood and wire, and post and rail, allow air to play through them, and in this respect have a very distinct advantage over the dyke. Best of all is a fence after the description of those we see in our large public cattle markets. They have no projecting parts, such as the posts that distinguish the two just referred to. But they are rather expensive for the farm. The posts are no doubt a drawback to the efficiency of both the wire and the wood fence. It is possible, however, at a little extra cost, to qualify that disadvantage simply by doubling the fence, having wires or rails on both sides of the posts. This need not be done at all parts. Only those where sheep are liable to be pushed against need such protection, although when one looks closely into the matter there are few parts of the fanks where this does not occur.

The post-and-rail fence is superior to the post-and-wire fence in this connection. It does not yield so much to pressure, and a sheep pressed against a 4-inch flat rail is not so liable to derive harm as one jammed hard against thin wires. A fank fitted up with posts and rails, the latter doubled where necessary, and chamfered at the edges, forms an ideal one. The sheep get the benefit of all the air that is going, and the shepherds, without having to climb over obstructions, can see at a glance what is taking place in each of the enclosures. If the principal posts be set in concrete, and they and the rails are creosoted before use, the woodwork involved will last a long time.

In some of the narrow alleys of the fanks it is all but impossible to open and close the various gates when the sheep are closely packed therein. It is a good plan, therefore, to have those that are most encumbered in this way hung so as to move up and down vertically, after the manner of a window sash. This is a great convenience at some points of the fanks. The gates are narrow, therefore of no great weight, and no expensive arrangement is, in consequence, required for fitting them up in this style. Nothing further is needed than the lengthening of the posts, attaching guiding fillets to these to guide and control the movements of the door, fixing pulleys on the top of each post, providing the door with a rope and weight at each side, and the thing is complete. Door, ropes, and weights can be taken down and stowed away under shelter after each occasion of their use. At other places little wickets, hung in the ordinary way, serve to introduce the sheep separately from the sorting alley or conversely, while larger ones guard the openings that lead direct from pen to gathering yard.

The Floors of Pen and Alley.

It is advantageous, where it can be accomplished, to have some firm unyielding floor in the pens and alleys of the fanks. If the ground beneath the animals' feet is soft, the different places soon become coated with mud; if dry, the animals are not long in stirring up a dust, and making matters unpleasant both to themselves and their attendants. The court floor is not so important so long as it is neither unduly wet nor dusty. The sheep have more room to move about in it than within the smaller enclosures, and, therefore, the floor or surface of the same is less liable to be cut up. But in the closely packed alley the innumerable footprints of the many small hoofs are not long in taking effect.

Here, again, we are face to face with concrete as being a suitable medium for floors at the homestead, this time at the sheep fanks, the last department we have to deal with. It need not be so heavy here as at the other places we have discussed in the pages behind us. All we want is a thin coat that will resist the action of the sheeps' feet. What will do this will bear the weight of the shepherds as well, for it is hardly practicable to form a coat of concrete that will not conform to both requirements. Four inches of sound bottoming, with 1½ inches of Portland cement and fine gravel laid thereon (one to five), would serve the end in view admirably, and would not be expensive. Alleys and pens floored in this manner can easily be kept clean. A hard broom or a scraper and a bucketful or two of water enable one to clean out alleys and pens in a very short time. In fact, if left to rain alone they will be found well washed between the different times of using. A clean floor such as we are advocating is of great advantage at a place where the process of dipping is carried on. Very little dirt can be carried therefrom on the feet of the sheep into the dip tank. From an ash laid floor or a gravel strewn one a good deal of extraneous stuff can be conveyed on the "trotters" into the tank, and much more from a muddy one. Besides, when the sheep happen to be gathered together, in order to have their feet attended to, what a benefit it is to be able to have a clean and firm surface for them to stand upon, both before and after treatment. It is heartless work dressing diseased hoofs that have just been in contact with either dusty or dirty floors, and being obliged to turn them back into dust or mess after treatment is not very conducive to quick recovery. Tar macadam seems a suitable material for the floors of these places; but concrete is within everyone's reach, and easy of application.

The floors must, of course, have as much hang or incline as will prevent water lodging upon any of them. Each must be able to clear itself of its own share and what may come from another in such a way that the various enclosures as a whole may be kept free of water. And the pen which contains the dipper must have the floor so arranged that the drippings from the sheep operated on will gravitate back into the tank.

Care must be taken, however, that none of the pens or alleys have too much incline. Tight packing for a little upon the level will not harm the animals, but if jamming takes place towards the lower end of a floor with much inclination, there will be more or less trampling as well as jamming. Some of the sheep at the foot of the incline are certain to be pushed down and trampled under foot by the others, which, if not soon relieved, may be seriously hurt, if not there and then made ready for classification under the head of loss—total loss, we may say—not even "braxy."

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THE END.

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